

HAZWRAP

HAZARDOUS WASTE REMEDIAL ACTIONS PROGRAM

PLATING SHOP - BUILDING 3001

FINAL REMEDIAL INVESTIGATION REPORT VOLUME I OF III: TEXT

U.S. AIR FORCE
INSTALLATION RESTORATION PROGRAM
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

JUNE 1992

prepared by
HALLIBURTON NUS
Environmental Corporation

Prepared for
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TABLE OF CONTENTS

TEXT - VOLUME I

| <u>SECTION</u> | <u>PAGE</u> |
|--|-------------|
| ACRONYMS AND ABBREVIATIONS | vi |
| EXECUTIVE SUMMARY | ES-1 |
| 1.0 INTRODUCTION | 1-1 |
| 1.1 BACKGROUND | 1-1 |
| 1.2 AUTHORITY | 1-2 |
| 1.3 GENERAL PURPOSE AND SCOPE | 1-2 |
| 1.4 INSTALLATION LOCATION AND DESCRIPTION | 1-2 |
| 1.5 REPORT ORGANIZATION | 1-5 |
| 2.0 ENVIRONMENTAL SETTING | 2-1 |
| 2.1 GEOGRAPHIC SETTING | 2-1 |
| 2.1.1 Location and Land Use | 2-1 |
| 2.1.2 Physiographic Setting | 2-1 |
| 2.1.3 Meteorology | 2-3 |
| 2.1.4 Surface Water Drainage | 2-3 |
| 2.2 GEOLOGIC AND HYDROGEOLOGIC SETTING | 2-3 |
| 2.2.1 Regional Geologic Setting | 2-3 |
| 2.2.2 Subsurface Investigation - Plating Shop Facility | 2-5 |
| 2.2.3 Hydrogeologic Setting | 2-5 |
| 3.0 INVESTIGATION ACTIVITIES AND PROCEDURES | 3-1 |
| 3.1 FIELD ACTIVITIES AND PROCEDURES | 3-1 |
| 3.1.1 Mixed-Acid Sump | 3-1 |
| 3.1.1.1 Soil Borings | 3-1 |
| 3.1.1.2 Soil Sampling | 3-3 |
| 3.1.1.3 Sample Identification | 3-3 |
| 3.1.2 Plating Shop Facility | 3-4 |
| 3.1.2.1 Soil Borings | 3-4 |
| 3.1.2.2 Monitoring Well Installation | 3-4 |
| 3.1.2.3 Aquifer Testing | 3-5 |
| 3.1.2.4 Subsurface Soil Sampling | 3-5 |
| 3.1.2.5 Groundwater Sampling | 3-6 |
| 3.1.2.6 Sample Identification | 3-7 |
| 3.1.2.7 Decontamination Procedures | 3-8 |
| 3.1.2.8 Waste Management | 3-8 |
| 3.1.2.9 Surveying | 3-8 |
| 3.2 DATA QUALITY OBJECTIVES | 3-9 |
| 3.3 FIXED BASE LABORATORY METHODS | 3-10 |
| 3.4 DATA VALIDATION | 3-10 |
| 4.0 NATURE AND EXTENT OF CONTAMINATION | 4-1 |
| 4.1 PREVIOUS INVESTIGATIONS | 4-1 |
| 4.2 CHARACTERIZATION OF BACKGROUND CONDITIONS | 4-2 |
| 4.3 MIXED-ACID SUMP | 4-2 |
| 4.3.1 Site Characterization | 4-2 |

TABLE OF CONTENTS

| <u>SECTION</u> | <u>PAGE</u> |
|-------------------|-------------|
| 4.3.2 | 4-7 |
| 4.3.2.1 | 4-7 |
| 4.3.2.2 | 4-13 |
| 4.3.3 | 4-22 |
| 4.4 | 4-24 |
| 4.4.1 | 4-24 |
| 4.4.1.1 | 4-24 |
| 4.4.1.2 | 4-32 |
| 4.4.2 | 4-42 |
| 4.4.2.1 | 4-44 |
| 4.4.2.2 | 4-48 |
| 4.5 | 4-52 |
| 5.0 | 5-1 |
| 5.1 | 5-1 |
| 5.1.1 | 5-2 |
| 5.1.2 | 5-3 |
| 5.2 | 5-3 |
| 5.3 | 5-4 |
| 6.0 | 6-1 |
| 6.1 | 6-2 |
| 6.1.1 | 6-3 |
| 6.1.2 | 6-4 |
| 6.2 | 6-6 |
| 6.2.1 | 6-8 |
| 6.2.2 | 6-9 |
| 6.3 | 6-10 |
| 6.3.1 | 6-16 |
| 6.3.2 | 6-16 |
| 6.4 | 6-21 |
| 6.4.1 | 6-23 |
| 6.4.2 | 6-23 |
| 6.4.3 | 6-28 |
| 7.0 | 7-1 |
| 7.1 | 7-1 |
| 7.1.1 | 7-1 |
| 7.1.2 | 7-1 |
| 7.1.3 | 7-2 |
| 7.2 | 7-2 |
| REFERENCES | R-1 |

TABLE OF CONTENTS

| <u>SECTION</u> | | <u>PAGE</u> |
|--------------------------------|--|-------------|
| APPENDICES - VOLUME II | | |
| A | BORING LOGS, MONITORING WELL CONSTRUCTION, DEVELOPMENT AND SAMPLING FORMS, SLUG TEST CALCULATIONS AND ENGINEERING SURVEY DATA | A-1 |
| B | ANALYTICAL DATA SUMMARY TABLES AND LABORATORY ANALYSIS DATA SHEETS | B-1 |
| APPENDICES - VOLUME III | | |
| C | TENTATIVELY IDENTIFIED COMPOUND ANALYTICAL DATA SUMMARY TABLES AND LABORATORY ANALYSIS DATA SHEETS | C-1 |
| D | GROUNDWATER, SOIL AND WASTE SAMPLE DATA VALIDATION SUMMARIES AND SUPPORTING QA/QC DATA | D-1 |
| E | RISK ASSESSMENT CALCULATIONS | E-1 |

LIST OF TABLES

| <u>NUMBER</u> | | <u>PAGE</u> |
|---------------|---|-------------|
| 4-1 | Average Background Concentrations for Inorganics in Soils | 4-4 |
| 4-2 | Organic Compounds Detected in Soils, Mixed-Acid Sump | 4-8 |
| 4-3 | Inorganics Detected in Soils, Mixed-Acid Sump | 4-14 |
| 4-4 | Comparison of Inorganics Detected Within the Mixed-Acid Sump, Soils to Background Concentrations | 4-19 |
| 4-5 | Organic Compounds Detected in Soils | 4-25 |
| 4-6 | Inorganics Detected in Soils | 4-33 |
| 4-7 | Comparison of Inorganics Detected Within the Plating Shop, Soils to Background Concentrations | 4-40 |
| 4-8 | Frequency and Distribution of Inorganic Detections Above Background Concentrations Found Within the Plating Shop Soils | 4-41 |
| 4-9 | Groundwater Chemistry Data Comparison | 4-43 |
| 4-10 | Organic Compounds Detected in Groundwater | 4-45 |
| 4-11 | Inorganics Detected in Groundwater | 4-49 |
| 6-1 | Chemicals of Concern - Mixed-Acid Sump | 6-5 |
| 6-2 | Chemicals of Concern - Plating Shop Area | 6-7 |
| 6-3 | Regulatory Requirements and Dose - Response Parameters for Chemicals of Concern | 6-11 |
| 6-4 | Exposure Assessment Summary - Direct contact with Soil | 6-19 |
| 6-5 | Hazard Quotients - Direct Contact with Subsurface Soil (Mixed-Acid Sump) | 6-24 |
| 6-6 | Incremental Cancer Risks - Direct Contact with Subsurface Soil (Mixed-Acid Sump) | 6-25 |
| 6-7 | Hazard Quotients - Direct Contact with Subsurface Soil (Plating Shop Area) | 6-26 |
| 6-8 | Incremental Cancer Risks - Direct Contact with Subsurface Soil (Plating Shop Area) | 6-27 |
| 6-9 | Total Hazard Indices | 6-29 |
| 6-10 | Total Incremental Cancer Risks | 6-30 |

LIST OF FIGURES

| <u>NUMBER</u> | | <u>PAGE</u> |
|---------------|--|-------------|
| ES-1 | Building 3001 and Plating Shop Location Map | ES-2 |
| ES-2 | Site Plan, Plating Shop | ES-3 |
| 1-1 | Regional Location Map | 1-3 |
| 1-2 | Building 3001 and Plating Shop Location Map | 1-4 |
| 2-1 | Surface Drainage Map | 2-2 |
| 2-2 | Geologic Map | 2-4 |
| 2-3 | Site Plan and Geologic Cross-Section Location Plan | 2-6 |
| 2-4 | Geologic Cross-Section A-A' and Legend | 2-7 |
| 2-5 | Geologic Cross-Section B-B' | 2-8 |
| 2-6 | Geologic Cross-Section C-C' | 2-9 |
| 2-7 | Groundwater Elevation Contour Map, Perched Aquifer | 2-11 |
| 2-8 | Groundwater Elevations, Building 3001, Perched Aquifer | 2-12 |
| 3-1 | Site Plan, Plating Shop | 3-2 |
| 4-1 | Background Soil Sample Locations, Plating Shop Investigation | 4-3 |
| 4-2 | Site Plan, Plating Shop | 4-5 |
| 4-3 | Boring Locations, Mixed-Acid Sump | 4-6 |
| 4-4 | Cadmium and Chromium Concentration in Soil, Mixed-Acid Sump | 4-21 |
| 4-5 | Nickel and Silver Concentration in Soil, Mixed-Acid Sump | 4-23 |
| 4-6 | Trichloroethene Isoconcentration Map (µg/L) | 4-47 |

ACRONYMS AND ABBREVIATIONS

| | |
|-----------------|---|
| AA | Atomic Absorption |
| AFB | Air Force Base |
| AFLC | Air Force Logistics Command |
| ARAR | Applicable or Relevant and Appropriate Requirement |
| ASTM | American Society for Testing and Materials |
| AWQC | Ambient Water Quality Criteria |
| BNA | Base Neutral/Acid Extractable |
| BW | Body Weight |
| CEC | Cation Exchange Capacity |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| CFR | Code of Federal Regulations |
| CLP | Contract laboratory Program |
| CRDL | Contract Required Detection Limit |
| CM | Centimeter |
| CSF | Cancer Slope Factor |
| DEQPPM | Defense Environmental Quality Program Policy Memorandum |
| DERP | Defense Environmental Restoration Program |
| DOD | Department of Defense |
| DOE | Department of Energy |
| DQOs | Data Quality Objectives |
| ED | Exposure Duration |
| Energy Systems | Martin Marietta Energy Systems, Inc. |
| EPA | Environmental Protection Agency |
| FT | Feet |
| GC/MS | Gas Chromatography/Mass Spectrometry |
| GW | Groundwater Sample |
| Halliburton NUS | Halliburton NUS Environmental Corporation |
| HAZWRAP | Hazardous Waste Remedial Actions Program |
| HPLC | High Pressure Liquid Chromatography |
| ICP | Inductively Coupled Plasma |
| IRP | Installation Restoration Program |
| IWTP | Industrial Waste Treatment Plant |
| Kg | Kilogram |
| LOAEL | Lowest Observed Adverse Effect Level |
| MCL | Maximum Contaminant Level |

ACRONYMS AND ABBREVIATIONS (CONTINUED)

| | |
|--------|---|
| MCLG | Maximum Contaminant Level Goal |
| Mg | Milligram |
| MSL | Mean Sea Level |
| MW | Monitoring Well |
| NGVD | National Geodetic Vertical Datum |
| NOAEL | No Observed Adverse Effect Level |
| NOEL | No Observed Effect Level |
| NPL | National Priorities List |
| PARCC | Precision, Accuracy, Representativeness, Comparability and Completeness |
| PID | Photoionization Detector |
| QA/QC | Quality Assurance/Quality Control |
| RCRA | Resource Conservation and Recovery Act |
| RfD | Reference Dose |
| RI | Remedial Investigation |
| SARA | Superfund Amendments and Reauthorization Act |
| SB | Soil Boring |
| SEC | Second |
| SU | Subsurface Soil Sample |
| SVOC | Semi-volatile Organic Compounds |
| SW | Solid Waste |
| TAL | Target Analyte List |
| TCL | Target Compound List |
| TCLP | Toxicity Characteristic Leaching Procedure |
| TD | Total Depth |
| TIC | Tentatively Identified Compound |
| TOC | Total Organic Carbon |
| UCL | Upper Confidence Limit |
| USACOE | U.S. Army Corps of Engineers |
| USEPA | U.S. Environmental Protection Agency |
| VOC | Volatile Organic Compound |

CHEMICAL COMPOUNDS

| | |
|-----------|----------------------------|
| 1,2-DCE | 1,2-Dichloroethene (total) |
| PCE | Tetrachloroethene |
| TCE | Trichloroethene |
| 1,1,1-TCA | 1,1,1-Trichloroethane |

EXECUTIVE SUMMARY

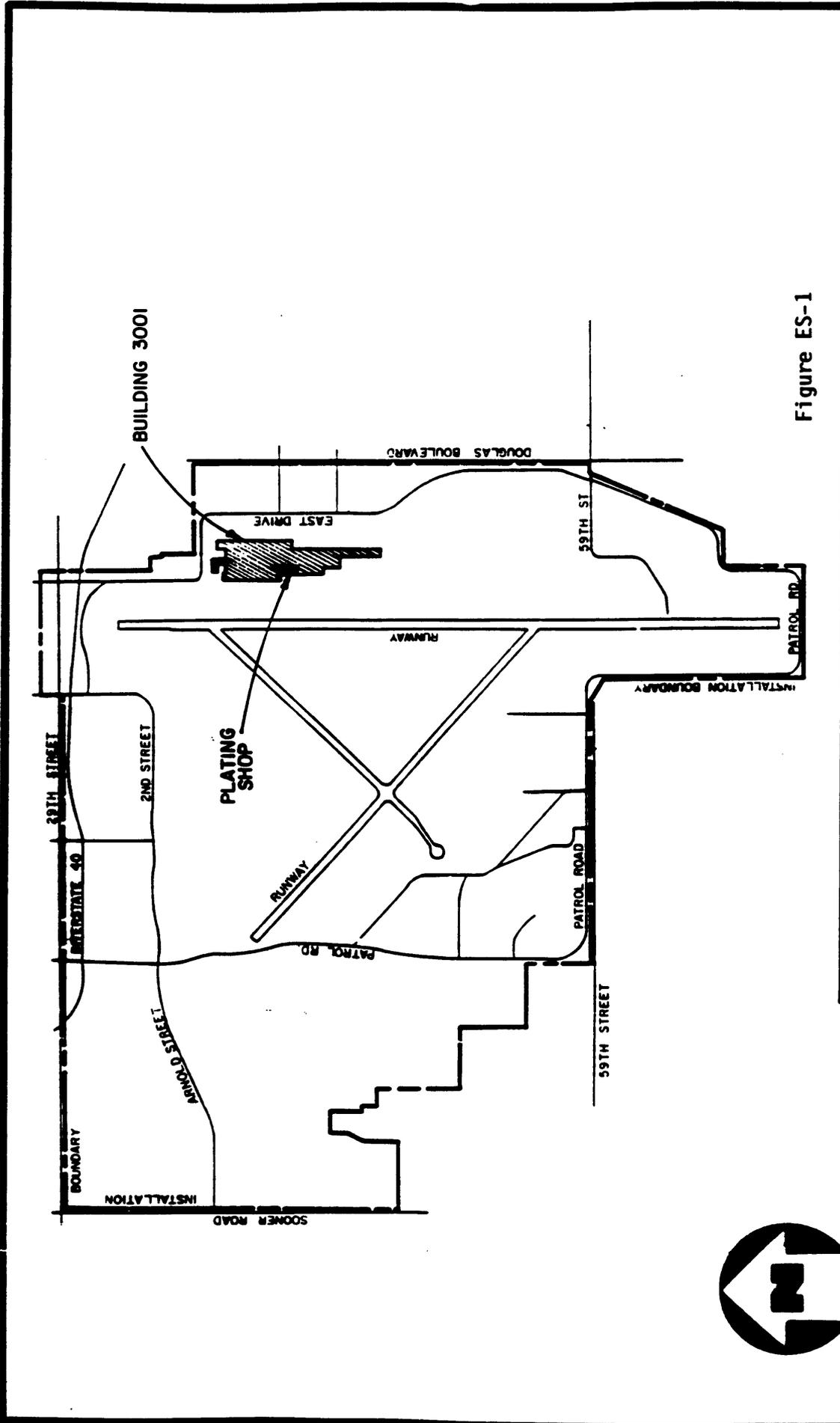
BACKGROUND

This Remedial Investigation for the plating shop in Building 3001 at Tinker Air Force Base was conducted in response to reported leakage of waste acids generated by the plating shop from the mixed-acid sump. The broad objectives of this investigation were to:

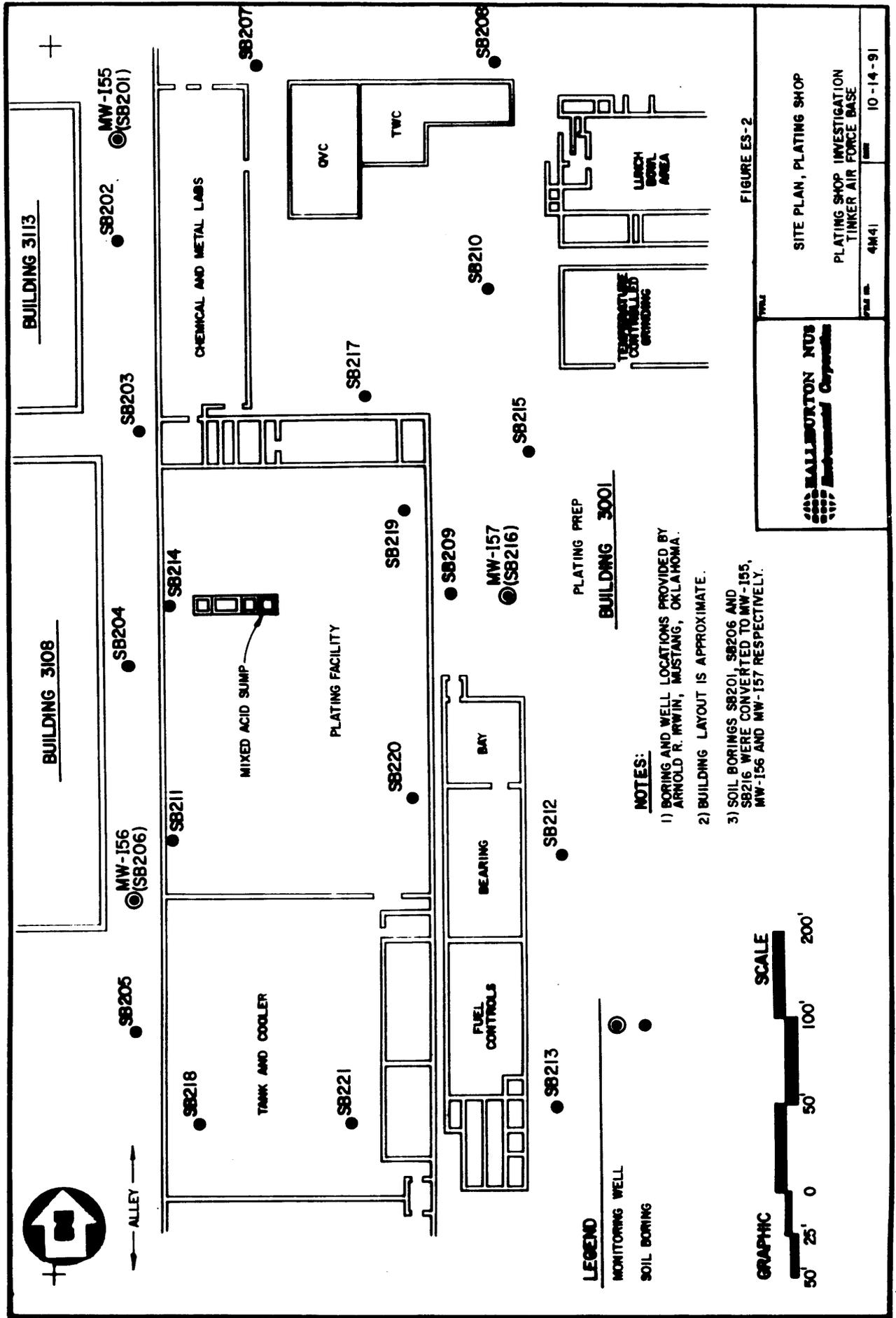
- Confirm or deny the presence of contaminated soils surrounding the mixed-acid sump.
- Determine the nature and extent of contaminated soils and shallow groundwater beneath the plating shop facility.
- Perform an assessment of the actual or potential risks to public health and/or the environment posed by the site.

Tinker Air Force Base is located in southeastern Oklahoma City, near the center of Oklahoma. The industrial facilities located on-base support the activities of the Oklahoma Air Logistics Center. One of these facilities, Building 3001, which was placed on the National Priorities List (NPL) in 1987, is located in the northeast portion of the base and houses an industrial complex used in the maintenance of aircraft. The plating shop, including the mixed-acid sump, is located in the west-central portion of the building, as illustrated on Figures ES-1 and ES-2. Plating tanks within the shop hold solutions containing cadmium, chromium, nickel, and silver and are used to apply protective alloy coatings to aircraft components. Concrete sump pits located below the plating vats store spent plating solutions until they are removed for proper disposal. A green liquid, found to contain highly elevated levels of cadmium, chromium, and nickel, was observed to seep from the concrete into the mixed-acid sump during routine maintenance. This finding initiated the Remedial Investigation at the mixed-acid sump/plating shop facility.

The installation is underlain by soils derived from the in-place weathering of the Hennessey Group shales and sandstones. Shallow groundwater is contained in these near-surface sediments. Previous investigations have confirmed soil and groundwater contamination originating from past waste management practices within Building 3001. Primary contaminants detected in previous studies of the shallow groundwater include trichloroethene and chromium.



| | |
|--|--------------|
| HALLIBURTON NUS <i>Environmental Corporation</i> | |
| TITLE BUILDING 3001 AND PLATING SHOP LOCATION MAP PLATING SHOP INVESTIGATION TINKER AIR FORCE BASE | DATE 4M41 |
| FILE NO. 4M41 | |



FINDINGS

Halliburton NUS Environmental Corporation drilled 16 borings (approximately 4.5 feet deep) horizontally into the walls of the mixed-acid sump and vertically into the floor of the sump to collect environmental soil samples. In addition, 21 borings (20 to 28 feet deep) were drilled within the plating shop to collect environmental soil and groundwater samples. Three of the soil borings were converted to permanent shallow groundwater monitoring wells.

Results of the Remedial Investigation revealed that soils surrounding the mixed-acid sump/plating shop are relatively free of volatile and semivolatile organic compounds. However, soils around the sump contain elevated levels of inorganics, such as arsenic, cadmium, calcium, chromium, mercury, nickel, silver, and cyanide. The presence of these inorganics in the soils is probably due to the escape of waste plating shop fluids from the sump through the floor joints or wall seams. Compared to sump soils, surrounding plating shop soils show much lower levels of these inorganics. Calculations show acceptable carcinogenic and noncarcinogenic risks to maintenance or construction workers periodically exposed to the soils beneath the plating shop during renovation, repair or replacement of the sumps.

Chlorinated aliphatic compounds and elevated levels of chromium, lead, mercury, and selenium were detected in the shallow groundwater during this investigation. Suspected sources of groundwater contamination exist to the northeast and southwest of the plating shop facility. Migration of these compounds under the plating shop can only be inferred until additional groundwater elevation data are obtained from the shallow monitoring wells surrounding Building 3001. However, groundwater contained in the shallow aquifer beneath the plating shop is scheduled for remediation as part of the overall CERCLA cleanup of Building 3001.

The mixed-acid sump/plating shop soils are not a suspected source of organic contaminants detected in the groundwater. However, soils around the mixed-acid sump (but not from the rest of the plating shop) are a potential source of inorganic groundwater contamination. Due to the limited potential for infiltrating water to interact with the soils surrounding the mixed-acid sump, the potential for leaching inorganics from these soils is considered low.

RECOMMENDATIONS

The major recommendations are summarized as follows:

- It is recommended that groundwater elevation data be collected on a quarterly basis to detect seasonal fluctuations in the shallow water table.

In addition, a combination of measures should be employed to eliminate leakage of plating shop acids from the sump and/or detect leakage when or if it occurs. Corrective measures that should be used to minimize the potential for leaks include:

- Redesign of the plating operation to eliminate the use of the in-ground sumps. Aboveground tanks with secondary containment could be installed outside Building 3001 or possibly within the sumps to store the spent plating wastes.
- If the existing mixed-acid sump will continue to store spent plating wastes, it should be made more leak resistant by applying a new waterproof coating to the concrete. Two liners should be installed in the sump with a leak detection system installed between the two linings and between the concrete and the liners.
- In combination with the above process controls the existing network of shallow monitoring wells should be employed to detect, in a timely manner, the presence of any inorganics coming from the sump or the soils surrounding the sump.

1.0 INTRODUCTION

1.1 BACKGROUND

The U.S. Air Force, because of its primary mission in defense of the United States, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. This has been recognized by the Department of Defense (DOD), and action has been taken to identify the locations and contents of past disposal sites on DOD installations and to eliminate the hazards to public health posed by the sites in an environmentally responsible manner. The DOD program is called the Defense Environmental Restoration Program (DERP). The Air Force component of the program is the Installation Restoration Program (IRP).

Current policy for the IRP is contained in Defense Environmental Quality Program Policy Memorandum (DEQPPM) 81-5, dated December 11, 1981. The IRP is similar to the Environmental Protection Agency's (EPA's) Superfund program under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The IRP is defined in DEQPPM 81-5 as a four-phased investigative and remedial effort designed to identify and evaluate past material disposal or spill sites and to control potential migration of environmental contamination. The magnitude of contamination is to be quantified by analysis of appropriate soil, sediment, water, and air samples. Data from these analyses are used to assess potential human health and environmental risks. The IRP was originally developed and implemented as a four-phased program, including problem identification (Phase I), confirmation (Phase II), technology development (Phase III), and remedial action (Phase IV).

This four-phased approach has been changed to ensure consistency between the IRP and other national hazardous waste cleanup programs. The terminology and procedures for the IRP have been changed to match those given in the National Contingency Plan (40 CFR 300, March 1990) as follows:

- Preliminary Assessment/Site Inspection
- Remedial Investigation/Feasibility Study
- Remedial Design/Remedial Action

Initial guidance for the four-phased IRP was published in January 1982. Air Force message 211807Z, January 1982, implemented DEQPPM 81-5 for Air Force properties. The IRP Guidance Manual was revised in 1989 and reflects the influence of the Superfund Amendments and Reauthorization Act (SARA) of 1986.

1.2 AUTHORITY

The Department of Energy (DOE) has entered into an Interagency Agreement with the Air Force Logistics Command (AFLC) to provide technical assistance to the IRP effort through Martin Marietta Energy Systems, Inc. (Energy Systems). This Remedial Investigation (RI) Report for the Plating Shop Facility, located in Building 3001 at Tinker Air Force Base (AFB) was prepared by Halliburton NUS Environmental Corporation (Halliburton NUS) under contract to the Hazardous Waste Remedial Actions Program (HAZWRAP) in response to General Order No. 13B-99784C, Task Order Y-04 dated September 7, 1989.

1.3 GENERAL PURPOSE AND SCOPE

The purpose of this report is to present the results of the RI conducted by Halliburton NUS for the mixed-acid sump/plating shop facility in Building 3001 at Tinker AFB, Oklahoma City, Oklahoma. The scope of this report includes general background information, a description of investigative activities, all data accumulated from the field investigations, the analytical program, a summary and interpretation of the data, results of the risk assessment, an evaluation of contaminant fate and transport, and recommendations regarding the future disposition of the site.

1.4 INSTALLATION LOCATION AND DESCRIPTION

Tinker AFB is located in central Oklahoma, in the southeast portion of the Oklahoma City metropolitan area. Figure 1-1 illustrates the general location of the installation within the state of Oklahoma. The base covers 5,001 acres and is surrounded by suburban residential and commercial development to the north, west, and east, with industrial and commercial development to the south. The plating shop facility is housed within Building 3001, which was placed on the NPL in 1987, and is located in the northeast portion of the installation, east of the main instrument runway (Figure 1-2). The location of the plating shop within Building 3001 is also shown on Figure 1-2.

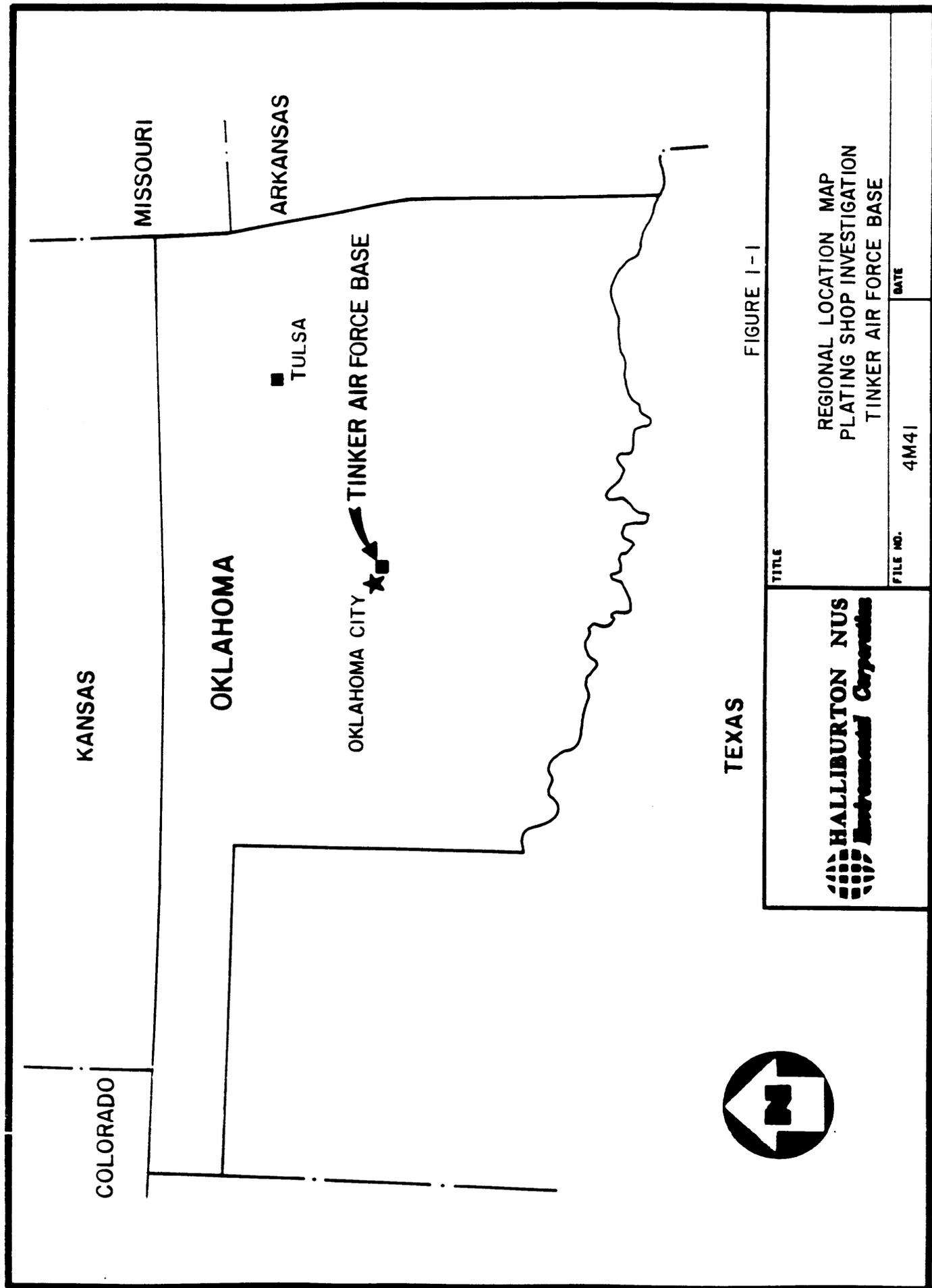


FIGURE 1-1

TEXAS

KANSAS

OKLAHOMA

■ TULSA

OKLAHOMA CITY

TINKER AIR FORCE BASE

MISSOURI

ARKANSAS

COLORADO



REGIONAL LOCATION MAP
PLATING SHOP INVESTIGATION
TINKER AIR FORCE BASE

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FILE NO.

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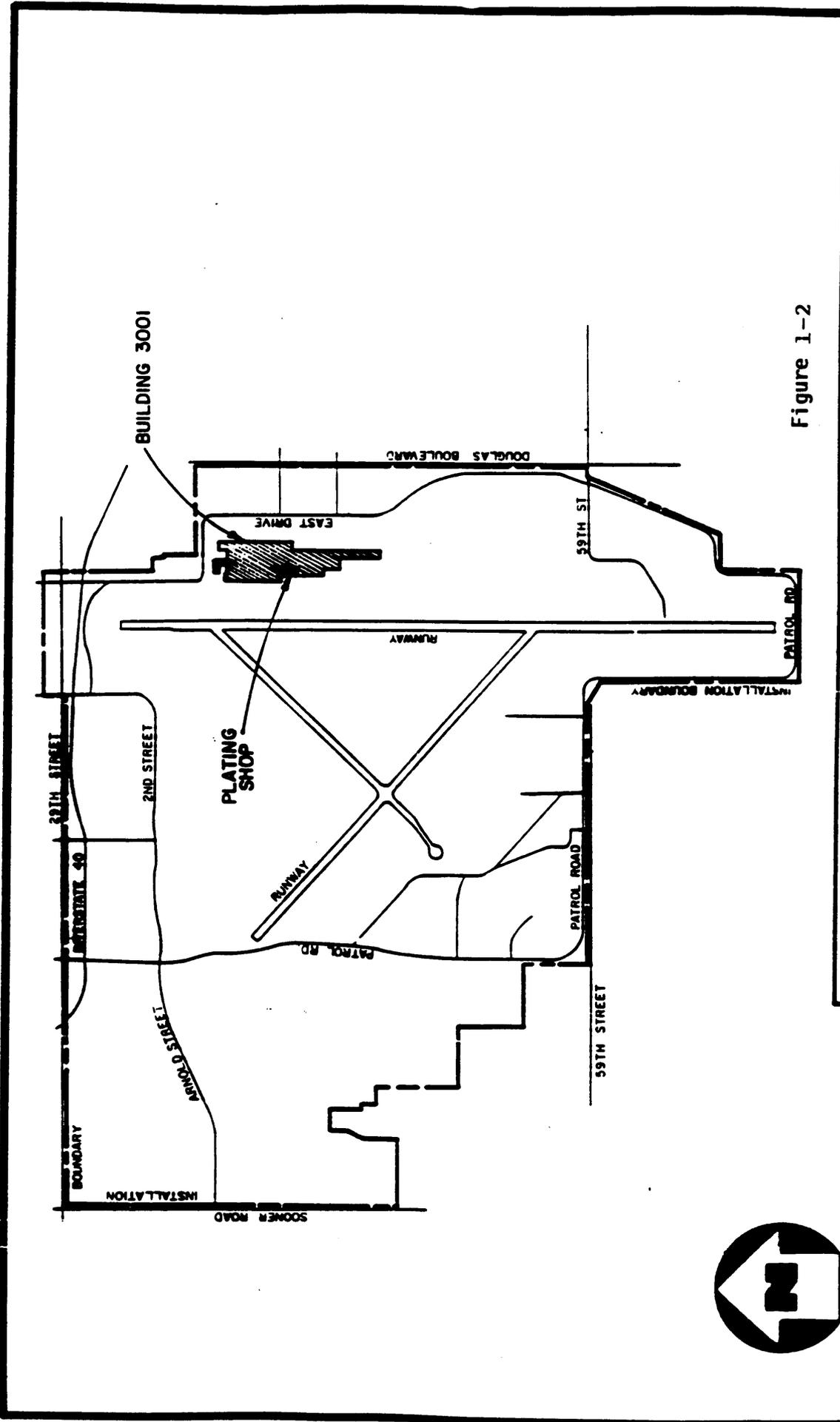


Figure 1-2

BUILDING 3001 AND
 PLATING SHOP LOCATION MAP
 PLATING SHOP INVESTIGATION
 TINKER AIR FORCE BASE

TITLE



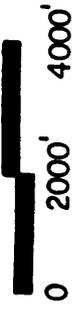
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GRAPHIC SCALE



Building 3001 occupies approximately 50 acres of land and houses an industrial complex used in the overhaul and modification of aircraft to support the activities of the Oklahoma Air Logistics Center. All phases of aircraft disassembly, engine overhaul, inspection, plating, testing, repair, and reassembly are conducted within Building 3001. These activities involve the use of industrial solvents, and plating solutions, which often contain high concentrations of metals.

Before the mid-1970s, industrial wastes were typically stored in concrete-lined pits located at various locations around the building. These pits were decommissioned in the 1970s. However, leakage from these pits has resulted in groundwater contamination (USACOE 1988). Operations specific to the plating shop facility include immersing aircraft components into plating solutions for applications of protective alloy coatings. Various plating tanks contain solutions of nickel, cadmium, silver, and chromium.

Concrete sump pits with synthetic liners are located below the plating vats to receive spent plating solutions. The sumps house the plating solutions until they can be removed for proper disposal as a hazardous waste. During routine maintenance, one of the concrete sump pits, the mixed-acid sump, was found to have been breached in several locations. The steel/synthetic liners were then removed from the containment cell and the concrete was cleaned. A green liquid was observed to seep into the cell from the concrete. This liquid was analyzed and found to contain high levels of nickel, cadmium, and chromium. These circumstances led to this RI at the mixed-acid sump/plating shop facility in Building 3001.

1.5 REPORT ORGANIZATION

This report is organized into seven sections, plus appendices. Section 1.0 outlines the purpose and scope of the RI, as well as general installation and site background information. Section 2.0 describes the environmental setting at Tinker AFB, and Section 3.0 provides a general description of the procedures and methodologies used by Halliburton NUS in conducting the field program, analytical program, and risk assessment for this RI. Section 4.0 presents a discussion of the nature and extent of site contaminants, and Section 5.0 examines the fate and migration of these contaminants after they are released into the environment. A risk assessment is presented in Section 6.0, and the findings and recommendations for the RI report are presented in Section 7.0.

2.0 ENVIRONMENTAL SETTING

A detailed discussion of the environmental setting of Tinker AFB was presented in the IRP Phase I Records Search (Engineering-Science 1982). Subsequent investigations, including the IRP Phase II Stage 1 Field Evaluation (Radian Corporation 1984a) and the Building 3001 Remedial Investigation (USACOE 1988), have added significant subsurface geologic and hydrogeologic information to the existing data base. Much of the discussion of the environmental setting presented in this report is derived from these previous documents. This information will be supplemented with data from the literature, plus a site-specific description of the geology and hydrogeology of the plating shop facility.

2.1 GEOGRAPHIC SETTING

A brief discussion of the geography at Tinker AFB, including the land use patterns around the base, physiographic setting, meteorology, and surface water hydrology, will be presented in Sections 2.1.1 through 2.1.4.

2.1.1 Location and Land Use

Tinker AFB is located in Oklahoma City, Oklahoma, immediately south of the suburb of Midwest City and east of Del City (Figure 2-1). The base is bordered by commercial and residential developments along Interstate Highway 40 to the north and residential and agricultural areas to the east. Residential areas also exist west of the base, while the industrial complex of the General Motors Plant and undeveloped lands are situated south of the base. Lake Stanley Draper is located approximately three-quarters of a mile southeast of the installation boundary.

2.1.2 Physiographic Setting

Tinker AFB is situated within the Central Redbed Plains section of the Central Lowland Physiographic Province (Curtis and Ham 1972). This area is characterized by flat to gently rolling prairie and grassland, with well-entrenched main streams. Local relief is primarily the result of stream erosion. Surface elevations in the Oklahoma City area range from 1,070 to 1,400 feet above mean sea level (MSL). Ground surface elevations on the base range from 1,190 to 1,310 feet above MSL. Building 3001, which includes the plating shop facility, is located upon a broad topographic high east of the main north-south runway at an approximate elevation of 1,275 feet above MSL.

2.1.3 Meteorology

The weather in central Oklahoma is characterized by long, hot summers and cold, windy winters. The mean annual temperature is approximately 61°F with rainfall averaging about 32 inches per year. Strong spring thunderstorms during May make it the wettest month. Winter and summer can be quite dry.

2.1.4 Surface Water Drainage

Tinker AFB is within the North Canadian River drainage basin. Surface water drainage is accomplished by overland flow of runoff to several intermittent streams (Figure 2-1). Crutch Creek, a tributary of the North Canadian River, drains the western sections of the base, including the main instrument runway. South of the runway, two intermittent streams channel a small quantity of runoff to Stanley Draper Lake. Building 3001 is located on a drainage divide. On the south, north, and east sides of the building, drainage flows into Soldier Creek, which generally flows northward to join Crutch Creek before it enters the North Canadian River. Surface and storm waters on the west side of Building 3001 (including the plating shop facility) drain to West Soldier Creek which eventually flows into Soldier Creek.

2.2 GEOLOGIC AND HYDROGEOLOGIC SETTING

This section describes the regional and site-specific geology and hydrogeology that are pertinent to this RI Report.

2.2.1 Regional Geologic Setting

The Oklahoma City area is located in a tectonically stable area on the eastern flank of the Anadarko Basin. Bedrock units in the Oklahoma City area dip at a low angle to the west-southwest toward the basin's center. No major faults or fault zones have been mapped under the Base. Figure 2-2 is a generalized geologic map of the Tinker AFB area after Wood and Burton (1968) and Radian (1984) showing that the Base is underlain by Permian-aged sedimentary rocks of the lower Hennessey Group. The lowermost unit of the Hennessey Group is the Fairmont Shale, which is described by Bingham and Moore (1975) as a red-brown, blocky shale that exhibits a gradational contact with the underlying Garber Sandstone. The subsurface investigations conducted during this and previous

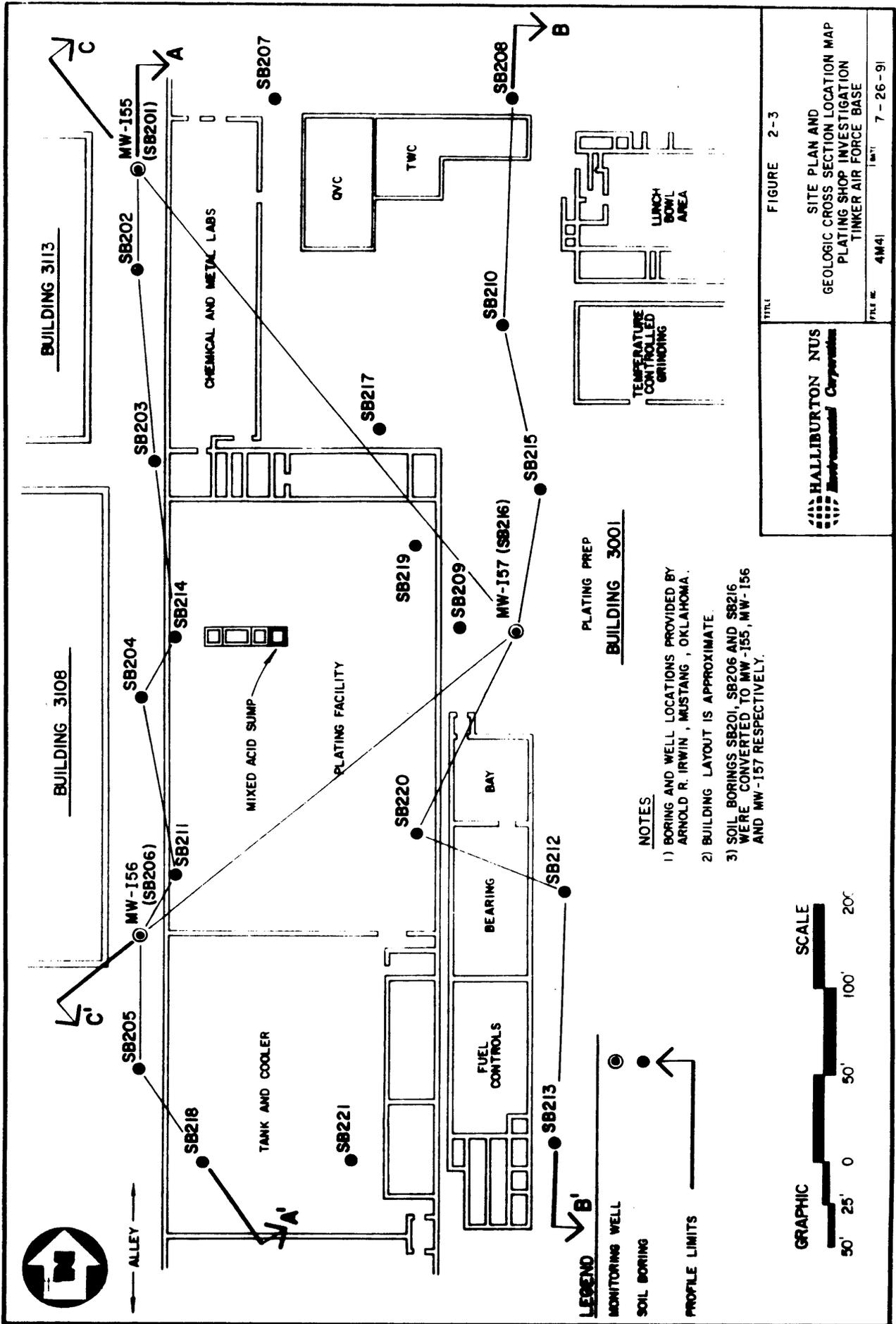
IRP investigations generally support this geologic interpretation, as most of the soil borings drilled on base have penetrated the uppermost unit of weathered bedrock consisting of shale and silty shale. These units are probably the residuum of the lowermost units of the Hennessey Group. The only geologic units younger than the Hennessey Group shales that occur on base are recent-aged alluvial deposits that are present in floodplains of the streams on base.

2.2.2 Subsurface Investigation - Plating Shop Facility

The locations of the 21 soil borings drilled within the plating shop facility during this investigation are illustrated on Figure 2-3. Three of these 21 borings were converted to monitoring wells. These borings were advanced to depths of between 20 and 28 feet and were drilled to investigate the nature and extent of soil and groundwater contamination beneath the plating shop facility. The shallow borings drilled to investigate the soils surrounding the mixed-acid sump are not shown on this map. Also shown on this site map are the locations of three geologic profiles, which are presented as Figures 2-4, 2-5, and 2-6. Groundwater in the perched aquifer underlying the plating shop facility flows through sediments derived from the in-place weathering of the Permian-aged Hennessey Group silts and clays. In general, all of the borings drilled during this investigation penetrated clays and clayey silts to a depth of approximately 15 to 20 feet, then fine-grained silty sand and/or sandstone to the total depth of the borings. Because no borings were advanced below a depth of 28 feet, the thickness of the lower sandstone units could not be determined. However, borings drilled for the RI at Building 3001 (USACOE 1988) indicate that the sandstone intervals are highly variable in vertical and lateral extent. This variability is illustrated in geologic profile C-C', which shows the interfingering nature of the sandstone unit encountered during the drilling of MW-155. One soil sample each from borings SB206 and SB216 was analyzed for engineering parameters. Both samples analyzed were inorganic silty clays having vertical permeabilities of 4.1×10^{-9} and 5.3×10^{-8} cm/sec.

2.2.3 Hydrogeologic Setting

The groundwater hydrogeology of the Tinker AFB area has been described by Jacobsen and Reed (1949), Wood and Burton (1968), Bingham and Moore (1975), Bedinger and Sniegocke (1976), and Wickersham (1979). Previous IRP investigations have determined that two distinct aquifers exist underlying the Base: a shallow, unconfined, perched aquifer and a deeper, regional aquifer (the Garber-Wellington Aquifer), which provides drinking water for over 500,000 residents of greater Oklahoma City. Tinker AFB is located over a major recharge zone for the unit. The Garber-Wellington Aquifer contains several producing zones, but most water for industrial and commercial use is obtained from depths ranging from 250 to 700 feet.



NOTES

- 1) BORING AND WELL LOCATIONS PROVIDED BY ARNOLD R. IRWIN, MUSTANG, OKLAHOMA.
- 2) BUILDING LAYOUT IS APPROXIMATE.
- 3) SOIL BORINGS SB201, SB206 AND SB216 WERE CONVERTED TO MW-155, MW-156 AND MW-157 RESPECTIVELY.

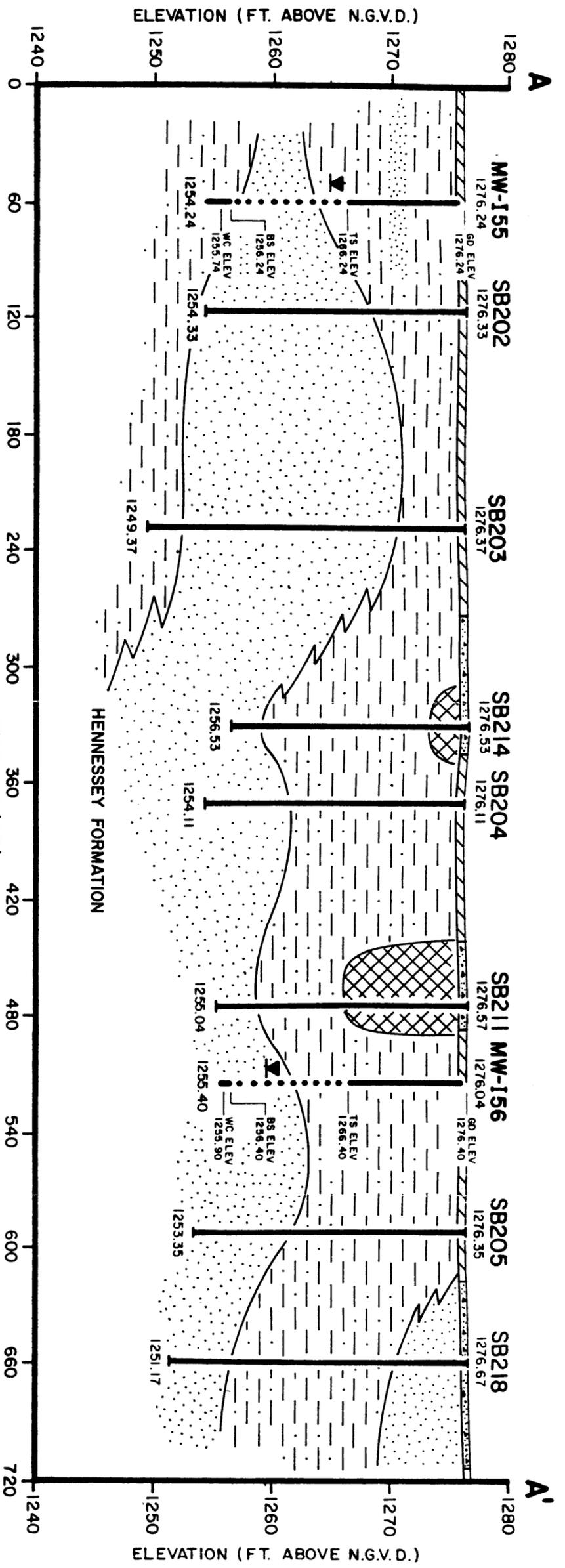
HALLIBURTON NUS
Environmental Corporation

FIGURE 2-3

**SITE PLAN AND
GEOLOGIC CROSS SECTION LOCATION MAP
PLATING SHOP INVESTIGATION
TINKER AIR FORCE BASE**

FILE NO. 4M41

DATE 7-26-91



LEGENDS

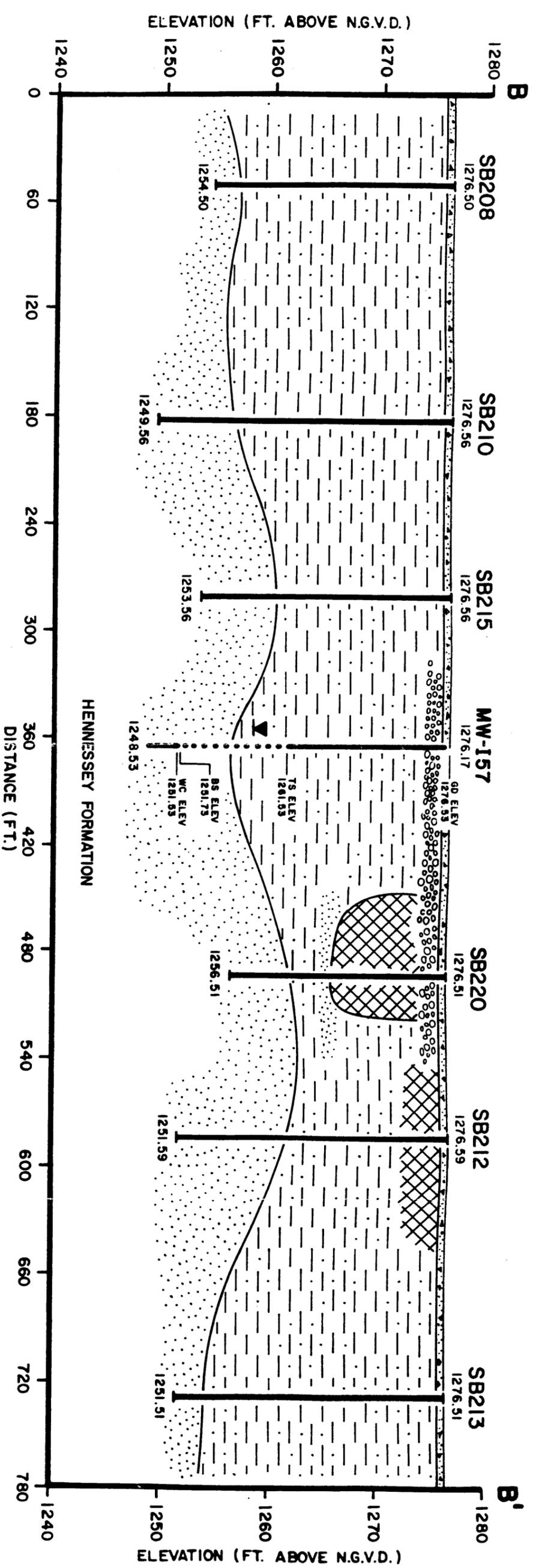
| | | |
|---|---|--|
| <p>WELL</p> <p>MW-155 (SB-12) 100.00 WELL DEPTH TOP OF WELL ELEVATION GROUND SURFACE ELEVATION</p> <p>SB-12 100.00 SOIL DEPTH GROUND SURFACE ELEVATION</p> <p>11 ELEV. TOP OF SCREEN ELEVATION 12 ELEV. WATER ELEVATION ON DATE INDICATED 13 ELEV. BOTTOM OF SCREEN ELEVATION 14 ELEV. WELL CAP ELEVATION 15 ELEV. BOTTOM OF BOWEN ELEVATION</p> | <p>BORING</p> <p>SOIL DEPTH GROUND SURFACE ELEVATION</p> <p>16 ELEV. BOTTOM OF BOWEN ELEVATION</p> | <p>LITHOLOGY</p> <p>SAND - REDDISH BROWN, SILTY, CLAYEY VERY FINE TO MEDIUM GRAINED, ROUNDED, MODERATE TO WELL SORTED, MASSIVE, RARELY CROSS BEDDED, GRADES TO WEATHERED SANDSTONE WITH DEPTH</p> <p>CLAYEY SILT - OR SILTY CLAY, REDDISH BROWN TO ORANGE, OCCASIONALLY SANDY, GENERALLY MASSIVE, STIFF TO VERY STIFF</p> <p>FILL - CLAY, SILTY, REDDISH BROWN VERY STIFF OR SAND, GREY, SILTY, FINE GRAINED, LOOSE</p> <p>CRUSHED STONE</p> <p>CONCRETE</p> <p>ASPHALT</p> |
|---|---|--|



TITLE: **FIGURE 2-4**

GEOLOGIC CROSS SECTION A-A' AND LEGEND
PLATING SHOP INVESTIGATION
TINKER AIR FORCE BASE

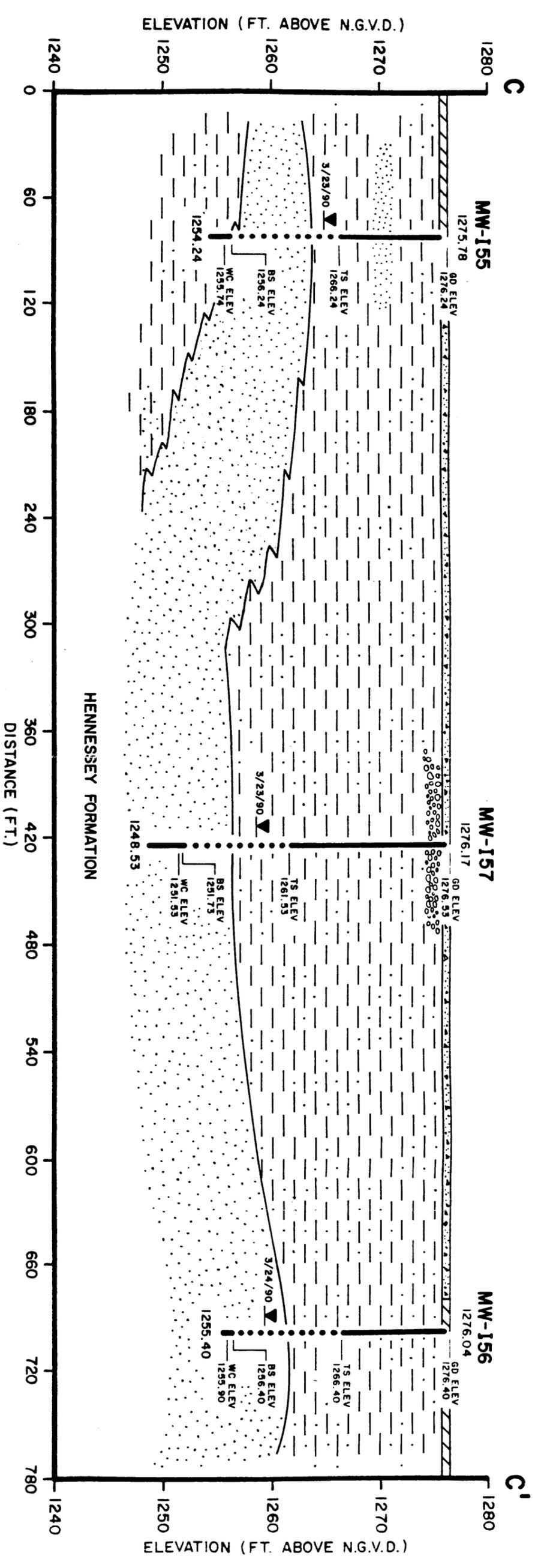
FILE NO. 4M41 DATE 7-26-91



CROSS-SECTION B-B'
 VERTICAL EXAGGERATION = 6 X HORIZONTAL

NOTE:
 FOR LEGEND, SEE FIGURE 2-4.

| | | |
|---|-----------------|---|
|  HALLIBURTON NUS <i>Environmental Corporation</i> | | TITLE FIGURE 2-5 |
| FILE NO. 4M41 | DATE 7-26-91 | GEOLOGIC CROSS SECTION B-B' PLATING SHOP INVESTIGATION TINKER AIR FORCE BASE |



CROSS-SECTION C-C'
VERTICAL EXAGGERATION = 6 X HORIZONTAL

NOTE:
FOR LEGEND, SEE FIGURE 2-4.

| | | |
|----------|--|------------|
| | TITLE | FIGURE 2-6 |
| | GEOLOGIC CROSS SECTION C-C' PLATING SHOP INVESTIGATION TINKER AIR FORCE BASE | |
| FILE NO. | 4M41 | DATE |
| | | 7-26-91 |

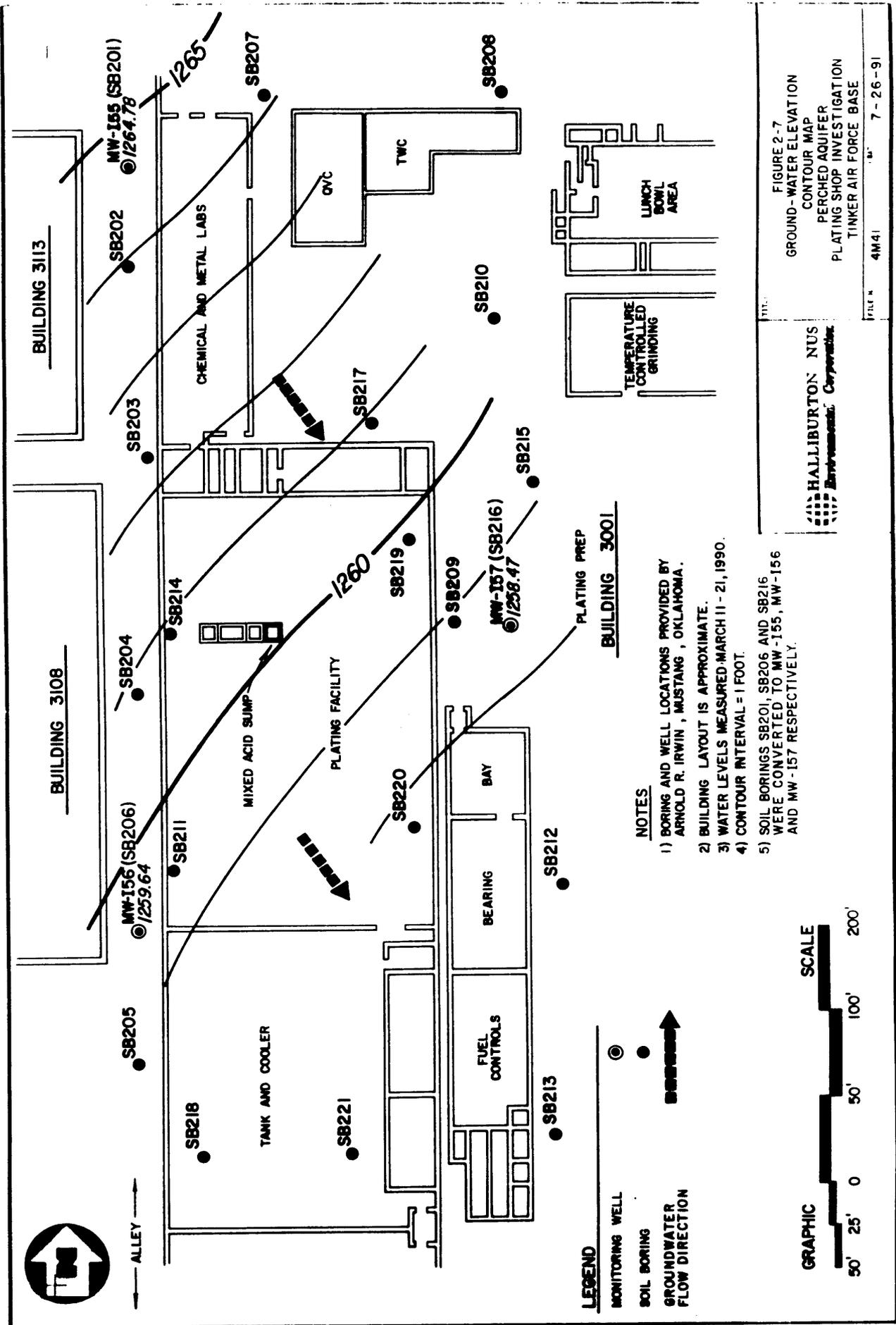
Contaminants detected in both aquifers during previous IRP investigations indicate that hydraulic connections exist between the two aquifers. Contaminants entering the perched water-bearing unit will tend to migrate vertically into the Garber-Wellington Aquifer.

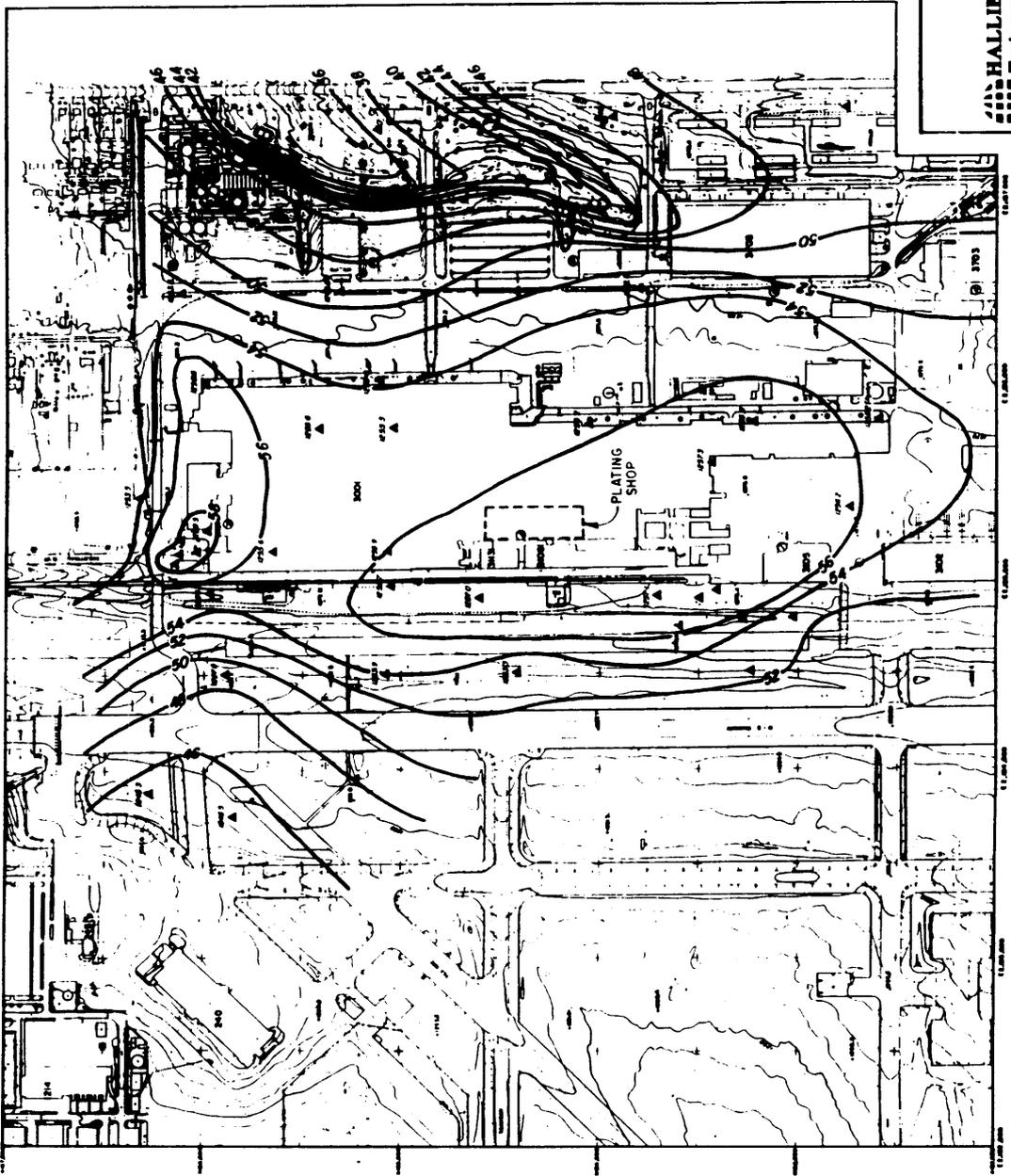
Each of the 21 soil borings drilled at the plating shop facility into the shallow aquifer encountered groundwater at depths between 10.8 and 18 feet below ground surface. Groundwater was not encountered by any of the borings drilled in the mixed-acid sump. Groundwater elevations at monitoring wells MW-I55, MW-I56, and MW-I57, as measured in March 1990, reveal that groundwater beneath the plating shop is flowing to the southeast (Figure 2-7). In contrast, the June 1987 data presented in the RI Report for Building 3001 (USACOE 1988) show a groundwater high existing within the perched aquifer beneath the building. A map illustrating the elevations of the shallow groundwater from the USACOE report is presented as Figure 2-8. This map indicates that the hydraulic gradient beneath the plating shop is virtually flat. The actual gradient beneath the plating shop is probably highly variable. Fluctuations of the water table during wet and dry seasons, leaking storm sewer or water lines beneath the building, and runoff from the roof drains are some of the factors that will have an impact on groundwater elevations in the shallow aquifer around Building 3001. Flow conditions in the shallow aquifer cannot be fully understood without data from frequent groundwater elevation measurements.

Water table elevations and hydraulic conductivity values derived from slug tests (see Section 3.1.2.3 for procedures used during the slug testing) for the three wells installed during this investigation are presented in the following table:

| Well | Ref. Elevation (feet) | Depth to Water (feet) | Water Table Elevation (feet) | Hydraulic Conductivity (cm/sec) |
|--------|-----------------------|-----------------------|------------------------------|---------------------------------|
| MW-I55 | 1275.88 | 11.1 | 1264.78 | 3.07×10^{-4} |
| MW-I56 | 1276.04 | 16.4 | 1259.64 | 1.54×10^{-3} |
| MW-I57 | 1276.17 | 17.7 | 1258.47 | 8.81×10^{-4} |

The calculated hydraulic conductivity values obtained from the perched aquifer during this investigation compare favorably to values obtained by the USACOE during their investigation of the shallow aquifer. Slug test results and sample calculations are included in Appendix A.





LEGEND

- MONITORING WELL CLUSTER ▲
- PIEZOMETER ●
- WATER SUPPLY WELL ○
- WATER SUPPLY WELL (PLUGGED) ◐
- WATER TABLE ELEVATION IN PERCHED AQUIFER (FEET) /293.9
- WATER TABLE CONTOUR (50'-ELEVATION 1250) —50—



Figure 2-8

HALLIBURTON NUS
Environmental Corporation

TITLE: GROUND-WATER ELEVATIONS
 BUILDING 3001 PERCHED AQUIFER
 PLATING SHOP INVESTIGATION
 TINKER AIR FORCE BASE

FILE NO. 4M41

DATE

3.0 INVESTIGATION ACTIVITIES AND PROCEDURES

Investigations were initiated within the mixed-acid sump and the plating shop facility to determine if soils and groundwater within the shallow aquifer have been impacted by past and current activities within the plating shop. A description of the activities and procedures used in this investigation are presented in the following sections.

3.1 FIELD ACTIVITIES AND PROCEDURES

Field investigation activities performed within the mixed-acid sump/plating shop facility included a soil boring program, the installation of monitoring wells, soil and groundwater sampling, and aquifer testing. All field activities were conducted in accordance with the approved Work Plan for the Plating Shop-Building 3001 at Tinker AFB (NUS 1989).

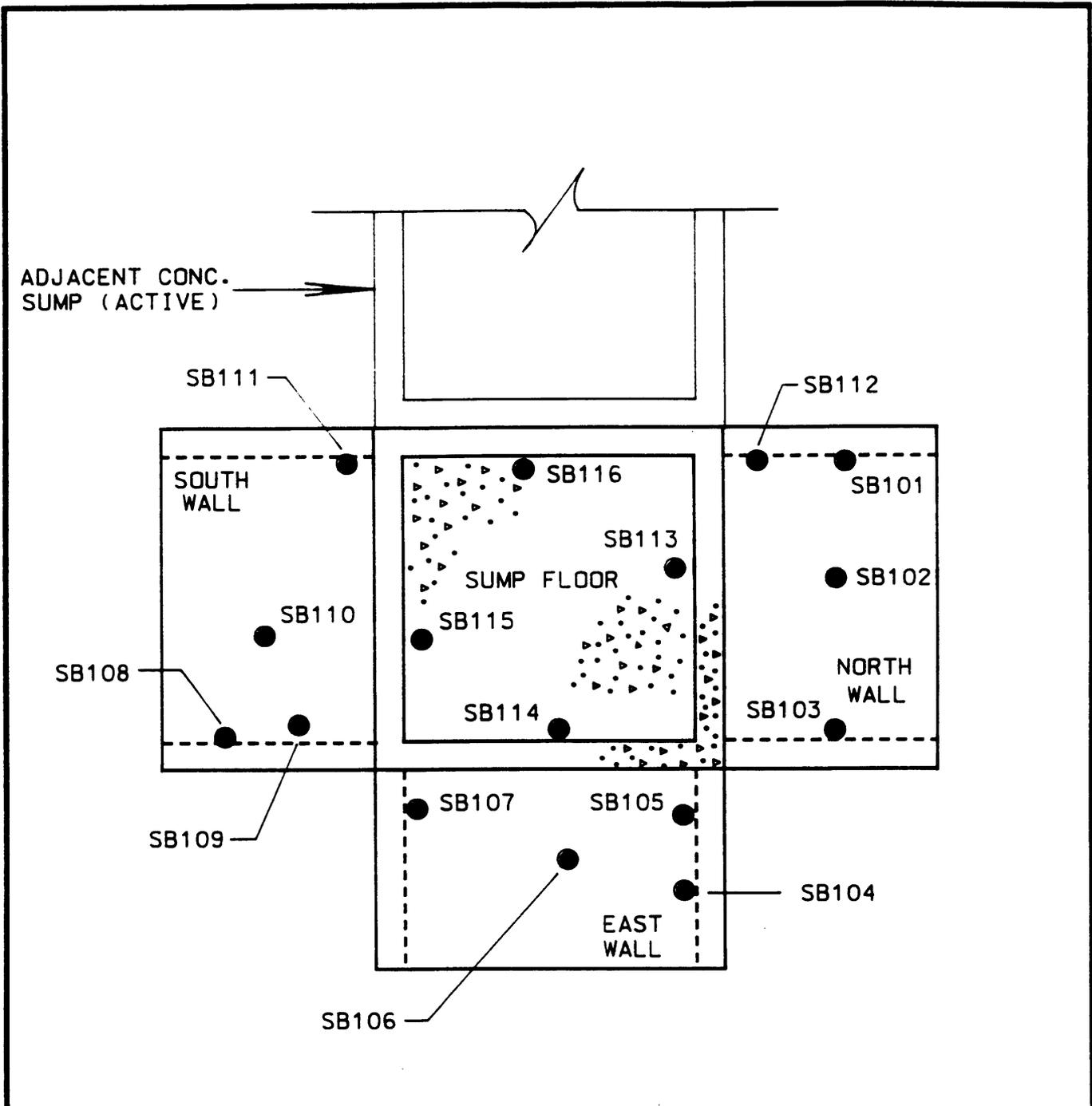
In addition to the 21 soil borings drilled within the plating shop facility (three of which were converted to monitoring wells), sixteen shallow borings designated SB101-SB116 were drilled in the mixed-acid sump. Figure 2-3 illustrates the location of the mixed-acid sump and the 21 soil borings (SB201-SB221) drilled within the plating shop facility. A summary of the field activities conducted within the mixed-acid sump and plating shop facility is provided below.

3.1.1 Mixed-Acid Sump

3.1.1.1 Soil Borings

Soil borings, drilled both horizontally into the walls and vertically into the floor of the sump, were the only field activities performed within the mixed-acid sump. A total of 16 borings (SB101 - SB116) illustrated on Figure 3-1 were drilled in the sump using the following procedures:

- Terracon, Inc., cored 4-inch-diameter holes through the concrete at the 16 sampling locations. Four vertical and 12 horizontal holes were drilled into the concrete.
- Each boring was then advanced using a hand auger to a maximum depth of 4 feet. Soil samples for laboratory analyses were collected from these hand augered borings.
- All borings were abandoned by first backfilling the hole with bentonite to the level of the concrete and then patching with a concrete and bentonite (5%) mixture.



LEGEND

SOIL BORING ●



SCALE: $\frac{3}{16}$ " = 1'-0"

FIGURE 3-1

NUS
CORPORATION

H A Halliburton Company

| | | |
|----------|---|------------------|
| TITLE | BORING LOCATIONS MIXED ACID SUMP BUILDING 3001 TINKER AIR FORCE BASE | |
| FILE NO. | 4M41G001 | DATE 10-14-91 |

3.1.1.2 Soil Sampling

Soil samples were collected by hand auger for chemical analyses from the 1- to 1.5-foot, 2- to 2.5-foot, and 3.5- to 4-foot intervals. Of the 48 proposed sampling points, only 40 samples were obtained. Several environmental samples, including all of the samples from boring SB110, could not be collected because of refusal of the hand auger on concrete, crushed stone backfill, or compacted soil. After collection, the samples were sent to the Halliburton NUS Laboratory Services Group in Houston, Texas, for analysis. Environmental samples were analyzed for target compound list (TCL), volatile organic compounds (VOCs), TCL semivolatile volatile organic compounds (SVOCs), target analyte list (TAL) inorganics and cyanide, pH, cation exchange capacity (CEC), and total organic carbon (TOC). The following table summarizes the analytical program used in analysis of the mixed-acid sump soils:

MIXED-ACID SUMP SOIL LABORATORY ANALYTES

| Parameter | Analytical Methods | Total Number of Environmental Samples Analyzed | HAZWRAP QA/QC Level ⁽¹⁾ |
|----------------------------|--------------------|--|------------------------------------|
| TCL Volatile Organics | CLP | 40 | D |
| TAL Inorganics and Cyanide | CLP | 29 | D |
| TCL Semivolatile Organics | CLP | 28 | D |
| pH | SW 9045 | 27 | E |
| CEC | SW 9081 | 1 | E |
| TOC | Walkley-Black | 1 | C |

(1) See Section 3.2 for a summary of HAZWRAP QA/QC levels.

The majority of the chemical analyses were performed employing HAZWRAP Level D quality assurance/quality control (QA/QC) protocols. The appropriate number of QA/QC samples was collected per these protocols. Splits of four soil samples from borings SB101, SB105, SB107, and SB111 were sent to the Oklahoma Department of Health Environmental Laboratory and the HAZWRAP Laboratory for analysis.

3.1.1.3 Sample Identification

Analytical soil samples obtained from within the sump are identified by a three-segment code. For example, in soil sample T-SU-SB101A the "T" (for Tinker AFB) is the base identifier, while the "SU" indicates that this sample is a subsurface soil sample. The remaining six digits identify the boring and sample number; SB101 indicates that the sample is from soil boring 101 and the "A" qualifier

indicates the depth from which the sample was collected. In general, "A" samples were collected from depths of 1 to 1.5 feet, "B" samples from 2 to 2.5 feet, and "C" samples from 3.5 to 4 feet. "X" qualifiers designate field duplicate samples. Sample designations with a "Y" or "Z" as the last character were split samples collected for the Oklahoma Department of Health Environmental Laboratory or the HAZWRAP Laboratory.

3.1.2 Plating Shop Facility

Field investigation activities conducted within the plating shop facility included the drilling of 21 soil borings. Monitoring wells were installed in three of these borings. Slug tests were conducted in each well to determine the value of hydraulic conductivity in the aquifer in the vicinity of each well. In addition, 66 soil samples and 20 groundwater samples were collected and submitted for chemical analysis at the Halliburton NUS laboratory. The only surface soil collected was a background sample collected to the west of the plating shop near the main runway.

3.1.2.1 Soil Borings

A.W. Pool, Inc., of Clinton, Oklahoma, conducted the soil boring program at the plating shop facility. Twenty-one soil borings numbered SB201 to SB221 were drilled within and adjacent to the plating shop facility in Building 3001. Borings were advanced by the hollow-stem auger method. Three types of drill rigs were used to accommodate drilling the restricted space in and around Building 3001: a Failing CF-15, a Gardner-Denver ATV, and a Mobile Drill B-24. A Halliburton NUS geologist monitored all drilling activities at the site and prepared field boring logs during drilling. Copies of these field logs are located in Appendix A. Borings were drilled to depths of 20 to 28 feet, a depth sufficient to penetrate the top of the shallow aquifer. Groundwater was encountered in all borings, with static water levels ranging from 10.8 to 18 feet below the ground surface. One boring, SB219, was abandoned at a depth of 2 feet after several unsuccessful attempts to locate the boring away from areas underlain by steel-reinforced concrete. Between borings the drill rig and the augers were decontaminated using a high pressure steam spray. Groundwater elevation was measured in each boring (where possible) and from each well using a steel tape and popper. Borings that were not completed as monitoring wells were backfilled with a cement/bentonite slurry and patched with concrete.

3.1.2.2 Monitoring Well Installation

Three shallow, groundwater monitoring wells were installed by A.W. Pool, Inc., under the supervision of a Halliburton NUS geologist as part of the plating shop investigation. Monitoring well MW-155 was

installed in soil boring SB201, well MW-156 in soil boring SB206, and well MW-157 in boring SB216. All monitoring wells were constructed using 2-inch, threaded, flush-joint Schedule 5S stainless steel screen and riser pipe, with the screened section intersecting the water table. All screens lengths installed in the wells were 10 feet long, with a screen slot size of 0.01 inch. A filter pack consisting of 20/40 graded silica sand was placed in the annular space between the borehole wall and the casing from the total depth of the boring to a depth approximately 2 feet above the top of the screen. Approximately 3 feet of bentonite pellets were placed on top of the sand pack and hydrated. The remaining annular space was filled with a cement/bentonite slurry. The three wells were constructed below grade and finished with locking watertight caps and Christy boxes. Each monitoring well was then subsequently developed by surging and bailing. The locations and elevations of the wells and borings were then determined by a land surveyor registered in the state of Oklahoma using accepted surveying techniques. Survey data, well construction and development forms, and boring logs are included in Appendix A.

3.1.2.3 Aquifer Testing

An aquifer testing program for the perched aquifer was conducted as part of the plating shop investigation. Water levels (below the top of the casing) were measured in all newly installed wells after each had been developed and allowed to stabilize. These data were collected to determine the hydraulic gradient.

Rising-head slug tests were conducted in the three wells to determine representative values of hydraulic conductivity for the perched aquifer in the vicinity of each well. The slug tests were conducted using a pressure transducer, a solid slug of known volume, and a data logging system.

An estimate of hydraulic conductivity in each well was obtained by artificially lowering the static water level in each well with the slug and precisely measuring the return of the water level to static or near-static conditions with a pressure transducer. Data reduction and calculations were conducted using the method of Bouwer and Rice (1976). Slug test calculations are included in Appendix A, and the results are summarized in Section 2.2.3.

3.1.2.4 Subsurface Soil Sampling

Sixty-six subsurface soil samples were collected during the field investigations at the plating shop facility, 64 samples for chemical analyses and 2 samples for the measurement of geotechnical parameters. Samples were collected by driving a 5- or 1.9-foot split spoon sampler in the near-surface unconsolidated soils, or by driving a thin-walled Shelby tube sampler. Christensen rock

core barrels were employed where split spoon samplers could not be driven. The two samples collected for geotechnical analyses were obtained using a Shelby tube sampler.

Samples were collected at depths of 5, 10, and 20 feet as specified in the Work Plan (NUS 1989). Before the samples were collected, the cores were scanned for the presence of volatile hydrocarbons with a photoionization detector (PID). Exact sampling intervals were selected at the discretion of the site geologist based on PID readings, visible staining, etc. All soil samples obtained during the plating shop investigation were analyzed for TCL VOCs, TCL SVOCs, and TAL inorganics including cyanide at HAZWRAP Level D QA/QC protocols. The appropriate number of QA/QC samples was collected per these protocols. In addition, selected samples were analyzed for pH, CEC, and TOC. The following table summarizes the analytical program for the plating shop subsurface soil investigation:

PLATING SHOP SOIL LABORATORY ANALYTES

| Parameter | Analytical Methods | Total Number of Samples Analyzed | HAZWRAP QA/QC Level ⁽²⁾ |
|----------------------------|--------------------|----------------------------------|------------------------------------|
| TCL Volatile Organics | CLP | 64 ⁽¹⁾ | D |
| TAL Inorganics and Cyanide | CLP | 64 ⁽¹⁾ | D |
| TCL Semivolatile Organics | CLP | 64 ⁽¹⁾ | D |
| Cation Exchange Capacity | SW9081 | 6 | E |
| Total Organic Carbon | Walkley-Black | 6 | C |
| Atterberg Limits | ASTM D3418 | 2 | E |
| Grain Size | ASTM 422 | 2 | E |
| Permeability | SW 9100 | 2 | E |
| Specific Gravity | ASTM D854 | 2 | E |
| Moisture Content | ASTM D2216 | 2 | E |
| Unit Weight | ASTM | 2 | E |
| Eh | ASTM 1498 | 2 | E |
| pH | EPA 150.1 | 64 ⁽¹⁾ | E |

(1) Includes one background sample.

(2) See Section 3.2 for a summary of HAZWRAP QA/QC Levels.

3.1.2.5 Groundwater Sampling

Groundwater samples were collected from the three newly installed monitoring wells and out of the open boreholes from 14 soil borings. All groundwater samples were analyzed for TCL VOCs, TCL SVOCs, TAL inorganics, cyanide, and pH. In addition, several samples were analyzed for TOC. TCL VOC, TCL SVOC, TAL inorganics including cyanide analyses were conducted employing HAZWRAP Level D QA/QC protocols. The appropriate number of QA/QC samples were collected and analyzed

per these protocols. The following table summarizes the analytical program for the groundwater samples collected during the plating shop investigation:

PLATING SHOP GROUNDWATER LABORATORY ANALYTES

| Parameter | Analytical Methods | Total Number of Samples | HAZWRAP QA/QC Level ⁽¹⁾ |
|----------------------------|--------------------|-------------------------|------------------------------------|
| TCL Volatile Organics | CLP | 20 | D |
| TAL Inorganics and Cyanide | CLP | 20 | D |
| TCL Semivolatile Organics | CLP | 20 | D |
| pH/Corrosivity | SW 9040 | 20 | E |

(1) See Section 3.2 for a summary of HAZWRAP QA/QC Levels

Monitoring Well Sampling

Monitoring wells were developed to remove fine-grained sediments and to break down the filter cake on the the borehole wall. Development was performed by bailing with a stainless steel bailer. Development continued until a quantity of water equal to at least five well volumes was removed or until the well was dry. The wells were allowed to stabilize for at least 24 hours, purged, and sampled for the analytes listed above. Inorganic water samples were filtered in the field using a 0.45 micron filter. The pH, temperature, specific conductance, turbidity, PID readings above the groundwater, and other pertinent information are included on the well development and sampling forms included in Appendix A.

Open Borehole Sampling

Groundwater samples were collected from open boreholes within the plating shop facility. The borings were allowed to sit open for approximately 24 hours before the groundwater samples were collected. Groundwater was not purged from the borings before sampling because it was determined that purging would only increase the turbidity of the water. The pH, temperature, and specific conductance of the groundwater were not recorded during sampling because the extremely muddy water would not have given an accurate assessment of these parameters. The open borehole samples were not filtered in the field.

3.1.2.6 Sample Identification

Analytical soil and groundwater samples obtained from within the plating shop facility are identified by the same numbering system used for the mixed-acid sump soil samples. For example, in soil sample

T-SU-SB201A the "T" (for Tinker AFB) is the base identifier, while the "SU" indicates that this sample is a subsurface soil sample. A "GW" here would indicate that this sample is a groundwater sample. The remaining six digits identify the boring and sample number; SB201 indicates that the sample is from soil boring 201 and the "A" qualifier indicates the depth from which the sample was collected. In general, "A" samples were collected from a depth of 5 feet, "B" samples from 10 feet, and "C" samples from 20 feet. However, any boring in which a Shelby tube was collected will have a "D" sample. "X" qualifiers designate that sample as a field duplicate sample. Sample designations with a "Y" or "Z" as the last character were split samples collected for the Oklahoma Department of Health Environmental Laboratory or the HAZWRAP Laboratory.

3.1.2.7 Decontamination Procedures

Major equipments such as the drill rigs were decontaminated between each boring using high pressure steam and a laboratory-grade detergent. All downhole sampling equipment including spilt spoons, rock and core barrels, bailers, etc. were decontaminated using the following procedures.

- Wash with laboratory-grade detergent.
- Rinse with potable water.
- Rinse with pesticide-grade methanol.
- Rinse with deionized (HPLC grade) water.
- Air dry.
- Wrap in aluminum foil, if not to be used immediately.

3.1.2.8 Waste Management

During the course of this field investigation, soil boring cuttings and groundwater well development waters were containerized, labeled appropriately, and stored at a site designated by Tinker AFB personnel. In order to determine the proper disposition for the soil boring cuttings, soil samples from each of the 19 drums were collected and analyzed applying the Toxicity Characteristic Leaching Procedure (TCLP). Preliminary results of the TCLP data were sent on April 13, 1990, to Tinker AFB personnel, who arranged for the disposal of the contents of the drums.

3.1.2.9 Surveying

The services of Mr. Arnold Irwin, a registered land surveyor in the State of Oklahoma, were retained to provide accurate horizontal and vertical locations for all borings and monitoring wells installed

during this investigation. The benchmark that was used by the survey crew is "RM-1" located at N = 2,186,531.75 and E = 152,486.81 of the Oklahoma State Plane Coordinates.

3.2 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) for the field and analytical data collected during this investigation were discussed in detail in Section 3.0 of the Work Plan (Halliburton NUS 1989). A majority of the chemical analyses performed of this RI were conducted at HAZWRAP QC Level "D" (corresponding to EPA Level 4). The remainder of the analytical program was conducted under HAZWRAP QC Levels "C" and "E." Five general levels of analytical options to support data collection were identified by CERCLA and have been adopted by HAZWRAP to define QC requirements. HAZWRAP QC levels A, B, C, D, and E correspond to EPA levels 1, 2, 3, 4, and 5 as defined in the EPA document "Data Quality Objectives for Remedial Response Activities Development Process" (1987).

A brief summary of the appropriateness of HAZWRAP QC Levels A, B, C, D, and E are presented here. Detailed discussions of these specifications can be found in "Requirements for Quality Control of Analytical Data" (DOE/HWP-65/R1, 1990) and "Quality Control Requirements for Field Methods" (DOE/HWP-69/R1, 1990).

Level A: Data meeting Level A requirements are qualitative or semiquantitative in nature and can be used for the delineation of contaminated zones, gross determination of contamination in samples and/or health and safety screening.

Level B: Level B data are also used for field screening. However, they offer more quantitative results from Level A data. Soil organic vapor surveys conducted using field gas chromatographs are an example of field analyses which should be governed by Level B QC.

Level C: Level C QC protocols are designed for fixed base laboratory analysis at sites near a populated area but not on the NPL, and not likely to be undergoing litigation. These data can be used for risk assessment.

Level D: Level D QC is used when comprehensive data quality documentation is required. For example, Level D data should be used for NPL sites, or sites near populated areas. This level of QC should also be used for sites likely to undergo litigation.

Level E: Level E QC is used for analysis of nonstandard matrixes, such as air, biota or pure waste. It may also be used for nonstandard methods.

3.3 FIXED BASE LABORATORY METHODS

The majority of the fixed base laboratory analyses for the RI at the plating shop facility were performed using HAZWRAP Level D protocols, which are synonymous with Contract Laboratory Program (CLP) EPA Level 4 data quality objectives. The analytical methods, QA/QC, and reporting requirements are found in the following:

- TCL VOCs and SVOCs - Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration, (USEPA CLP 1988a).
- TAL metals plus cyanide - Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, (USEPA CLP 1988b).

VOC and SVOC analyses were performed using gas chromatography/mass spectrometry (GC/MS) methodology. All GC/MS analyses include identification of 10 tentatively identified compounds (TICs) not on the TCL per fraction. A purge-and-trap technique was used for VOCs. A preliminary extraction using methylene chloride was performed and introduced into the GC/MS for quantitation of SVOCs. The complete VOC and SVOC analyte lists can be found in Appendix B.

Following preliminary acid digestion, most of the 23 metals were measured by inductively coupled plasma (ICP). The ICP uses atomic emission techniques to determine analyte concentration. For metals for which the ICP did not have sufficient sensitivity to achieve the Contract Required Detection Limits (CRDLs) as specified in the protocol, graphite furnace atomic absorption (AA) spectrometer was used. In addition, mercury was measured using a separate cold-vapor AA technique.

Cyanide was measured by a distillation and colorimetric technique in which cyanide gas, released after acidification, was trapped in a highly basic medium (sodium hydroxide). The sodium hydroxide solution was buffered, chlorinated, and treated with pyridine-barbituric acid. The color intensity of the solution is proportional to the concentration of cyanide in the sodium hydroxide scrubber solution.

3.4 DATA VALIDATION

Formal data validation performs three basic functions. It serves as an independent QA check of the veracity of laboratory results; it is a means of evaluating laboratory performance and determining the impact of noncompliances to the data; and, through the use of data qualifiers, it lends interpretive guidance as to the proper usage and limitations of the data.

Formal data validation is a systematic review and evaluation of the data conducted according to the following EPA National Protocols:

- Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses (USEPA 1988c).
- Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses (USEPA 1988a).

As per the National Protocols, organic data are evaluated based on the following:

- Data completeness
- Holding times
- GC/MS tuning and mass calibration
- Initial and continuing calibration
- Laboratory blank analyses
- Surrogate spike recoveries
- Matrix spike/matrix spike duplicate analyses
- Internal standards performance
- Detection limits
- Sample quantitation
- Field duplicates
- Compound identification
- System performance
- Tentatively Identified Compounds

In accordance with National Protocols, inorganic data are evaluated based on the following:

- Data completeness
- Holding times
- Initial and continuing calibration verification
- Interference check sample results
- Laboratory control sample results
- Furnace AA results
- Blanks
- Field duplicates
- Matrix spikes/matrix spike duplicates
- Sample quantitation
- Serial dilutions

4.0 NATURE AND EXTENT OF CONTAMINATION

The analytical results for the soil and groundwater samples collected during the plating shop field investigations are presented in this section. The results of previous investigations and site characterizations are also discussed.

4.1 PREVIOUS INVESTIGATIONS

Previous investigations have confirmed environmental contamination associated with Building 3001. A search of records pertaining to past waste disposal practices identified the Building 3001 industrial complex as a potential site for subsurface contamination (Engineering-Science 1982). Subsurface contamination was confirmed during the field evaluation (Radian 1984a) when high concentrations of trichloroethene (TCE) were detected in a water supply well located north of the plating shop. Groundwater samples collected from monitoring wells installed around the periphery of Building 3001 during the confirmation/quantification study (Radian 1984b) confirmed off-site migration of volatile and semivolatile contaminants. The Radian Corporation report recommended that abandoned waste pits and tanks beneath the building complex be sampled for the presence of contaminants, the limits of contamination be defined, and a plan for remedial action be initiated to treat the contaminated groundwater.

Building 3001 was placed on the National Priorities List (NPL) in 1987, due in part to preliminary information compiled by Radian Corporation.

The Tulsa District USACOE conducted an RI at Building 3001 to address the recommendations of the earlier IRP investigations. This study involved location, sampling, and abandonment of the old waste tanks and pits, and a hydrogeologic investigation of the contaminated aquifer. The RI Report concluded that past industrial practices at Building 3001 resulted in groundwater contamination in the two aquifers beneath the site, to a depth of about 175 feet. The report recommended installing an additional monitoring well cluster, conducting a soil survey beneath Building 3001, and additional groundwater sampling of existing monitoring wells. They also recommended tank tightness testing and sampling at two tank areas, removal of the contents of four abandoned pits within the building, and conducting further groundwater investigations around the Industrial Waste Treatment Plant (IWTP).

No previous investigations have been conducted immediately within the plating shop. The closest subsurface data were obtained from a well cluster located approximately 400 feet northwest of the

shop, outside the building (see Figure 2-8). A sample of liquid waste was analyzed from the mixed-acid sump within the plating shop and was found to contain high levels of nickel, cadmium, and chromium. This fluid had apparently seeped into the surrounding soil or backfill, probably through joints or seams in the concrete.

4.2 CHARACTERIZATION OF BACKGROUND CONDITIONS

During 1986, four soil borings were drilled around the perimeter of Tinker AFB (Figure 4-1) for the purpose of characterizing background concentrations of metals in the soils on-base. Analytical results for 10 analytes from 16 subsurface soil samples collected from these borings were averaged to determine a representative background concentration (USACOE 1990). These results are presented in Table 4-1. If the parameter was not detected in a particular sample the sample detection limit for that parameter was used in the calculation. For inorganics not analyzed for by the Corps of Engineers, the value from the background sample collected for this investigation, T-SU-BB001A, was used.

As illustrated on Figure 4-1 all of these borings were drilled in soils derived from sedimentary rocks of the Hennessey Group Building 3001, and specifically the plating shop is also located on soils derived from the Hennessey Group. Therefore, the values presented in Table 4-1 should provide an accurate representation of background conditions for the mixed-acid sump/plating shop facility.

4.3 MIXED-ACID SUMP

4.3.1 Site Characterization

The mixed-acid sump is located in the west-central portion of the plating shop along post line I and between post lines 59 and 61. The mixed acid sump has 12 inch thick reinforced concrete walls sealed with an acid and alkaline resistant coating which is lined with $\frac{1}{4}$ inch thick steel and a "koroseal" liner. The sump is the easternmost of a line of four sumps. These sumps are approximately 10 feet wide, 10 feet long, and 7 feet deep (Figures 4-2 and 4-3). The sumps periodically contain spent plating solutions until they can be removed for disposal as hazardous waste.

During sampling operations, the concrete appeared badly corroded and pitted (presumably from contact with the acids in the sump). However, no cracks, pervasive cavities, or dissolution features deeper than 1 inch were observed in the concrete. A small amount of standing water (less than 0.5

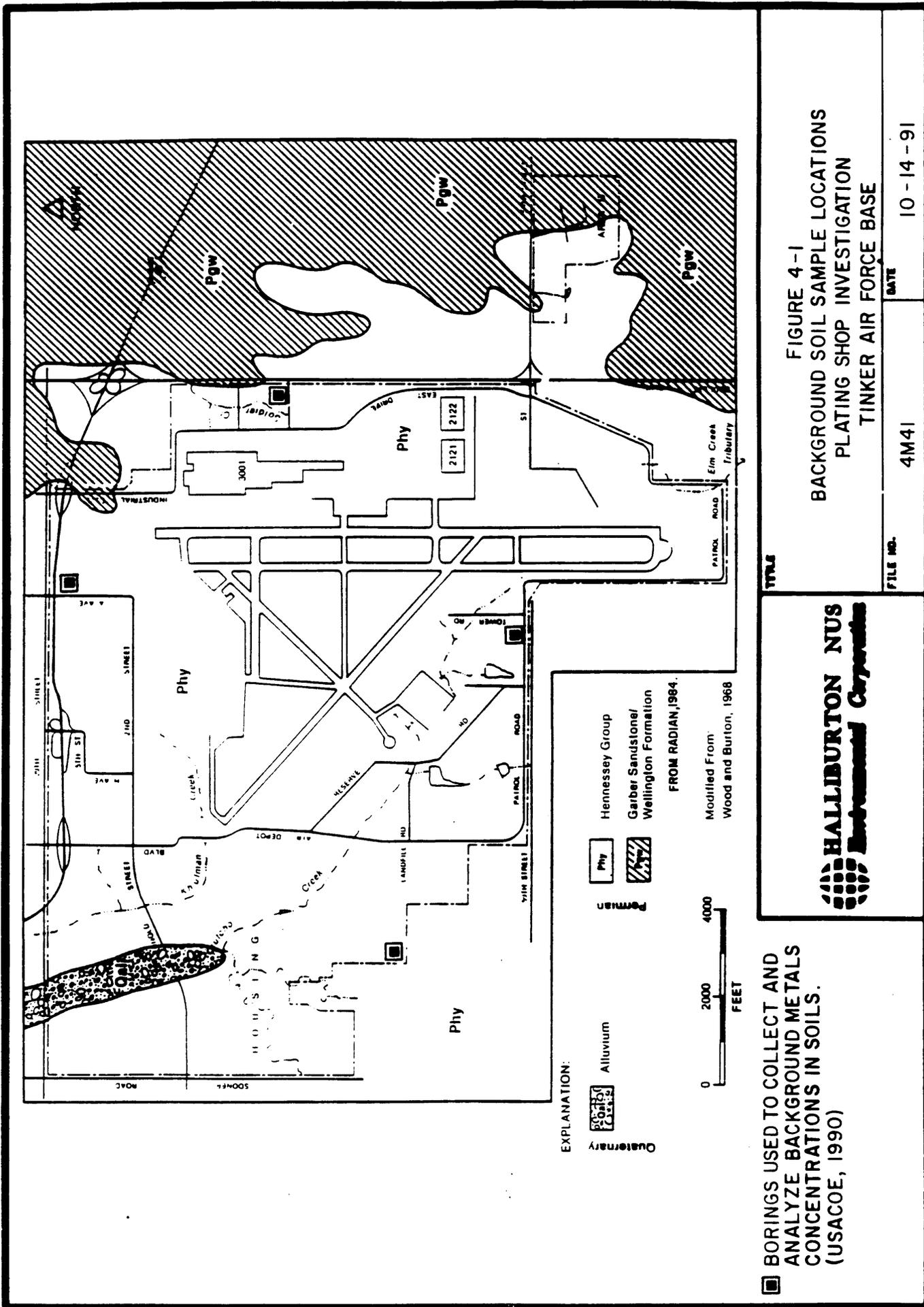
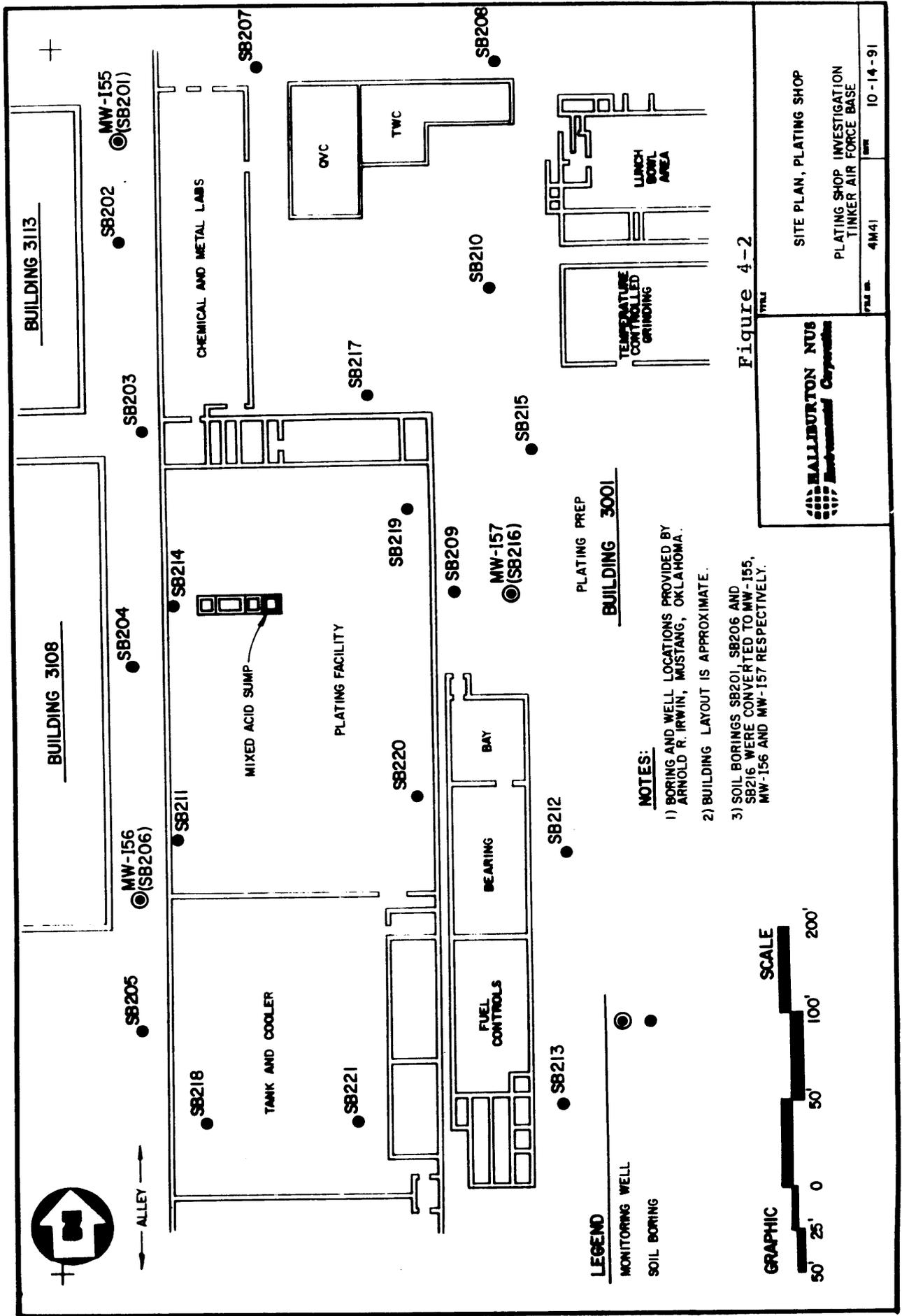


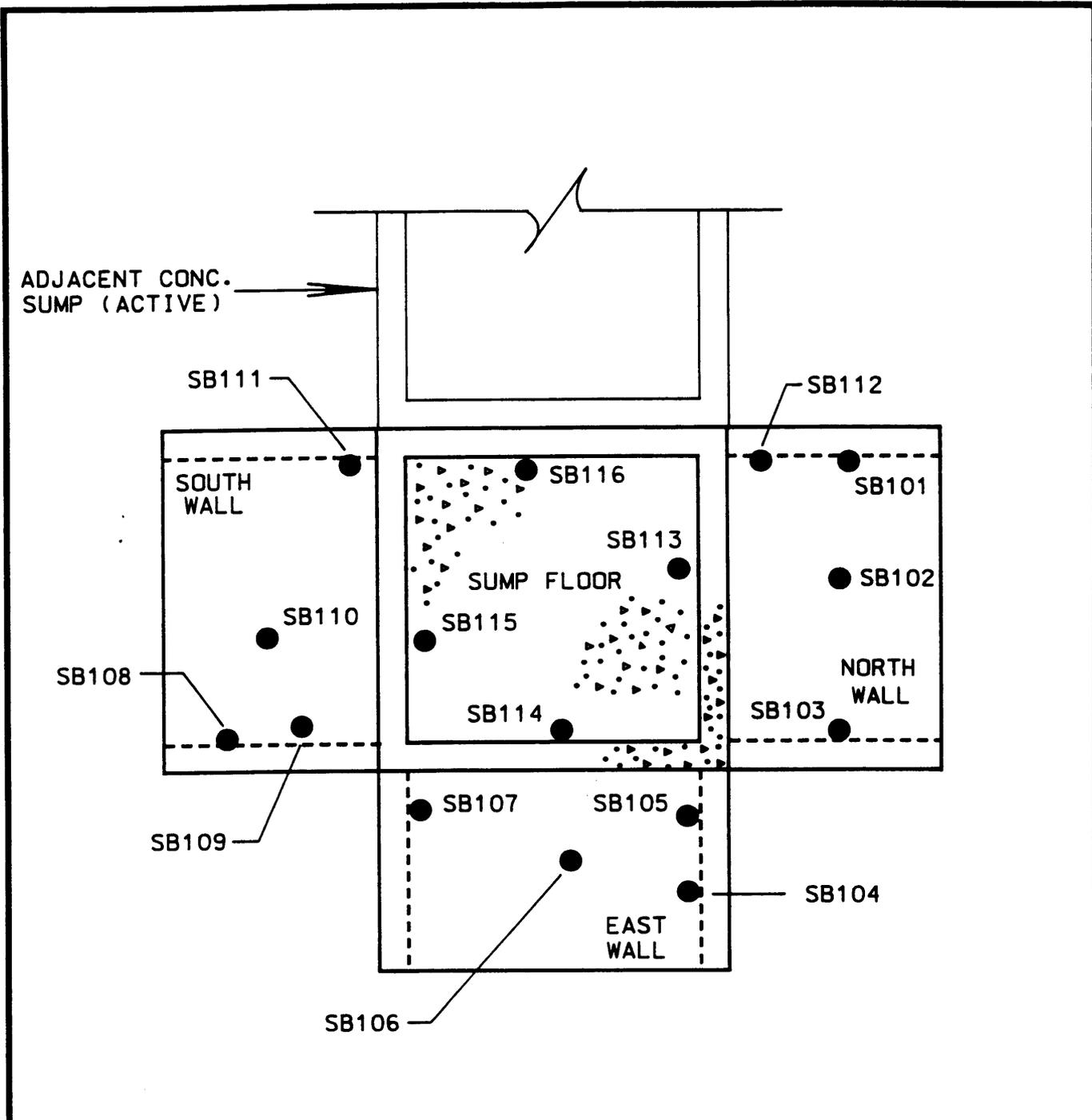
TABLE 4-1

AVERAGE BACKGROUND CONCENTRATIONS FOR
INORGANICS IN SOILS
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

| Analyte | Concentration (mg/kg) |
|-----------|-----------------------|
| Aluminum | 37,400J(a) |
| Antimony | < 1.1(a)(b) |
| Arsenic | 1.1(c) |
| Barium | 220(c) |
| Beryllium | 1.5(a) |
| Cadmium | 0.72(c) |
| Calcium | 4,600(a) |
| Chromium | 23.0(c) |
| Cobalt | 15.4(a) |
| Copper | 37.8(a) |
| Iron | 29,500J(a) |
| Lead | 15.0(c) |
| Magnesium | 11,600(a) |
| Manganese | 944J(a) |
| Mercury | < 0.10(b)(c) |
| Nickel | 21.0(c) |
| Potassium | 6,750(a) |
| Selenium | < 0.10(b)(c) |
| Silver | 0.56(c) |
| Sodium | 599(a) |
| Thallium | < 0.26(a)(b) |
| Vanadium | 36.4(a) |
| Zinc | 25.0(c) |

- (a) Source - Background Sample T-SU-BB001A.
- (b) Instrument detection limit used to quantify background conditions.
- (c) Source - USACOE 1990.





LEGEND

SOIL BORING ●



SCALE: $\frac{3}{16}$ " = 1'-0"

Figure 4-3

| | | |
|--|--|------|
|  A Halliburton Company | TITLE BORING LOCATIONS MIXED ACID SUMP BUILDING 3001 TINKER AIR FORCE BASE | |
| | FILE NO. 4M41G001 | DATE |

inch) was present in the southeast corner of the sump while sampling activities were being conducted. A dark green precipitate associated with this water was noticed on the floor of the sump. This precipitate and the water appeared to be coming from the seam where the wall meets the floor.

The field boring logs completed for each of the horizontal and vertical hand augered borings drilled within the mixed-acid sumps are enclosed in Appendix A. Hand augering revealed backfill composed of a brown, fine-grained, silty sand containing occasional pieces of crushed stone or concrete. The backfill ranged in thickness from 2 to 4 feet and exhibited no obvious discoloration or odor. Beyond the backfill exists red-brown, silty sand, which appears to be native soils or compacted fill materials derived from native soils. This interval was generally dry and quite hard. Samples collected from depths of 2.0 to 2.5 feet and 3.5 to 4 feet from beneath the floor of the sump were described as wet to very wet, suggesting that they were collected from within or near the saturated zone.

All of the soil samples collected from depth intervals of 1 to 1.5 feet and 2 to 2.5 feet were analyzed by the fixed base laboratory. However, the samples collected from the depth interval of 3.5 to 4 feet were not analyzed because the samples analyzed from the 2- to 2.5-foot depth interval did not show significantly elevated levels of inorganics when compared to the samples collected from 1 to 1.5 feet.

4.3.2 Soil Analytical Results

A discussion of the analytical results obtained from the soil samples is presented in this section. Drilling, sampling, and laboratory procedures were discussed in Section 3.

4.3.2.1 Organic Compounds

Table 4-2 presents the analytical results for organic compounds detected in soils collected within the mixed-acid sump. The concentration of VOC or SVOC compounds that were detected in one or more samples are included on the table. Copies of the laboratory analysis data sheets (Form 1s) as well as data summary tables listing all analytes and their qualifiers are included in Appendix B (Tables B-1 and B-2). Tentatively Identified Compounds (TICs) for organic compounds are reported in Appendix C (Table C-1) and data validation letters with their supporting QA/QC data are included in Appendix D. In addition, the analytical results for a surface soil sample, T-SU-BB001A, collected to help characterize background soil chemistry at the plating shop are also presented on this table. This sample was collected from the area west of Building 3001, near the runway. All soil samples were collected from within the vadose zone except the deeper samples beneath the sump's floor.

TABLE 4-2

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA

| Sample Number Depth (ft) Units | T-SU-SB101A 1-1.5 µg/kg | T-SU-SB101X 1-1.5 µg/kg | T-SU-SB101B 2-2.5 µg/kg | T-SU-SB101C 3.5-4 µg/kg | T-SU-SB102A 1-1.5 µg/kg | T-SU-SB1028 2-2.5 µg/kg | T-SU-SB102C 3.5-4 µg/kg | T-SU-SB103A 1-1.5 µg/kg | T-SU-SB103B 2-2.5 µg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| VOCs(b) | | | | | | | | | |
| 1,2-Dichloroethene (total) | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4-Methyl 2-pentanone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | |
| Di-n-butyl phthalate | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Butylbenzyl phthalate | -- | NA | -- | NA | -- | -- | NA | -- | 25 J |
| Bis(2-ethylhexyl) phthalate | -- | NA | -- | NA | -- | 36 J | NA | -- | -- |
| Di-n-octyl phthalate | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Diethyl phthalate | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Acenaphthene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Phenanthrene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Anthracene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Fluoranthene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Pyrene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Benzo(a) anthracene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Chrysene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Benzo(b) fluoranthene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Benzo(a) pyrene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Indeno (1,2,3-cd) pyrene | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Pentachlorophenol | -- | NA | -- | NA | -- | -- | NA | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-1 and B-2) of this report.

(b) Samples collected February 15 - March 23, 1990.

(c) Volatile Organic Compounds.

(c) Semi Volatile Organic Compounds.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-2

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE TWO

| Sample Number Depth (ft) Units | T-SU-SB104A 1-1.5 µg/kg | T-SU-SB104B 2-2.5 µg/kg | T-SU-SB104C 3.5-4 µg/kg | T-SU-SB105A 1-1.5 µg/kg | T-SU-SB105X 1-1.5 µg/kg | T-SU-SB105B 2-2.5 µg/kg | T-SU-SB105C 3.5-4 µg/kg | T-SU-SB106A 1-1.5 µg/kg | T-SU-SB106X 1-1.5 µg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| VOCs(b) | | | | | | | | | |
| 1,2-Dichloroethene (total) | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4-Methyl 2-pentanone | -- | -- | -- | -- | -- | -- | -- | 1 J | -- |
| SVOCs(c) | | | | | | | | | |
| Di-n-butyl phthalate | 28 J | 300 J | NA | -- | NA | NA | NA | -- | NA |
| Butyl benzyl phthalate | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Bis(2-ethylhexyl) phthalate | -- | 390 | NA | -- | NA | NA | NA | -- | NA |
| Di-n-octyl phthalate | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Diethyl phthalate | 6 J | -- | NA | -- | NA | NA | NA | -- | NA |
| Acenaphthene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Phenanthrene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Anthracene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Fluoranthene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Pyrene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Benzo(a) anthracene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Chrysene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Benzo(b) fluoranthene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Benzo(a) pyrene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Indeno (1,2,3-cd) pyrene | -- | -- | NA | -- | NA | NA | NA | -- | NA |
| Pentachlorophenol | -- | -- | NA | -- | NA | NA | NA | -- | NA |

(a) Complete data summary tables are in Appendix B (Tables B-1 and B-2) of this report.

(b) Samples collected February 15 - March 23, 1990.

(c) Volatile Organic Compounds.

(d) Semi Volatile Organic Compounds.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-2

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE THREE

| Sample Number Depth (ft) Units | T-SU-SB107A 1-1.5 µg/kg | T-SU-SB107B 2-2.5 µg/kg | T-SU-SB107C 3.5-4 µg/kg | T-SU-SB108A 1-1.5 µg/kg | T-SU-SB108B 2-2.5 µg/kg | T-SU-SB109A 1-1.5 µg/kg | T-SU-SB109B 2-2.5 µg/kg | T-SU-SB109C 3.5-4 µg/kg | T-SU-SB111A 1-1.5 µg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| VOCs(b) | | | | | | | | | |
| 1,2-Dichloroethene (total) | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | 3 J |
| 4-Methyl 2-pentanone | 2 J | -- | -- | -- | -- | 1 J | -- | -- | 1 J |
| SVOCs(c) | | | | | | | | | |
| Di-n-butyl phthalate | -- | 43 J | NA | 45 J | -- | -- | -- | NA | -- |
| Butyl benzyl phthalate | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Bis(2-ethylhexyl) phthalate | -- | 46 J | NA | 160 J | -- | -- | -- | NA | -- |
| Di-n-octyl phthalate | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Diethyl phthalate | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Acenaphthene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Phenanthrene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Anthracene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Fluoranthene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Pyrene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Benzo(a) anthracene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Chrysene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Benzo(b) fluoranthene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Benzo(a) pyrene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Indeno (1,2,3-cd) pyrene | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Pentachlorophenol | -- | -- | NA | -- | -- | -- | -- | NA | -- |

(a) Complete data summary tables are in Appendix B (Tables B-1 and B-2) of this report.

Samples collected February 15 - March 23, 1990.

(b) Volatile Organic Compounds.

(c) Semi Volatile Organic Compounds.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-2

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE FOUR

| Sample Number Depth (ft) Units | T-SU-SB111X 1-1.5 µg/kg | T-SU-SB111B 2-2.5 µg/kg | T-SU-SB111C 3-5-4 µg/kg | T-SU-SB112A 1-1.5 µg/kg | T-SU-SB112X 1-1.5 µg/kg | T-SU-SB112B 2-2.5 µg/kg | T-SU-113A 1-1.5 µg/kg | T-SU-SB113B 2-2.5 µg/kg | T-SU-SB113C 3-5-4 µg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-----------------------------|-------------------------------|-------------------------------|
| VOCs(b) | | | | | | | | | |
| 1,2-Dichloroethene (total) | -- | -- | -- | -- | -- | -- | -- | 2 J | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | 10 | 9 |
| 2-Butanone | 3 J | -- | 3 J | 3 J | 4 J | -- | -- | -- | -- |
| 4-Methyl 2-pentanone | 1 J | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | |
| Di-n-butyl phthalate | NA | -- | NA | 36 J | NA | -- | -- | -- | NA |
| Butyl benzyl phthalate | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Bis(2-ethylhexyl) phthalate | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Di-n-octyl phthalate | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Diethyl phthalate | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Acenaphthene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Phenanthrene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Anthracene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Fluoranthene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Pyrene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Benzo(a) anthracene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Chrysene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Benzo(b) fluoranthene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Benzo(a) pyrene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Indeno (1,2,3-cd) pyrene | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Pentachlorophenol | NA | -- | NA | -- | NA | -- | 210 J | -- | NA |

(a) Complete data summary tables are in Appendix B (Tables B-1 and B-2) of this report.

(b) Samples collected February 15 - March 23, 1990.

(c) Semi Volatile Organic Compounds.

Data Qualifier Legend

- J - The associated numerical value is an estimated quantity.
- Analyte was not detected.
- NA - Not analyzed.

TABLE 4-2

ORGANIC COMPOUNDS DETECTED IN SOILS^(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE FIVE

| Sample Number Depth (ft) Units | T-SU-SB114A 1-1.5 µg/kg | T-SU-SB114B 2-2.5 µg/kg | T-SU-SB114C 3.5-4 µg/kg | T-SU-SB115A 1-1.5 µg/kg | T-SU-SB115B 2-2.5 µg/kg | T-SU-SB115C 3.5-4 µg/kg | T-SU-SB116A 1-1.5 µg/kg | T-SU-SB116B 2-2.5 µg/kg | T-SU-SB116C 3.5-4 µg/kg | T-SU-BB001A Surface µg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|---------------------------------|
| VOCs(b) | | | | | | | | | | |
| 1,2-Dichloroethene (total) | -- | -- | 4 J | -- | -- | 3 J | -- | -- | 4 J | -- |
| Tetrachloroethene | -- | -- | 8 | -- | 8 | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4-Methyl 2-pentanone | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | | |
| Di-n-butyl phthalate | -- | -- | NA | -- | -- | NA | -- | 33 J | NA | -- |
| Butyl benzyl phthalate | -- | -- | NA | -- | -- | NA | -- | -- | NA * | -- |
| Bis(2-ethylhexyl) phthalate | -- | -- | NA | -- | -- | NA | -- | 84 J | NA | -- |
| Di-n-octyl phthalate | -- | -- | NA | -- | -- | NA | -- | 6 J | NA | -- |
| Diethyl phthalate | -- | 190 J | NA | -- | -- | NA | -- | -- | NA | -- |
| Acenaphthene | -- | -- | NA | -- | -- | NA | -- | 27 J | NA | -- |
| Phenanthrene | -- | -- | NA | -- | -- | NA | -- | 190 J | NA | -- |
| Anthracene | -- | -- | NA | -- | -- | NA | -- | 30 J | NA | -- |
| Fluoranthene | -- | -- | NA | -- | -- | NA | -- | 240 J | NA | -- |
| Pyrene | -- | -- | NA | -- | -- | NA | -- | 160 J | NA | -- |
| Benzo(a) anthracene | -- | -- | NA | -- | -- | NA | -- | 64 J | NA | -- |
| Chrysene | -- | -- | NA | -- | -- | NA | -- | 100 J | NA | -- |
| Benzo(b) fluoranthene | -- | -- | NA | -- | -- | NA | -- | 84 J | NA | -- |
| Benzo(a) pyrene | -- | -- | NA | -- | -- | NA | -- | 50 J | NA | -- |
| Indeno (1,2,3-cd) pyrene | -- | -- | NA | -- | -- | NA | -- | 37 J | NA | -- |
| Pentachlorophenol | -- | -- | NA | -- | -- | NA | -- | -- | NA | -- |

(a) Complete data summary tables are in Appendix B (Tables B-1 and B-2) of this report.

(b) Samples collected February 15 - March 23, 1990.

(c) Volatile Organic Compounds.
 Semi Volatile Organic Compounds.

Data Qualifier Legend

- J - The associated numerical value is an estimated quantity.
- Analyte was not detected.
- NA - Not analyzed.

The data in Table 4-2 indicate that significant quantities of VOC and SVOC compounds do not exist within the soils sampled from the mixed-acid sump. VOCs detected in the soils include the compounds 1,2-dichloroethene (1,2-DCE) found in four samples, tetrachloroethene (PCE) found in four samples, 2-butanone found in five samples, and 4-methyl 2-pentanone found in one sample. The maximum VOC concentration was 10 µg/kg.

Semivolatile organic compounds detected in the soils show trends similar to the VOCs. Although several soil samples contain SVOC compounds, all concentrations are less than 400 µg/kg. The phthalate esters are found sporadically throughout the data set, at a maximum concentration of 390 µg/kg. In addition, a suite of 12 compounds, consisting primarily of polynuclear aromatic hydrocarbons, was detected in T-SU-SB116B at concentrations ranging from 27J to 240J µg/kg.

These data indicate that the soils below and around the mixed-acid sump contain only minor amounts of man-made organic compounds. No significant amounts of organic contamination were anticipated because no organic chemicals are used in the plating process. The relative absence of these compounds indicates that no other major sources of organic contamination exist within the soils near the sump.

4.3.2.2 Inorganic Compounds

Table 4-3 presents the results of the analytical program for the inorganic compounds detected within the soils at the mixed-acid sump. Copies of the laboratory analysis data sheets (Form 1s) as well as the data summary table listing all analytes and their qualifiers is included in Appendix B (Table B-3). Data validation letters with their supporting QA/QC data are included in Appendix D. Because inorganics (except cyanide) are present as naturally occurring components of soils, it is difficult to determine if the levels of inorganics found within a soil sample are elevated due to man's activities. For purposes of this discussion, levels of inorganics found within the soils will be compared to the analytical results for background soils at Tinker AFB, identified in Table 4-1. It is assumed that the values in Table 4-1 represent an average for the naturally-occurring soils at Tinker AFB. Any of the inorganics occurring in concentrations significantly greater than the concentrations in this sample may contain inorganics from a man-made source.

Table 4-4 is a breakdown of the data from Table 4-3 by sample depth. The table shows a range of concentrations for each analyte and the maximum concentration of each analyte divided by the background level. For example, the analyte arsenic exists in background concentrations at 1.1 mg/kg. The range of concentrations found in all samples collected from depths of 1 to 1.5 feet and analyzed

TABLE 4-3

INORGANICS DETECTED IN SOILS^(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA

| Sample Number Depth (ft) Units | T-SU-SB101A 1-1.5 mg/kg | T-SU-SB101X 1-1.5 mg/kg | T-SU-SB101B 2-2.5 mg/kg | T-SU-SB101C 3.5-4 mg/kg | T-SU-SB102A 1-1.5 mg/kg | T-SU-SB102B 2-2.5 mg/kg | T-SU-SB102C 3.5-4 mg/kg | T-SU-SB103A 1-1.5 mg/kg | T-SU-SB103B 2-2.5 mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Aluminum | 4,620 | NA | 2,690 | NA | 3,350 | 2,370 | NA | 2,400 | 3,840 |
| Antimony | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Arsenic | 0.58 | NA | 0.67 | NA | 0.59 | 0.51 | NA | 0.57 | 0.80 |
| Barium | 57.2 | NA | 47.7 | NA | 41.0 | 41.2 | NA | 40.2 | 61.4 |
| Beryllium | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Cadmium | -- | NA | -- | NA | 0.72 | 4.7 | NA | -- | 1.0 |
| Calcium | 6,930 | NA | 6,300 | NA | 5,520 | 5,530 | NA | 5,030 | 8,320 |
| Chromium | 20.6 | NA | 12.4 | NA | 14.4 | 13.2 | NA | 10.8 | 15.6 |
| Cobalt | -- | NA | 1.7 | NA | -- | 2.1 | NA | -- | 2.7 |
| Copper | -- | NA | -- | NA | -- | -- | NA | -- | 3.4 |
| Iron | 4,260 | NA | 2,980 | NA | 3,790 | 2,860 | NA | 3,240 | 3,980 |
| Lead | 2.0 | NA | 2.0 | NA | 2.2 | 2.7 | NA | 1.8 | 2.9 |
| Magnesium | 1,530 | NA | 1,360 | NA | 1,360 | 1,340 | NA | 1,040 | 1,860 |
| Manganese | 63.8 | NA | 44.3 | NA | 52.9 | 74.6 | NA | 48.1 | 66.3 |
| Mercury | -- | -- | -- | -- | 0.85 | -- | 0.57 | 0.22 | -- |
| Nickel | -- | NA | 2.9 | NA | 292 | 354 | NA | 28.7 | 209 |
| Potassium | 1,080 | NA | -- | NA | 711 | 462 | NA | 510 | 730 |
| Selenium | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Silver | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Sodium | -- | NA | 170 | NA | 2,120 | 141 | NA | -- | 163 |
| Thallium | -- | NA | -- | NA | -- | -- | NA | -- | -- |
| Vanadium | -- | NA | -- | NA | -- | -- | NA | -- | 9.8 |
| Zinc | -- | NA | -- | NA | -- | 13.2 | NA | -- | 14.9 |
| Cyanide | -- | -- | -- | -- | -- | -- | NA | -- | -- |

(a) The complete data summary table is in Appendix B (Table B-3) of this report.
 Samples collected February 15 - March 23, 1990.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.
 -- Analyte was not detected.
 NA - Not analyzed.

TABLE 4-3

INORGANICS DETECTED IN SOILS(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE TWO

| Sample Number Depth (ft) Units | T-SU-SB104A 1-1.5 mg/kg | T-SU-SB104B 2-2.5 mg/kg | T-SU-SB104C 3.5-4 mg/kg | T-SU-SB105A 1-1.5 mg/kg | T-SU-SB105X 1-1.5 mg/kg | T-SU-SB105B 2-2.5 mg/kg | T-SU-SB105C 3.5-4 mg/kg | T-SU-SB106A 1-1.5 mg/kg | T-SU-SB106X 1-1.5 mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Aluminum | 3,940 J | 6,260 | NA | 6,420 | NA | 2,450 J | NA | 3,700 | NA |
| Antimony | -- | -- | NA | -- | NA | -- | NA | -- | NA |
| Arsenic | 0.86 | 1.0 | NA | 1.2 | NA | 0.93 | NA | 0.53 | NA |
| Barium | 50.3 | 125 | NA | 61.6 | NA | 46.0 | NA | 47.1 | NA |
| Beryllium | -- | 0.60 | NA | -- | NA | -- | NA | -- | NA |
| Cadmium | 34.0 | 125 | NA | 1.7 | NA | 1.7 | NA | 60.1 | NA |
| Calcium | 3,800 | 13,400 | NA | 9,580 | NA | 6,440 | NA | 4,320 | NA |
| Chromium | 71.8 | 210 | NA | 8.2 | NA | 8.4 | NA | 191 | NA |
| Cobalt | -- | 6.5 | NA | 1.9 | NA | -- | NA | 7.1 | NA |
| Copper | -- | 19.3 | NA | -- | NA | -- | NA | 5.9 | NA |
| Iron | 3,500 | 2,640 | NA | 5,200 | NA | 2,730 | NA | 3,840 | NA |
| Lead | 2.5 | 5.2 | NA | 2.6 | NA | 1.9 | NA | 2.7 | NA |
| Magnesium | 1,220 | 2,730 | NA | 2,350 | NA | 1,230 | NA | 1,580 | NA |
| Manganese | 75.3 | 173 | NA | 91.8 | NA | 44.2 | NA | 95.4 | NA |
| Mercury | 0.17 | 0.36 J | 0.37 J | 0.46 J | -- | 0.32 | -- | 0.25 J | 0.17 J |
| Nickel | 1,500 | 1,260 | NA | 112 | NA | 96.2 | NA | 2,190 | NA |
| Potassium | 787 | 1,100 | NA | 1,380 | NA | 468 | NA | 897 | NA |
| Selenium | -- | -- | NA | -- | NA | -- | NA | -- | NA |
| Silver | -- | 3.4 | NA | -- | NA | -- | NA | 2.3 | NA |
| Sodium | -- | 510 | NA | 321 | NA | -- | NA | 654 | NA |
| Thallium | -- | -- | NA | -- | NA | -- | NA | -- | NA |
| Vanadium | -- | 14.9 | NA | 10.8 | NA | -- | NA | -- | NA |
| Zinc | 21.5 | 40.9 | NA | 14.0 | NA | -- | NA | 22.1 | NA |
| Cyanide | -- | 2.4 | 0.36 | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Table B-3) of this report.
 Samples collected February 15 - March 23, 1990.

Data Qualifier Legend

- J - The associated numerical value is an estimated quantity.
- Analyte was not detected.
- NA - Not analyzed.

TABLE 4-3

INORGANICS DETECTED IN SOILS(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE THREE

| Sample Number Depth (ft) Units | T-SU-SB107A 1-1.5 mg/kg | T-SU-SB107B 2-2.5 mg/kg | T-SU-SB107C 3.5-4 mg/kg | T-SU-SB108A 1-1.5 mg/kg | T-SU-SB108B 2-2.5 mg/kg | T-SU-SB109A 1-1.5 mg/kg | T-SU-SB109B 2-2.5 mg/kg | T-SU-SB109C 3.5-4 mg/kg | T-SU-SB111A 1-1.5 mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Aluminum | 3,060 | 1,660 | NA | 2,750 | 2,330 J | 4,280 | 2,900 J | NA | 1,350 J |
| Antimony | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Arsenic | 0.62 | 0.88 | NA | 1.5 | 2.3 | 0.87 | 0.79 | NA | 0.63 |
| Barium | 47.6 | 37.8 | NA | 63.3 | 38.2 | 145 | 45.3 | NA | 34.0 |
| Beryllium | -- | 0.49 | NA | -- | -- | 0.37 | -- | NA | -- |
| Cadmium | -- | -- | NA | 10.6 | 18.9 | 2.7 | 43.2 | NA | 16.1 |
| Calcium | 8,200 | 9,160 | NA | 221,000 | 243,000 | 6,140 | 4,930 | NA | 3,850 |
| Chromium | 14.3 | 5.0 | NA | 16.2 | 19.8 | 14.2 | 26.1 | NA | 29.0 |
| Cobalt | 2.3 | 1.4 | NA | 3.1 | 1.9 | 1.8 | 1.4 | NA | -- |
| Copper | 9.0 | -- | NA | -- | -- | -- | -- | NA | -- |
| Iron | 3,500 | 2,010 | NA | 3,050 | 2,890 | 3,820 | 3,090 | NA | 1,550 |
| Lead | 1.6 | 1.9 | NA | 3.0 | 2.6 | 2.4 | 2.0 | NA | 1.6 |
| Magnesium | 1,430 | 991 | NA | 21,600 | 12,200 | 1,600 | 1,340 | NA | -- |
| Manganese | 46.7 | 49.9 | NA | 152 | 107 | 63.8 | 45.9 | NA | 32.4 |
| Mercury | -- | -- | -- | -- | 0.15 | -- | -- | -- | -- |
| Nickel | 3.6 | 2.6 | NA | 36.5 | 24.8 | 76.3 | 115 | NA | -- |
| Potassium | 771 | 377 | NA | 775 | 469 | -- | 654 | NA | 432 |
| Selenium | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Silver | -- | -- | NA | 1.7 | 5.0 | -- | -- | NA | -- |
| Sodium | 399 | 154 | NA | 771 | -- | 635 | 819 | NA | -- |
| Thallium | -- | -- | NA | -- | -- | -- | -- | NA | -- |
| Vanadium | -- | -- | NA | -- | 6.7 | -- | 7.6 | NA | 3.3 |
| Zinc | 13.4 | -- | NA | -- | -- | 12.8 | -- | NA | -- |
| Cyanide | -- | -- | -- | 6.6 | -- | 1.0 | 4.9 | 5.0 | -- |

(a) The complete data summary table is in Appendix B (Table B-3) of this report.
 Samples collected February 15 - March 23, 1990.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.
 -- Analyte was not detected.
 NA - Not analyzed.

TABLE 4-3

INORGANICS DETECTED IN SOILS^(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE FOUR

| Sample Number Depth (ft) Units | T-SU-SB111X 1-1.5 mg/kg | T-SU-SB111B 2-2.5 mg/kg | T-SU-SB111C 3-5-4 mg/kg | T-SU-SB112A 1-1.5 mg/kg | T-SU-SB112X 1-1.5 mg/kg | T-SU-SB112B 2-2.5 mg/kg | T-SU-SB113A 1-1.5 mg/kg | T-SU-SB113B 2-2.5 mg/kg | T-SU-SB113C 3-5-4 mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Aluminum | NA | 1,900 J | NA | 3,700 | NA | 2,940 J | 4,720 | 3,670 | NA |
| Antimony | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Arsenic | NA | 0.92 | NA | 0.54 | NA | 0.77 | 0.57 | 0.85 | NA |
| Barium | NA | 36.3 | NA | 45.6 | NA | 51.8 | 64.5 | 48.0 | NA |
| Beryllium | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Cadmium | NA | 76.2 | NA | -- | NA | -- | -- | -- | NA |
| Calcium | NA | 5,170 | NA | 5,170 | NA | 4,360 | 8,670 | 5,480 | NA |
| Chromium | NA | 96.1 | NA | 14.4 | NA | 15.4 | 16.5 | 9.0 | NA |
| Cobalt | NA | 1.5 | NA | 1.9 | NA | 1.9 | -- | -- | NA |
| Copper | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Iron | NA | 2,220 | NA | 3,310 | NA | 2,850 | 4,200 | 3,520 | NA |
| Lead | NA | 1.6 | NA | 2.3 | NA | 2.7 | 2.0 | 2.2 | NA |
| Magnesium | NA | 888 | NA | 1,420 | NA | 1,140 | 1,560 | 1,350 | NA |
| Manganese | NA | 39.5 | NA | 55.3 | NA | 42.3 | 77.0 | 56.1 | NA |
| Mercury | -- | 0.13 | 0.17 | -- | 0.73 J | 0.15 | -- | -- | -- |
| Nickel | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Potassium | NA | -- | NA | 765 | NA | -- | 809 | 567 | NA |
| Selenium | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Silver | NA | -- | NA | -- | NA | -- | -- | 13.3 | NA |
| Sodium | NA | -- | NA | 147 | NA | -- | -- | -- | NA |
| Thallium | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Vanadium | NA | 6.1 | NA | -- | NA | 6.8 | -- | -- | NA |
| Zinc | NA | -- | NA | -- | NA | -- | -- | -- | NA |
| Cyanide | -- | 3.5 | 2.0 | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Table B-3) of this report.
 Samples collected February 15 - March 23, 1990.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.
 -- Analyte was not detected.
 NA - Not analyzed.

TABLE 4-3

INORGANICS DETECTED IN SOILS(a)
 MIXED-ACID SUMP - PLATING SHOP, BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE FIVE

| Sample Number Depth (ft) Units | T-SU-SB114A 1-1.5 mg/kg | T-SU-SB114B 2-2.5 mg/kg | T-SU-SB114C 3.5-4 mg/kg | T-SU-SB115A 1-1.5 mg/kg | T-SU-SB115B 2-2.5 mg/kg | T-SU-115C 3.5-4 mg/kg | T-SU-SB116A 1-1.5 mg/kg | T-SU-SB116B 2-2.5 mg/kg | T-SU-SB116C 3.5-4 mg/kg | T-SU-BB001A Surface mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-----------------------------|-------------------------------|-------------------------------|-------------------------------|---------------------------------|
| Aluminum | 5,030 J | 2,880 J | NA | 2,650 J | 3,240 J | NA | 5,300 J | 3,610 J | NA | 37,400 J |
| Antimony | -- | -- | NA | -- | -- | NA | -- | -- | NA | -- |
| Arsenic | 1.1 | 0.68 | NA | 0.53 | 1.1 | NA | 0.70 | 0.84 | NA | 1.1 |
| Barium | 48.9 | 119 | NA | 55.9 | 54.8 | NA | 94.9 | 47.3 | NA | 681 |
| Beryllium | -- | -- | NA | -- | -- | NA | -- | -- | NA | 1.5 |
| Cadmium | -- | -- | NA | -- | 0.94 | NA | -- | 0.95 | NA | -- |
| Calcium | 3,850 | 5,210 | NA | 4,800 | 2,760 | NA | 10,800 | 5,080 | NA | 4,600 |
| Chromium | 14.7 | 8.3 | NA | 17.8 | 10.3 | NA | 29.8 | 9.5 | NA | 41.6 J |
| Cobalt | -- | -- | NA | -- | -- | NA | -- | -- | NA | 15.4 |
| Copper | -- | -- | NA | -- | -- | NA | -- | -- | NA | 37.8 |
| Iron | 4,310 | 3,240 | NA | 2,670 | 3,380 | NA | 5,300 | 3,710 | NA | 29,500 J |
| Lead | 2.4 | -- | NA | -- | 2.3 | NA | 2.2 | 2.0 | NA | 14.1 |
| Magnesium | 1,150 | 1,230 | NA | 1,070 | 1,220 | NA | 1,680 | 1,280 | NA | 11,600 |
| Manganese | 65.7 | 72.6 | NA | 39.7 | 57.9 | NA | 213 | 63.7 | NA | 944 J |
| Mercury | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | -- | -- | NA | -- | -- | NA | -- | -- | NA | 32.8 |
| Potassium | 861 | 475 | NA | 493 | 512 | NA | 874 | 571 | NA | 6,750 |
| Selenium | -- | -- | NA | -- | -- | NA | -- | -- | NA | -- |
| Silver | -- | 3.9 | NA | -- | -- | NA | 2.4 | 3.4 | NA | -- |
| Sodium | -- | -- | NA | -- | -- | NA | -- | -- | NA | 599 |
| Thallium | -- | -- | NA | -- | -- | NA | -- | -- | NA | -- |
| Vanadium | -- | -- | NA | -- | -- | NA | -- | -- | NA | 36.4 |
| Zinc | -- | -- | NA | -- | -- | NA | -- | -- | NA | 56.3 J |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Table B-3) of this report.
 Samples collected February 15 - March 23, 1990.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.
 -- Analyte was not detected.
 NA - Not analyzed.

TABLE 4-4

COMPARISON OF INORGANICS DETECTED WITHIN THE MIXED-ACID SUMP
SOILS TO BACKGROUND CONCENTRATIONS AT TINKER AIR FORCE BASE
MIXED-ACID SUMP, PLATING SHOP - BUILDING 3001
TINKER AIR FORCE BASE
OKLAHOMA CITY, OKLAHOMA

| Analyte (mg/kg) | Background Conditions ⁽¹⁾ | Range of Concentrations for 1 - 1.5 depth | Max Con. Background Con. | Range of Concentrations for 2 - 2.5 depth | Max Con. Background Con. |
|-----------------|--------------------------------------|---|--------------------------|---|--------------------------|
| Aluminum | 37,400J | 1,350J - 6,420 | 0.2 | 1,660 - 6,260 | 0.2 |
| Antimony | <1.1 ⁽²⁾ | ND | -- | ND | -- |
| Arsenic | 1.10 | 0.53 - 1.5 | 1.4 | 0.51 - 2.3 | 2.0 |
| Barium | 220 | 34 - 145 | 0.6 | 36.3 - 125 | 0.6 |
| Beryllium | 1.5 | ND - 0.37 | 0.2 | ND - 0.95 | 0.6 |
| Cadmium | 0.72 | ND - 60.1 | 83.5 | ND - 125 | 174 |
| Calcium | 4,600 | 3,800 - 221,000 | 48.0 | 2,760 - 243,000 | 52.8 |
| Chromium | 23.0 | 8.2 - 191 | 8.3 | 5 - 210 | 9.1 |
| Cobalt | 15.4 | ND - 13.1 | 0.9 | 1.5 - 9.5 | 0.6 |
| Copper | 37.8 | ND - 9.0 | 0.2 | 1.6 - 19.3 | 0.5 |
| Iron | 29,500J | 1,550 - 5,300 | 0.2 | 2,010 - 3,980 | 0.1 |
| Lead | 15.0 | 1.4 - 3.0 | 0.2 | 1.6 - 19.3 | 1.3 |
| Magnesium | 11,600 | 642 - 21,600 | 1.9 | 888 - 12,200 | 1.1 |
| Manganese | 944J | 32.4 - 213 | 0.2 | 39.5 - 172 | 0.2 |
| Mercury | <0.1 | ND - 0.85 | 8.5 | ND - 0.36J | 3.6 |
| Nickel | 21.0 | ND - 2,190 | 104.3 | 2.6 - 1,260 | 60 |
| Potassium | 6,750 | 297 - 1,380 | 0.2 | 377 - 1,100 | 0.2 |
| Selenium | <0.1 | ND | -- | ND | -- |
| Silver | 0.56 | ND - 2.4 | 4.3 | ND - 13.3 | 23.8 |
| Sodium | 599 | 147 - 2,120 | 3.5 | ND - 819 | 1.4 |
| Thallium | <0.26 ⁽²⁾ | ND | -- | ND | -- |
| Vanadium | 36.4 | ND - 10.8 | 0.3 | 6.1 - 14.9 | 0.4 |
| Zinc | 25 | 7.7 - 22.1 | 0.9 | 5.3 - 40.9 | 1.6 |
| Cyanide | <0.25 ⁽³⁾ | ND - 6.6 | 26.4 | ND - 4.9 | 19.6 |

⁽¹⁾ Values for the analytes aluminum, antimony, beryllium, calcium, cadmium, cobalt, copper, iron, magnesium, manganese, potassium, sodium, thallium, and vanadium were obtained from sample T-SU-BB001A. Values for arsenic, barium, cadmium, chromium, lead, mercury, nickel, selenium, silver, and zinc were obtained from the USACOE 1990.

⁽²⁾ The values are reported as non-detects.

⁽³⁾ Cyanide is not a naturally-occurring compound in soils.

ND - Non-detect.

J - Estimated value.

is 0.53 mg/kg to 1.5 mg/kg. The maximum concentration (1.5 mg/kg) divided by the value detected in background conditions (1.1 mg/kg) is 1.4. Because this value is above unity, it is possible that a man-made source of arsenic has been introduced into the soils at the mixed-acid sump.

By applying the above criteria to all of the analytes listed on Table 4-4, twelve of these analytes have maximum concentrations greater than the concentration of that analyte in the background soil sample. These inorganics are arsenic, cadmium, calcium, chromium, lead, magnesium, mercury, nickel, silver, sodium, zinc, and cyanide.

Because of their low toxicity and their wide variability in naturally occurring soils, the analytes calcium, magnesium, sodium, and zinc will not be discussed further. However, the distribution and concentration of the other seven inorganics will be examined in more detail.

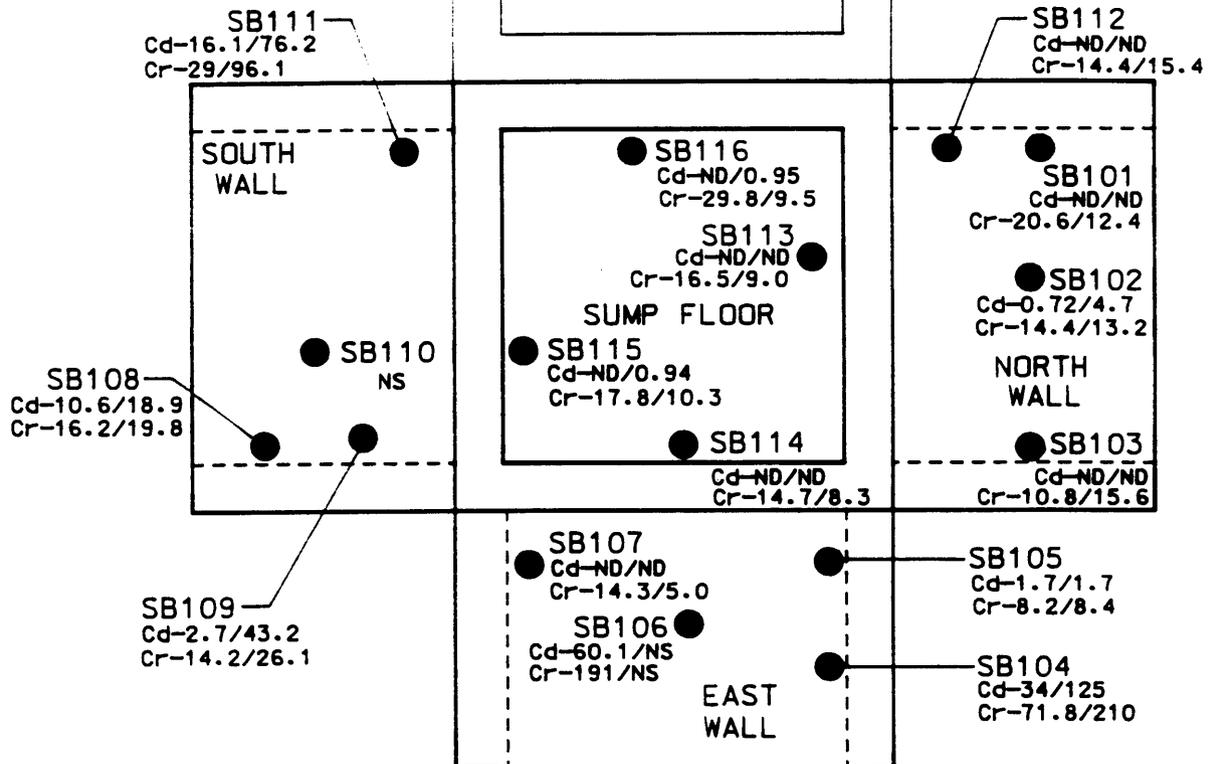
Arsenic was found in only five soil samples collected from the mixed-acid sump at a maximum concentration of 2.3 times the background soil sample. Lead was detected in only one sample (19.3 mg/kg) above background concentrations. Mercury was detected in 21 samples, each at levels below 1 mg/kg. Cyanide was detected in seven samples at a maximum concentration of 6.6 mg/kg. These inorganics may have a man-made source, however, they are detected rather infrequently and at fairly low levels in relation to the background conditions. The analytes cadmium, chromium, nickel, and silver are of particular interest because they are used extensively in plating shop processes. Their distribution is discussed in the following sections.

Cadmium

Figure 4-4 illustrates the distribution of cadmium and chromium in the soils surrounding the mixed-acid sump. Many samples contain cadmium in concentrations greater than the instrument detection limit of 0.6 mg/kg. Two general statements can be made regarding the distribution and concentrations of this element in the soils. First, concentrations are greatest in soils collected from the east and south walls and lowest in the samples collected from the floor area. Second, a comparison of the concentrations observed from 1 to 1.5 feet and 2 to 2.5 feet indicates that the deeper samples generally contain the higher concentrations.



ADJACENT CONC.
SUMP (ACTIVE)



LEGEND

| | |
|--------------------------------|-------------|
| SOIL BORING | ● |
| CADMIUM CONCENTRATION (mg/kg) | Cd-34/125 |
| CHROMIUM CONCENTRATION (mg/kg) | Cr-71.8/210 |
| NOT SAMPLED | NS |
| NOT DETECTED | ND |

NOTE:

Cd-"A"/"B" } = CONCENTRATION IN "A" SAMPLE/CONCENTRATION IN "B" SAMPLE.
Cr-"A"/"B"

SCALE: $\frac{3}{16}$ " = 1'-0"

Figure 4-4

| | | |
|--|--|-----------------------|
| | TITLE CADMIUM AND CHROMIUM CONCENTRATION IN SOIL MIXED ACID SUMP BUILDING 3001 TINKER AIR FORCE BASE | |
| | FILE NO. 4M41G002 | DATE 8-2-91 |

Chromium

Chromium concentrations from the sump borings are also illustrated on Figure 4-4. The chromium, which is reported to be of the hexavalent type (USACOE 1988), is present in the highest concentrations along the east and south walls, in the same samples that contain high cadmium. However, unlike the distribution of cadmium, the deeper soil samples do not show the trend of increasing chromium concentrations.

Nickel

The distribution of the element nickel, as illustrated on Figure 4-5 follows a pattern similar to the cadmium and chromium distribution. Nickel levels are relatively high on the south and east walls and relatively low in the floor samples. Nickel concentrations are also elevated in samples collected from the north wall (SB102 and SB103).

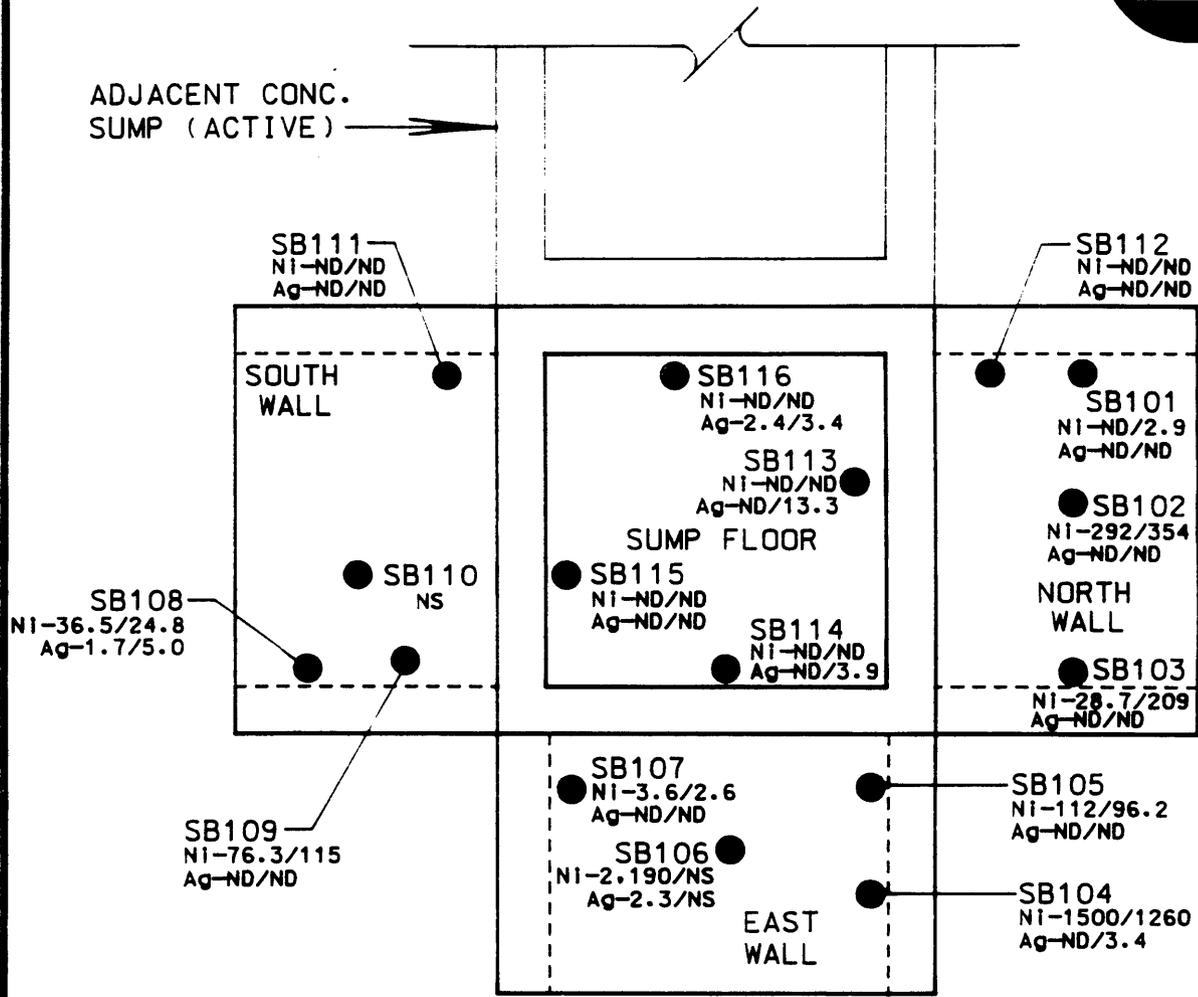
Silver

Many of the soil samples collected during the field activities contained silver below the detection limit. The distribution of silver within the soils is illustrated on Figure 4-5. The highest concentration of silver is found in soil samples collected from the floor area, unlike the distribution for the other three analytes.

4.3.3 Contamination Assessment Summary

A summary of the findings of the investigation of the mixed-acid sump is presented below.

- Although the concrete on the surface of the sump is pitted, no cracks or cavities were found that would allow migration of fluids out of the sump. However, the floor joints or wall seams may have allowed fluids to escape from the sump.
- Organic compounds (VOCs and SVOCs) in soil samples collected from the sump were detected in very low levels (390J $\mu\text{g}/\text{kg}$ - maximum). This finding was expected, as no organic solvents are used in the industrial processes at the plating facility.



LEGEND

| | |
|------------------------------|-------------|
| SOIL BORING | ● |
| NICKEL CONCENTRATION (mg/kg) | NI-76.3/115 |
| SILVER CONCENTRATION (mg/kg) | Ag-1.7/5.0 |
| NOT SAMPLED | NS |
| NOT DETECTED | ND |

NOTE:

Ni-"A"/"B" } = CONCENTRATION IN "A" SAMPLE/CONCENTRATION IN "B" SAMPLE.
 Ag-"A"/"B" }

SCALE: 3/16" = 1'-0"

Figure 4-5

| | | |
|--|---|-----------------------|
| | TITLE NICKEL AND SILVER CONCENTRATION IN SOIL MIXED ACID SUMP BUILDING 3001 TINKER AIR FORCE BASE | |
| | FILE NO. 4M41G003 | DATE 8-2-91 |

- Elevated levels of inorganic compounds are present in the soils around the mixed-acid sump. Arsenic, cadmium, calcium, chromium, lead, magnesium, mercury, nickel, silver, sodium, and zinc concentrations show varying degrees of elevation above background levels. Cyanide, a compound which is not naturally-occurring in soils was also detected during the investigation.
- Spent plating shop acids released into the environment are the most likely source of the elevated concentrations of arsenic, cadmium, chromium, lead, mercury, nickel, silver, and cyanide in these soils. The elevated levels of calcium, magnesium, sodium, and zinc may be attributed to natural variations.

4.4 PLATING SHOP FACILITY

The results of the analytical program for the plating shop investigation are presented in this section. Soil analytical data are presented first, followed by a discussion of the groundwater analytical results.

4.4.1 Soils

Twenty-one soil borings were drilled within and around the plating shop facility to investigate the nature and extent of contamination at the site. Soil samples were collected from these borings at depths of 5, 10, and 20 feet below the ground surface. The analytical results for these samples are presented in Sections 4.4.1.1 and 4.4.1.2.

4.4.1.1 Organic Compounds

VOC and SVOC analytical results for 63 soil samples (including results for field duplicate samples) collected from within the plating shop facility are presented in Table 4-5. Copies of the laboratory analysis data sheets (Form 1s) as well as data summary tables listing all analytes and their qualifiers are included in Appendix B (Tables B-4 and B-5). Tentatively Identified Compounds (TICs) for organic compounds are reported in Appendix C and data validation letters with their supporting QA/QC data are included in Appendix D. Soil samples collected from depths of 5 and 10 feet below the ground surface were obtained from vadose zone soils, while the samples collected from a depth of 20 feet were all from saturated zone soils. Results for the background sample, T-SU-BB001A, are also included on Table 4-5.

TABLE 4-5

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA

| Sample Number Depth (ft) Units | T-SU-SB201A 5(A) µg/kg | T-SU-SB201X 5(A) µg/kg | T-SU-SB201B 14(A) µg/kg | T-SU-SB201C 19(B) µg/kg | T-SU-SB202A 5(A) µg/kg | T-SU-SB202B 10(A) µg/kg | T-SU-SB202C 20(B) µg/kg | T-SU-SB203A 5(A) µg/kg | T-SU-SB203B 10(A) µg/kg |
|--------------------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|
| VOCs(b) | | | | | | | | | |
| Methylene Chloride | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Acetone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vinyl Acetate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chloromethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Trichloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1,1-Trichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1-Dichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | |
| Phenol | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Fluoranthene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-butyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-octyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Bis(2-ethylhexyl) phthalate | -- | -- | -- | -- | -- | -- | -- | 7 J | -- |
| Diethyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzoic acid | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-4 and B-5) of this report.

Samples collected March 6 - 23, 1990.

(b) Volatile Organic Compounds.

(c) Semi Volatile Organic Compounds.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-5

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE TWO

| Sample Number Depth (ft) Units | T-SU-SB203B 20(B) µg/kg | T-SU-SB204A 5(A) µg/kg | T-SU-SB204B 10(A) µg/kg | T-SU-SB204X 10(A) µg/kg | T-SU-SB204C 19.5(B) µg/kg | T-SU-SB205A 5(A) µg/kg | T-SU-SB205B 10(A) µg/kg | T-SU-SB205C 20(B) µg/kg | T-SU-SB206A 5(A) µg/kg |
|--------------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|---------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|
| VOCs(b) | | | | | | | | | |
| Methylene Chloride | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Acetone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vinyl Acetate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chloromethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Trichloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1,1-Trichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1-Dichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | |
| Phenol | 8 J | -- | -- | -- | -- | -- | -- | -- | -- |
| Fluoranthene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-butyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-octyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Bis(2-ethylhexyl) phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Diethyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzoic acid | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-4 and B-5) of this report.

(b) Samples collected March 6 - 23, 1990.

(c) Volatile Organic Compounds.

(A) Semi Volatile Organic Compounds.

(B) Samples collected from soils above the water table.

(C) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-5

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE THREE

| Sample Number Depth (ft) Units | T-SU-SB206C 10(A) µg/kg | T-SU-SB206D 19(B) µg/kg | T-SU-SB207A 5(A) µg/kg | T-SU-SB207B 10(A) µg/kg | T-SU-SB207C 20(B) µg/kg | T-SU-SB207X 20(B) µg/kg | T-SU-SB208A 5(A) µg/kg | T-SU-SB208B 10(A) µg/kg | T-SU-SB208C 20(B) µg/kg |
|--------------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|
| VOCs(b) | | | | | | | | | |
| Methylene Chloride | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Acetone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vinyl Acetate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chloromethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Trichloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1,1-Trichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1-Dichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | |
| Phenol | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Fluoranthene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-butyl phthalate | -- | -- | 66 J | 36 J | -- | 19 J | 32 J | -- | 19 J |
| Di-n-octyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Bis(2-ethylhexyl) phthalate | -- | -- | -- | -- | 1,100 | 750 | -- | -- | -- |
| Diethyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzoic acid | -- | -- | 42 J | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-4 and B-5) of this report.

(b) Samples collected March 6 - 23, 1990.

(c) Volatile Organic Compounds.

(A) Semi Volatile Organic Compounds.

(B) Samples collected from soils above the water table.

(C) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-5

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE FOUR

| Sample Number Depth (ft) Units | T-SU-SB209A 3(A) µg/kg | T-SU-SB209B 10(A) µg/kg | T-SU-SB209C 20(B) µg/kg | T-SU-SB210A 5(A) µg/kg | T-SU-SB210B 10(A) µg/kg | T-SU-SB210C 20(B) µg/kg | T-SU-SB211A 5-5.5(A) µg/kg | T-SU-SB211X 4-5.5(A) µg/kg | T-SU-SB211B 10(A) µg/kg |
|--------------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|----------------------------------|----------------------------------|-------------------------------|
| VOCs(b) | | | | | | | | | |
| Methylene Chloride | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Acetone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | 7 J | -- | -- | -- | -- | -- | -- | -- |
| Vinyl Acetate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chloromethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Trichloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1,1- Trichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1- Dichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCS(c) | | | | | | | | | |
| Phenol | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Fluoranthene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-butyl phthalate | 36 J | 36 J | -- | 44 J | 29 J | 36 J | -- | -- | -- |
| Di-n-octyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Bis(2-ethylhexyl) phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Diethyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzoic acid | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-4 and B-5) of this report.

Samples collected March 6 - 23, 1990.

(b) Volatile Organic Compounds.

(c) Semi Volatile Organic Compounds.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-5

ORGANIC COMPOUNDS DETECTED IN SOILS^(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE FIVE

| Sample Number Depth (ft) Units | T-SU-SB211C 20(B) µg/kg | T-SU-SB212A 5(A) µg/kg | T-SU-SB212B 10(A) µg/kg | T-SU-SB212C 18(B) µg/kg | T-SU-SB213A 5(A) µg/kg | T-SU-SB213B 20(B) µg/kg | T-SU-SB214A 5(A) µg/kg | T-SU-SB214B 10(A) µg/kg | T-SU-SB215A 5(A) µg/kg |
|--------------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|------------------------------|-------------------------------|------------------------------|
| VOCs(b) | | | | | | | | | |
| Methylene Chloride | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Acetone | -- | -- | -- | -- | 5 J | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vinyl Acetate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chloromethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Trichloroethene | -- | -- | -- | -- | 19 | -- | -- | -- | -- |
| Tetrachloroethene | 4 J | -- | -- | -- | 12 | -- | -- | -- | 5 J |
| 1,1,1-Trichloroethane | -- | -- | 25 | -- | -- | -- | -- | -- | -- |
| 1,1-Dichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | |
| Phenol | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Fluoranthene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-butyl phthalate | 48 J | -- | -- | -- | 26 J | -- | -- | -- | -- |
| Di-n-octyl phthalate | 130 J | -- | -- | -- | -- | -- | -- | -- | -- |
| Bis(2-ethylhexyl) phthalate | 130 J | -- | -- | -- | -- | -- | -- | -- | -- |
| Diethyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzoic acid | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-4 and B-5) of this report.

Samples collected March 6 - 23, 1990.

(b) Volatile Organic Compounds.

(c) Semi Volatile Organic Compounds.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-5

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE SIX

| Sample Number Depth (ft) Units | T-SU-SB2158 10(A) µg/kg | T-SU-SB215C 20(B) µg/kg | T-SU-SB216A 5(A) µg/kg | T-SU-SB216B 10(A) µg/kg | T-SU-SB216X 10(A) µg/kg | T-SU-SB216C 20(B) µg/kg | T-SU-SB217A 5(A) µg/kg | T-SU-SB217B 10(A) µg/kg | T-SU-SB217C 20(B) µg/kg |
|--------------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|
| VOCs(b) | | | | | | | | | |
| Methylene Chloride | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Acetone | -- | -- | 170 J | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | 36 J | 0.7 J | -- | -- | 7 J | -- | -- |
| Vinyl Acetate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Chloromethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Trichloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Tetrachloroethene | 2 J | -- | -- | -- | 3 J | -- | -- | -- | -- |
| 1,1,1-Trichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1-Dichloroethane | -- | -- | -- | 0.2 J | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | |
| Phenol | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Fluoranthene | -- | -- | -- | -- | -- | 51 J | -- | -- | -- |
| Di-n-butyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-octyl phthalate | -- | -- | -- | -- | -- | -- | -- | 4 J | -- |
| Bis(2-ethylhexyl) phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Diethyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzoic acid | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-4 and B-5) of this report.

Samples collected March 6 - 23, 1990.

(b) Volatile Organic Compounds.

(c) Semi Volatile Organic Compounds.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-5

ORGANIC COMPOUNDS DETECTED IN SOILS(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE SEVEN

| Sample Number Depth (ft) Units | T-SU-SB218A 5(A) µg/kg | T-SU-SB218B 20(B) µg/kg | T-SU-SB218X 20(B) µg/kg | T-SU-SB220A 5(A) µg/kg | T-SU-SB220B 10(A) µg/kg | T-SU-SB220C 20(B) µg/kg | T-SU-SB221A 5(A) µg/kg | T-SU-SB221B 10(A) µg/kg | T-SU-SB221C 20(B) µg/kg | T-SU-BB001A Surface µg/kg |
|--------------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|---------------------------------|
| VOCs(b) | | | | | | | | | | |
| Methylene Chloride | -- | -- | -- | -- | -- | 1 J | 49 | -- | 48 | -- |
| Acetone | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vinyl Acetate | -- | -- | -- | -- | -- | -- | 0.1 J | -- | -- | -- |
| Chloromethene | -- | -- | -- | -- | -- | -- | -- | -- | 9 J | -- |
| Trichloroethene | -- | -- | -- | -- | -- | -- | 2 J | -- | -- | -- |
| Tetrachloroethene | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1,1-Trichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,1-Dichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | | |
| Phenol | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Fluoranthene | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-butyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Di-n-octyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Bis(2-ethylhexyl) phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Diethyl phthalate | -- | 5 J | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzoic acid | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-4 and B-5) of this report.

(b) Samples collected March 6 - 23, 1990.

(c) Volatile Organic Compounds.

(A) Semi Volatile Organic Compounds.

(B) Samples collected from soils above the water table.

(C) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

Although 15 individual VOC and SVOC compounds were detected in the soil samples from the plating shop, 56 of 63 samples contained no or only one organic compound. Of the positive detections shown on Table 4-5, only two compounds were found in concentrations above 100 µg/kg: bis(2-ethylhexyl) phthalate at a concentration of 750 and 1,100 µg/kg and acetone at a concentration of 170 µg/kg. The most common families of organic chemicals found within the soils at the site are chlorinated aliphatic compounds, including PCE, TCE, and 1,1,1-TCA, and the phthalate esters. Chlorinated aliphatic compounds were detected in seven samples at concentrations ranging from 21 to 25 µg/kg, while the phthalate esters were observed in 14 samples, most commonly in concentrations below 100 µg/kg.

In general, these analytical results indicate that the soil samples collected from the plating shop facility are relatively free of man-made organic compounds. However, because no organic compounds are used in the plating shop process, these results offer little insight regarding the degree to which plating shop wastes may have been released into the soils at the site.

4.4.1.2 Inorganic Compounds

Inorganic analytical results for the 63 soil samples collected are presented in Table 4-6. Copies of the laboratory analysis data sheets (Form 1s) as well as the data summary table listing all analytes and their qualifiers are included in Appendix B (Table B-6). Data validation letters with their supporting QA/QC data are included in Appendix D. Results for the background sample, T-SU-BB001A, are also included on this table. The inorganics quantified in the soil samples from the plating shop facility were compared to background conditions (see Table 4-1) as a means of determining whether levels of inorganics in the soil samples near the plating shop are significantly elevated. Levels of inorganics, when compared to background conditions on base, may indicate that these compounds have been artificially raised by industrial activities. The tabulated comparison presented in Table 4-7 shows the range of concentrations for each of the TAL inorganic compound. The maximum concentration detected for each analyte was then divided by the concentration of that analyte detected in the background sample. This number represents the amount any particular analyte is above the background level.

As illustrated on Table 4-7, the maximum concentration of 18 analytes were elevated above average background levels. Because of their low toxicity and/or relatively low maximum concentration above average background levels, the analytes aluminum, beryllium, calcium, copper, iron, lead, magnesium, potassium, sodium, and vanadium will not be discussed further in this section. The analytes arsenic, barium, chromium, cobalt, manganese, nickel, selenium, and zinc will be included in

TABLE 4-6

INORGANICS DETECTED IN SOILS (a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA

| Sample Number Depth (ft) Units | T-SU-SB201A 5(A) mg/kg | T-SU-SB201X 5(A) mg/kg | T-SU-SB201B 14(A) mg/kg | T-SU-SB201C 19(B) mg/kg | T-SU-SB202A 5(A) mg/kg | T-SU-SB202B 10(A) mg/kg | T-SU-SB202C 20(B) mg/kg | T-SU-SB203A 5(A) mg/kg | T-SU-SB203B 10(A) mg/kg |
|--------------------------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|
| Aluminum | 20,900 | 21,100 | -- | 18,100 | 32,700 | -- | 10,200 | 24,800 | -- |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | 0.93 J | 1.3 J | -- | 6.3 J | 1.7 J | -- | 0.96 J | 1.1 J | 0.42 J |
| Barium | -- | 346 J | -- | 619 J | 155 J | -- | 252 J | 416 J | 92.8 J |
| Beryllium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Cadmium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 2,040 | 6,960 | 1,860 | 5,080 J | 2,530 | -- | 3,100 J | 2,360 | -- |
| Chromium | 63.8 | 25.1 | 6.2 | 39.1 | 33.4 | 9.1 | 28.8 | 26.8 | 9.5 |
| Cobalt | 7.1 | 12.5 | -- | 8.5 | 11.5 | 3.2 | 6.6 | 38.1 | 1.8 |
| Copper | -- | 24.7 | -- | -- | 19.6 | -- | 12.4 | 14.0 | -- |
| Iron | 26,100 | 21,000 | -- | 21,900 | 26,300 | 7,130 | 21,600 | 20,700 | 6,170 |
| Lead | 4.0 J | 22.9 J | -- | 7.4 J | 12.1 J | 2.9 J | 7.4 J | 12.8 J | 2.3 J |
| Magnesium | 6,440 | 5,530 | -- | 7,420 | 7,770 | -- | 4,490 | 4,220 | -- |
| Manganese | 170 J | 948 J | -- | 256 J | 274 J | 283 J | 215 J | 618 J | 783 J |
| Mercury | -- | -- | -- | -- | -- | -- | -- | -- | 0.15 J |
| Nickel | 26.0 | 23.7 | -- | 27.3 | 24.3 | -- | 20.7 | 18.7 | -- |
| Potassium | 3,910 | 2,890 | -- | 4,290 | 5,840 | -- | 2,190 | 2,520 | -- |
| Selenium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sodium | 1,100 | 1,180 | -- | -- | 780 | -- | -- | -- | -- |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | 40.6 | 20.0 | 6.4 | 63.6 | 30.8 | 15.1 | 31.8 | 30.1 | 12.3 |
| Zinc | 26.5 | 43.3 | 4.6 | 17.6 | 30.8 | 7.6 | 20.3 | 35.2 | 8.1 |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Tables B-6) of this report.

Samples collected March 6 - 23, 1990.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-6

INORGANICS DETECTED IN SOILS (a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE TWO

| Sample Number Depth (ft) Units | T-SU-SB203C 20(B) mg/kg | T-SU-SB204A 5(A) mg/kg | T-SU-SB204B 10(A) mg/kg | T-SU-SB204X 10(A) mg/kg | T-SU-SB204C 19.5(B) mg/kg | T-SU-SB205A 5(A) mg/kg | T-SU-SB205B 10(A) mg/kg | T-SU-SB205C 20(B) mg/kg | T-SU-SB206A 5(A) mg/kg |
|--------------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|---------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|
| Aluminum | 5,620 | 16,900 | 11,000 | 7,600 | -- | 32,400 | 4,060 | 533 | 33.00 |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | 0.46 J | 3.3 J | 0.72 J | 0.53 J | 0.30 J | -- | 0.52 | 0.53 | 1.2 |
| Barium | 566 J | 515 J | -- | -- | 346 J | 399 | 10.7 | 17.0 | 402 |
| Beryllium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Cadmium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 6,820 | 4,990 | -- | -- | -- | 3,230 | 4,100 | 1,010 | 4,670 |
| Chromium | 15.6 | 19.3 | 30.0 | 26.3 | 5.4 | 32.8 | 14.6 | 4.0 | 34.8 |
| Cobalt | 4.3 | 3.0 | 5.8 | 5.8 | 1.4 | 16.7 | 5.7 | -- | 12.0 |
| Copper | -- | -- | -- | -- | -- | 38.8 | 4.0 | -- | 21.0 |
| Iron | 10,900 | 13,000 | 16,800 | 16,900 | -- | 26,000 | 11,900 | 1,730 | 24,500 |
| Lead | 3.5J | 21.5 J | 4.9 J | 3.0 J | 1.7 J | 11.6 J | 10.7 J | 1.2 J | 10.6 J |
| Magnesium | 5,870 | 3,130 | 3,170 | 2,530 | -- | 10,600 | 4,080 | 847 | 6,460 |
| Manganese | 276J | 358J | 248 J | 290 J | 206 J | 1,400 J | 234 J | 54.0 J | 375 J |
| Mercury | -- | 0.06 J | -- | -- | 0.36 J | -- | -- | -- | -- |
| Nickel | 12.5 | 13.2 | 20.2 | 18.7 | -- | 45.6 | 11.9 | -- | 23.3 |
| Potassium | -- | -- | 2,020 | -- | -- | 4,350 | 642 | 108 | 4,990 |
| Selenium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sodium | -- | -- | -- | -- | -- | 1,540 | -- | -- | -- |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | 17.8 | 28.0 | 17.9 | 19.6 | 4.4 | 29.9 | 25.7 | 4.9 | 41.1 |
| Zinc | 11.2 | 27.9 | 15.5 | 18.0 | 5.5 | 57.6 | 17.0 | -- | 50.0 |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Tables B-6) of this report.

Samples collected March 6 - 23, 1990.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-6

INORGANICS DETECTED IN SOILS (a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE THREE

| Sample Number Depth (ft) Units | T-SU-SB206C 10(A) mg/kg | T-SU-SB206D 19(B) mg/kg | T-SU-SB207A 5(A) mg/kg | T-SU-SB207B 10(A) mg/kg | T-SU-SB207C 20(B) mg/kg | T-SU-SB207X 20(B) mg/kg | T-SU-SB208A 5(A) mg/kg | T-SU-SB208B 10(A) mg/kg | T-SU-SB208C 20(B) mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|
| Aluminum | 7,940 | 799 | 23,700 | 6,770 | 21,500 | 16,200 | 24,100 | 29,100 | 20,700 |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | 1.3 | -- | 2.5 | 0.87 | 1.6 | 2.5 | 2.5 | -- | 1.0 |
| Barium | 100 | 6.9 | 297J | 821 J | 102 J | 68.6 J | 769 J | 494 J | 86.2 J |
| Beryllium | -- | -- | 0.99 | -- | 0.97 | 0.86 | 0.72 | 0.96 | 0.96 |
| Cadmium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 4,380 | 1,420 | 2,150 | 580 | 4,880 | 5,710 | 23,000 | 32,500 | 3,190 |
| Chromium | 23.1 | 4.3 | 46.1 J | 13.4 J | 44.1 J | 33.4 J | 23.8 J | 29.1 J | 54.8 J |
| Cobalt | 5.4 | 1.7 | 28.8 | 5.7 | 14.3 | 9.8 | 7.2 | 13.3 | 12.1 |
| Copper | 4.5 | -- | -- | -- | 31.8 | -- | -- | 35.8 | -- |
| Iron | 16,900 | 2,000 | 27,100 | 12,800 | 33,000 | 28,600 | 18,200 | 20,900 | 32,000 |
| Lead | 7.7 J | 1.1 J | 11.6 J | 2.7 J | 11.5 J | 7.0 J | 8.9 J | 3.4 J | 5.0 J |
| Magnesium | 4,820 | 1,240 | 5,180 | 2,250 | 8,990 | 7,440 | 4,890 | 21,500 | 7,040 |
| Manganese | 387 | 69.7 | 2,360 | 91.0 | 410 | 356 | 142 | 944 | 323 |
| Mercury | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | 16.2 | -- | 32.2 | -- | 42.7 | 28.4 | 15.2 | 32.7 | 30.7 |
| Potassium | 1,340 | 150 | 4,320 | 1,350 | 4,280 | 3,420 | 2,000 | 6,390 | 4,460 |
| Selenium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sodium | -- | -- | 917 | -- | -- | -- | 699 | 1,030 | 645 |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | 29.1 | 5.0 | 36.2 | 20.2 | 46.0 | 39.6 | 29.0 | 17.4 | 54.5 |
| Zinc | -- | -- | 42.5 | 18.3 | 54.3 | 44.6 | 36.2 | 51.1 | -- |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Tables B-6) of this report.

Samples collected March 6 - 23, 1990.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-6

INORGANICS DETECTED IN SOILS (a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE FOUR

| Sample Number Depth (ft) Units | T-SU-SB209A 3(A) mg/kg | T-SU-SB209B 10(A) mg/kg | T-SU-SB209C 20(B) mg/kg | T-SU-SB210A 5(A) mg/kg | T-SU-SB210B 10(A) mg/kg | T-SU-SB210C 20(B) mg/kg | T-SU-SB211A 5-5.5(A) mg/kg | T-SU-SB211X 5-5.5(A) mg/kg | T-SU-SB211B 10(A) mg/kg |
|--------------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|----------------------------------|----------------------------------|-------------------------------|
| Aluminum | 29,300 | 34,200 | 1,130 | 37,200 | 27,300 | 2,100 | 3,310 J | 3,200 | 9,650 |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | 3.1 | 2.0 | -- | 2.8 | 1.9 | 0.47 | 0.47 J | 0.75 J | 0.61 J |
| Barium | 151 J | 222 J | 19.0 J | 1,760 J | 55.8 J | 8.9 J | 48.6 J | 58.8 J | 59.0 J |
| Beryllium | 0.70 | 0.91 | -- | 1.2 | 0.90 | -- | -- | -- | -- |
| Cadmium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 2,600 | 4,260 | -- | 3,720 | 33,800 | -- | 5,640 | 6,630 | 3,880 |
| Chromium | 27.4 J | 34.1 J | 4.5 J | 36.7 J | 30.5 J | 7.7 J | 150 J | 23.8 J | 23.4 J |
| Cobalt | 8.7 | 7.5 | 1.8 | 13.1 | 12.6 | 1.8 | -- | 1.8 | 4.8 |
| Copper | -- | -- | -- | 20.2 | 27.4 | -- | 2.7 | 3.0 | 4.8 |
| Iron | 18,400 | 24,200 | 1,690 | 26,500 | 21,800 | 3,480 | 3,010 J | 3,020 | 11,000 |
| Lead | 11.9 J | 12.7 J | -- | 13.9 J | 6.4 J | -- | 2.2 J | 2.5 J | 3.3 J |
| Magnesium | 4,120 | 5,200 | -- | 7,270 | 19,200 | -- | 1,440 | 1,690 | 3,040 |
| Manganese | 765 | 291 | 84.6 | 526 | 922 | 35.1 | 55.3 J | 68.6 J | 214 J |
| Mercury | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | -- | 17.4 | -- | 27.6 | 31.5 | -- | -- | -- | -- |
| Potassium | 2,420 | 2,780 | 261 | 3,910 | 5,300 | 443 | 660 | 650 | 1,720 |
| Selenium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sodium | -- | 800 | -- | 948 | 1,090 | -- | 1,080 | 1,520 | 323 |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | 41.1 | 47.2 | 3.3 | 42.6 | 19.9 | 8.9 | 9.6 | 13.4 | 19.0 |
| Zinc | 36.0 | 41.9 | 5.0 | 47.7 | 47.9 | -- | 9.3 J | 9.0 J | 25.2 J |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Tables B-6) of this report.

Samples collected March 6 - 23, 1990.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-6

INORGANICS DETECTED IN SOILS (a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE FIVE

| Sample Number Depth (ft) Units | T-SU-SB211C 20(B) mg/kg | T-SU-SB212A 5(A) mg/kg | T-SU-SB212B 10(A) mg/kg | T-SU-SB212C 18(B) mg/kg | T-SU-SB213A 5(A) mg/kg | T-SU-SB213B 20(B) mg/kg | T-SU-SB214A 5(A) mg/kg | T-SU-SB214B 10(A) mg/kg | T-SU-SB215A 5(A) mg/kg |
|--------------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|------------------------------|-------------------------------|------------------------------|
| Aluminum | 1,360 | 3,810 | 12,900 | 709 | 12,600 | 5,330 | 25,500 | 3,230 | 32,200 |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | -- | 0.54 J | 1.9 J | -- | 0.73 J | 0.93 J | 3.1 J | 0.32 J | 3.0 |
| Barium | 688J | 76.4 J | 70.1 J | 12.5 J | 92.1 J | 49.4 J | 488 J | 113 J | 2,540 J |
| Beryllium | -- | -- | -- | -- | -- | -- | -- | -- | 0.75 |
| Cadmium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 5,100 | 1,140 | 905 | 92.8 | 1,160 | 11,600 | 2,170 | 1,200 | 8,110 J |
| Chromium | -- | 12.0 J | 24.3 J | -- | 14.4 J | 13.6 J | 32.0 J | 10.7 J | 30.8 |
| Cobalt | 3.5 | 3.0 | 4.2 | 1.9 | 3.9 | 4.4 | 7.2 | 4.5 | 14.0 |
| Copper | 7.1 | 4.1 | 4.4 | -- | 6.1 | 4.7 | 9.0 | 4.5 | 18.5 |
| Iron | 2,270 | 7,560 | 17,100 | 960 | 9,680 J | 6,230 | 23,900 | 4,230 | 24,000 |
| Lead | 2.4J | 2.7 J | 4.8 J | 0.50 J | 5.0 J | 3.4 J | 12.2 J | 3.3 J | 11.7 |
| Magnesium | 1,310 | 1,250 | 2,840 | -- | 1,910 | 8,070 | 3,200 | 1,280 | 4,380 |
| Manganese | 83.9 J | 330 J | 100 J | 73.0 J | 120 J | 323 J | 421 J | 670 J | 421 J |
| Mercury | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | -- | -- | 13.8 | 3.2 | -- | 13.5 | 17.3 | 11.8 | 23.4 |
| Potassium | 339 | 499 | 2,200 | -- | 1,160 | 1,030 | 2,210 | 436 | 3,950 |
| Selenium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sodium | -- | 101 | 629 | 103 | -- | -- | 511 | -- | 748 |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | 3.5 | 11.3 | 22.9 | 1.7 | 15.5 | 16.2 | 38.9 | 11.8 | 36.8 |
| Zinc | 8.0 J | 12.1 J | 17.7 J | -- | 18.6 J | 19.4 J | 122 J | 31.6 J | 44.4 |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Tables B-6) of this report.

Samples collected March 6 - 23, 1990.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-6

INORGANICS DETECTED IN SOILS (a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE SIX

| Sample Number Depth (ft) Units | T-SU-SB215B 10(A) mg/kg | T-SU-SB215C 20(B) mg/kg | T-SU-SB216A 5(A) mg/kg | T-SU-SB216B 10(A) mg/kg | T-SU-SB216X 10(A) mg/kg | T-SU-SB216C 20(B) mg/kg | T-SU-SB217A 5(A) mg/kg | T-SU-SB217B 10(A) mg/kg | T-SU-SB217C 20(B) mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|
| Aluminum | 19,100 | 1,320 | 20,300 | 40,000 | 13,600 | 19,400 | 25,400 | 4,470 | 3,890 |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | 1.4 J | 0.32 | 4.8 | 1.8 | 1.3 | 3.0 | 1.8 | 1.2 | 0.53 |
| Barium | 195 J | 5.8 J | 201 J | 1,160 J | 360 J | 1,340 J | 178 J | 66.3 J | 78.4 J |
| Beryllium | -- | -- | -- | 0.72 | -- | 0.39 | -- | -- | -- |
| Cadmium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 2,500 | 257 J | 2,520 J | 4,990 J | 2,980 J | 5,550 | 1,490 J | 553 J | 66,600 J |
| Chromium | 23.5 J | 3.7 | 19.5 | 45.2 | 18.5 | 25.4 | 22.6 | 8.5 | 8.9 |
| Cobalt | 9.6 | -- | 9.0 | 12.6 | 9.0 | 10.1 | 8.5 | -- | -- |
| Copper | 18.9 | -- | 7.3 | 17.1 | 9.6 | 10.9 | 6.6 | 1.8 | 12.1 |
| Iron | 16,400 | 3,280 | 21,200 | 29,100 | 14,800 | 19,400 | 16,600 | 5,870 | 8,470 |
| Lead | 8.1 J | 1.1 | 16.8 | 8.6 | 6.5 | 9.0 | 4.1 | 6.8 | 5.2 |
| Magnesium | 6,700 | 1,410 | 2,340 | 3,140 | 3,790 | 3,620 | 1,720 | 4,850 | 1,410 |
| Manganese | 383 J | 80.7 J | 759 J | 286 J | 250 J | 393 J | 195 J | 210 J | 879 J |
| Mercury | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | 26.4 | 4.9 | 13.4 | 30.5 | 19.5 | 18.8 | 13.8 | 9.7 | 12.6 |
| Potassium | 2,400 | -- | 1,300 | 5,360 | 1,510 | 2,720 | 2,300 | 851 | 835 |
| Selenium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sodium | 865 | -- | -- | -- | 792 | 695 | -- | -- | -- |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | 20.5 | 8.8 | 34.9 | 44.1 | 18.6 | 29.4 | 33.6 | 6.1 | 20.5 |
| Zinc | 63.8 J | 5.9 | 34.0 | 51.2 | 25.3 | 40.6 | 27.1 | 23.4 | 14.7 |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Tables B-6) of this report.

Samples collected March 6 - 23, 1990.

(A) Samples collected from soils above the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-6

INORGANICS DETECTED IN SOILS (a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE SEVEN

| Sample Number Depth (ft) Units | T-SU-SB218A 5(A) mg/kg | T-SU-SB218B 20(B) mg/kg | T-SU-SB218X 20(B) mg/kg | T-SU-SB220A 5(A) mg/kg | T-SU-SB220B 10(A) mg/kg | T-SU-SB220C 20(B) mg/kg | T-SU-SB221A 4(A) mg/kg | T-SU-SB221B 10(A) mg/kg | T-SU-SB221C 20(B) mg/kg | T-SU-BB001A Surface mg/kg |
|--------------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|------------------------------|-------------------------------|-------------------------------|---------------------------------|
| Aluminum | 5,110 | 1,820 J | 44,000 J | 14,700 | 8,220 | 959 | 23,700 J | 18,700 J | 11,500 J | 37,400 J |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | 0.62 | 0.57 | -- | 2.3 | 0.81 | -- | 1.5 | 1.1 | 1.0 | 1.1 |
| Barium | 123 J | 2,320 | 255 | 156 J | 44.0 J | 73.2 J | 63.8 | 37.5 | 269 | 681 |
| Beryllium | -- | 0.36 | 2.0 | 0.37 | -- | -- | 1.0 | 0.91 | 0.47 | 1.5 |
| Cadmium | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 24,300 | 13,500 | 3,240 | 3,960 J | 1,060 J | 325 J | 2,940 | 2,280 | 3,480 | 4,600 |
| Chromium | 6.2 | 9.7 J | 39.4 J | 19.8 | 18.9 | 7.0 | 33.7 J | 48.1 J | 21.4 J | 41.6 J |
| Cobalt | -- | -- | 14.4 | 9.5 | -- | -- | -- | -- | -- | 15.4 |
| Copper | 4.3 | -- | 4-/9 | 7.3 | 16.5 | -- | -- | -- | 8.7 | 37.8 |
| Iron | 5,790 | 4,510 J | 30,700 J | 14,100 | 8,100 | 2,100 | 22,500 J | 22,800 J | 13,500 J | 29,500 J |
| Lead | 12.5 | 3.7 | 12.9 | 10.5 | 4.9 | 0.51 | 7.7 | 5.5 | 4.1 | 14.1 |
| Magnesium | 3,330 | 8,260 | 11,500 | 2,480 | 1,340 | 431 | 4,140 | 4,330 | 3,410 | 11,600 |
| Manganese | 952 J | 481 J | 1,280 J | 75.4 J | 331 J | 202 J | 112 J | 380 J | 423 J | 944 J |
| Mercury | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nickel | 6.0 | 9.0 | 42.4 | 12.0 | 9.1 J | 2.5 | 14.3 | 63.2 | 13.4 | 32.8 |
| Potassium | 674 | 393 | 9,220 | 1,240 | 1,270 | -- | 2,830 | 2,470 | 1,510 | 6,750 |
| Selenium | -- | -- | -- | 1.4 J | 0.91 J | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sodium | -- | -- | -- | -- | -- | -- | 803 | 645 | -- | 599 |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | 9.5 | 15.5 | 35.9 | 36.2 | 12.9 | 3.2 | 39.9 | 31.5 | 20.8 | 36.4 |
| Zinc | 13.5 | 8.2 J | 55.8 J | 23.9 | 15.0 | 6.9 | 40.6 J | 35.2 J | 22.9 J | 56.3 J |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Tables B-6) of this report.

J - The associated numerical value is an estimated quantity.

-- Samples collected from soils above the water table.

(A) Samples collected from soils below the water table.

(B) Samples collected from soils below the water table.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-7

COMPARISON OF INORGANICS DETECTED WITHIN THE PLATING SHOP SOILS TO BACKGROUND CONCENTRATIONS AT TINKER AIR FORCE BASE PLATING SHOP FACILITY TINKER AIR FORCE BASE OKLAHOMA CITY, OKLAHOMA

| Analyte (mg/kg) | Background Concentrations | Range of Concentrations for 5-10' depth(1) | Max Con. Background Con. | Range of Concentrations for 20' depth(1) | Max Con. Background Con. |
|-----------------|---------------------------|--|--------------------------|--|--------------------------|
| Aluminum | 37,400J | ND - 40,000 | 1.1 | ND-44,000J | 1.2 |
| Antimony | <1.1(2) | ND | -- | ND | -- |
| Arsenic | 1.1 | ND-4.8 | 4.4 | ND-6.3J | 5.7 |
| Barium | 220 | ND-2,540J | 11.5 | 5.8J-2,320 | 10.5 |
| Beryllium | 1.5 | ND-1.8 | 1.2 | ND-2.0 | 1.3 |
| Cadmium | 0.72 | ND | -- | ND | -- |
| Calcium | 4,600 | ND-33,800 | 7.3 | ND-66,600 | 14.5 |
| Chromium | 23.0 | 6.2-150J | 6.5 | ND-44.1J | 1.9 |
| Cobalt | 15.4 | ND-38.1 | 2.5 | ND-14.4 | 0.9 |
| Copper | 37.8 | ND-38.8 | 1.0 | ND-31.8 | 0.8 |
| Iron | 29,500J | ND-29,100J | 1.0 | ND-33,000 | 1.1 |
| Lead | 15.0 | ND-22.9J | 1.5 | ND-12.9J | 0.9 |
| Magnesium | 11,600 | ND-21,500 | 1.9 | ND-11,500 | 1.0 |
| Manganese | 944J | 55.3J-2,360 | 2.5 | 54J-1,280J | 1.3 |
| Mercury | <0.1 | ND | -- | ND | -- |
| Nickel | 21.0 | ND-63.2 | 3.0 | ND-42.4 | 2.0 |
| Potassium | 6,750 | ND-6,390 | 0.9 | ND-9,220 | 1.4 |
| Selenium | <0.1 | ND-1.4J | 14 | ND | -- |
| Silver | 0.56 | ND | -- | ND | -- |
| Sodium | 599 | ND-1,540 | 2.6 | ND-695 | 1.2 |
| Thallium | <0.26(2) | ND | -- | ND | -- |
| Vanadium | 36.4 | 6.1-47.2 | 1.3 | 4.4-54.5 | 1.5 |
| Zinc | 25 | ND-122J | 4.9 | ND-55.8J | 2.2 |
| Cyanide | <0.25(2) | ND | -- | ND | -- |

(1) Values for arsenic, barium, cadmium, chromium, lead, mercury, nickel, selenium, silver, and zinc were obtained from the USACOE 1990. Values for the analytes aluminum, antimony, beryllium, calcium, cobalt, copper, iron, magnesium, manganese, potassium, sodium, thallium, and vanadium were obtained from sample T-SU-BB001A.

(2) The values are reported as non-detects.

(3) Cyanide is not a naturally-occurring compound in soils.

J - Qualifier indicates an estimated value.

ND - Indicates compound was not detected.

further discussions of the nature and extent of inorganic contamination at the plating shop. In addition, cadmium and silver which have been used extensively in the plating shop processes but were not detected above background concentrations, will also be included in the discussions of the nature and extent of contamination. Table 4-8 illustrates in more detail the distribution and variation in concentrations for these analytes.

Cadmium and silver were used extensively within the plating shop. Neither metal was detected in any of the soil samples collected during this portion of the investigation. Cobalt, manganese and selenium were detected at levels above background infrequently (fewer than or equal to six samples). The analytes arsenic, barium, chromium, nickel, and zinc were detected in between 18 and 31 samples. Arsenic (6.3J mg/kg), barium (max 2,540 mg/kg), and chromium (max 150 mg/kg) were each detected in concentrations greater than 5 times the background concentrations.

In summary, these data suggest that except for arsenic, barium, chromium, nickel, and zinc, inorganics contamination is not widespread beneath the plating shop facility. No analyte with appreciable toxicity was detected at levels greater than 14 times the background concentration of that analyte. Compared to soils collected from the mixed-acid sump (Table 4-3), levels of cadmium, chromium, nickel, and silver are much lower in the soils surrounding the plating shop. If waste acids have been released into the environment from the mixed-acid sump, they have not had a significant impact on soils away from the sump. These data also suggest that no other significant sources of inorganics exist within the soils at the plating shop facility.

4.4.2 Groundwater

Twenty-one soil borings were drilled to investigate the plating shop facility, and three were completed as permanent groundwater monitoring wells. Groundwater samples were collected from these wells and from the open boreholes of 14 additional soil borings. Groundwater samples were not collected from borings SB204, SB205, SB208, SB219, and SB220 because obstructions in the borehole prevented lowering a bailer into the groundwater.

Monitoring wells were developed after installation by bailing 10 to 50 gallons of water from each well. The wells were allowed to recharge, then purged and sampled. Groundwater samples collected from each well were described as clear to slightly turbid during sampling. Samples collected for inorganic analyses were filtered in the field before being placed in the appropriate sample bottles containing nitric acid as a preservative.

TABLE 4-8

FREQUENCY AND DISTRIBUTION OF INORGANIC DETECTIONS
 ABOVE BACKGROUND CONCENTRATIONS FOUND
 WITHIN THE PLATING SHOP SOILS
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA

| Analyte | Vadose Zone Soils ⁽¹⁾ | | | Saturated Zone Soils ⁽¹⁾ | | |
|-----------|--------------------------------------|--|--|--------------------------------------|--|--|
| | Number of Detections ≥ Background | Number of Detections > 2 Times Background | Number of Detections > 5 Times Background | Number of Detections ≥ Background | Number of Detections > 2 Times Background | Number of Detections > 5 Times Background |
| Arsenic | 24 | 11 | 0 | 4 | 2 | 1 |
| Barium | 15 | 8 | 3 | 8 | 5 | 2 |
| Cadmium | 0 | 0 | 0 | 0 | 0 | 0 |
| Chromium | 24 | 4 | 1 | 7 | 1 | 0 |
| Cobalt | 3 | 1 | 0 | 0 | 0 | 0 |
| Manganese | 5 | 1 | 0 | 1 | 0 | 0 |
| Nickel | 13 | 2 | 0 | 5 | 2 | 0 |
| Selenium | 2 | 2 | 2 | 0 | 0 | 0 |
| Silver | 0 | 0 | 0 | 0 | 0 | 0* |
| Zinc | 25 | 6 | 0 | 5 | 2 | 0 |

(1) There are 42 vadose zone soil samples and 21 saturated zone soil samples.

In contrast, the open boreholes were sampled employing different procedures. The boreholes were not developed or purged before sampling, because it was thought this process would only make the water more turbid. Groundwater samples collected from the boreholes were described as turbid to very muddy during sampling. Samples collected for inorganic analyses were not filtered.

A comparison of the analytical results from samples collected out of monitoring wells and open boreholes reveals significant differences between the two data sets, particularly for the inorganics. Table 4-9 compares selected organic and inorganic analytes for data collected from the monitoring wells and open boreholes. Included on Table 4-9 are groundwater analytical results from four existing shallow monitoring wells located near the plating shop facility (USACOE 1988). The VOCs detected by all three data sets compare favorably. The variations in the concentrations of any particular compound, particularly benzene, probably reflect variations in the distribution of these compounds in the shallow groundwater. However, the inorganic concentrations do not compare so favorably. Data from the open borehole groundwater samples contain concentrations of metals many times the levels found in the samples collected from the monitoring wells. Because the groundwater samples collected from the open boreholes were not filtered before being added to the acidified sample bottles, it is probable that fine-grained sediments and suspended solids were dissolved by the acid, thereby causing elevated levels of inorganics in the groundwater samples. These data are not representative of the dissolved inorganic constituents in the groundwater and were not used in discussing the nature and extent of contamination or in the risk assessment.

4.4.2.1 Organic Compounds

Analytical groundwater results from this investigation for organic compounds are presented in Table 4-10. Copies of the laboratory analysis data sheets (Form 1s) as well as data summary tables listing all analytes and their qualifiers are included in Appendix B (Tables B-7 and B-8). Tentatively Identified Compounds (TICs) for organic compounds are reported in Appendix C (Table C-3) and data validation letters with their supporting QA/QC data are included in Appendix D. Samples collected from the monitoring wells and from open boreholes are presented on this table. Although 15 individual VOC and SVOC compounds were detected in the groundwater beneath the plating shop facility, compounds of the chlorinated aliphatic group [1,2-DCE (total), PCE, and TCE] are the most widely distributed and occur in the greatest concentrations at the site. Figure 4-6 illustrates the distribution of TCE within the perched aquifer. Analyses of groundwater samples collected from both the open boreholes and the monitoring wells are presented on this map. As shown on Figure 4-6, the distribution of TCE within the groundwater is complex. TCE concentrations greater than 1,000 µg/L are found in the groundwater from the northern and southeastern portions of the site, with lower

TABLE 4-9

GROUND WATER CHEMISTRY DATA COMPARISON
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA

| | United States Army Corps of Engineer (1988)(1) | | | | Halliburton NUS (1991) (Monitoring Wells) | | | Halliburton NUS (1991) (Open Borehole Samples) Range of 17 Samples |
|--------------------------------|--|------|------|-------|---|---------|---------|--|
| | I-18 | I-78 | 25B | I-58 | MW155 | MW156 | MW157 | |
| ORGANICS (µg/L) | | | | | | | | |
| Benzene | 15 | <5 | 580 | <5 | <5 | <5 | 21 | <5 |
| Tetrachloroethene | 41 | <5 | <5 | 10 | 150 | 5 | 32 | <5 - 440 |
| Trichloroethene | 1,200 | 130 | 380 | 1,600 | 310J | <5 | 17 | <5 - 1,400 |
| 1,2-Dichloroethene (total) (2) | 47 | <5 | 52 | 18 | 230 | 12 | 6 | <5 - 180 |
| INORGANICS (µg/L) | | | | | | | | |
| Barium | 28,000 | <500 | <500 | <500 | 191 | 130 | <200(3) | <20,000(c) - 111,000 |
| Chromium | 870 | <10 | <10 | <10 | <10(3) | <10(3) | 8,620 | <1,000(c) - 283,000J |
| Iron | NA | NA | NA | NA | <100(3) | <100(3) | 262 | <10,000(c) - 836,000J |
| Lead | 290 | 48 | <25 | 33 | <5(3) | <5(3) | 1.1 | <5,000(c) - 6,700 |
| Nickel | 600 | 35 | 23 | 60 | 10.3 | <40(3) | 90.2 | <4,000(c) - 2,800 |
| Zinc | 630 | 78 | 78 | 95 | 481 | <20(3) | 41.5 | <2,000(c) - 35,700 |

(1) United States Army Corps of Engineers wells are located near the plating shop facility.

(2) United States Army Corps of Engineers reports trans-1,2-dichloroethene.

(3) Contract Required Quantitation Limit.

NA Not analyzed.

TABLE 4-10

ORGANIC COMPOUNDS DETECTED IN GROUNDWATER(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA

| Sample Number Location Units | T-GW-MW155A MW-155 µg/L | T-GW-MW156A MW-156 µg/L | T-GW-MW157A MW-157 µg/L | T-GW-SB201A SB201 µg/L | T-GW-SB202A SB202 µg/L | T-GW-SB202X SB202 µg/L | T-GW-SB203A SB203 µg/L | T-GW-SB207A SB207 µg/L | T-GW-SB209A SB209 µg/L | T-GW-SB210A SB210 µg/L |
|------------------------------|-------------------------|-------------------------|-------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|------------------------|
| VOCs(b) | | | | | | | | | | |
| Acetone | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Hexanone | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 4-Methyl 2-pentanone | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 2-Butanone | -- | -- | 2 J | -- | -- | -- | -- | -- | -- | 7 J |
| Carbon Disulfide | -- | 5 | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,2-Dichloroethene (total) | 230 | 12 | 6 | 240 | 12 | 8 | 6 | 110(d) | 8 | -- |
| Trichloroethene | 310 J | -- | 17 | 340 | 40 | 32 | 7 | 1,400(d) | 20 | 8 |
| Tetrachloroethene | 150 | 5 | 32 | 96 | 84 | 98 | 42 | -- | 46 | -- |
| 1,1,1-Trichloroethane | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Xylenes (total) | -- | 3 J | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzene | -- | -- | 2 J | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | | |
| Anthracene | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Diethyl phthalate | 5 J | -- | 5 J | -- | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-7 and B-8) of this report.

(b) Samples collected March 6 - 22, 1990.

(c) Volatile Organic Compounds.

(d) Semi Volatile Organic Compounds.

(e) Results obtained from a 10 x dilution.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-10

ORGANIC COMPOUNDS DETECTED IN GROUNDWATER(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE TWO

| Sample Number Location Units | T-GW-SB211A SB211 µg/L | T-GW-SB212A SB212 µg/L | T-GW-SB213A SB213 µg/L | T-GW-SB213X SB213 µg/L | T-GW-SB214A SB214 µg/L | T-GW-SB215A SB215 µg/L | T-GW-SB215X SB215 µg/L | T-GW-SB217A SB217 µg/L | T-GW-SB218A SB218 µg/L | T-GW-SB221A SB221 µg/L |
|------------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
| VOCs(b) | | | | | | | | | | |
| Acetone | -- | -- | -- | -- | -- | -- | -- | 65 | -- | -- |
| 2-Hexanone | -- | -- | -- | -- | -- | -- | -- | 2 J | -- | -- |
| 4-Methyl 2-pentanone | -- | -- | -- | -- | -- | -- | -- | 2 J | -- | -- |
| 2-Butanone | -- | -- | -- | -- | -- | -- | 140 J | 19 | -- | -- |
| Carbon Disulfide | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 1,2-Dichloroethene (total) | -- | 100(d) | -- | -- | 410 | -- | 8J | -- | 21 | 11 |
| Trichloroethene | -- | 1,000(d) | 1,300(d) | 1,000(d) | 26 | 14 | 14 | 7 | 8 | 74 |
| Tetrachloroethene | -- | 110(d) | 120(d) | 110(d) | 32 | 65 | 71 | 43 | 180 | 79 |
| 1,1,1-Trichloroethane | -- | -- | -- | -- | -- | 8 | 12 | -- | -- | -- |
| Xylenes (total) | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Benzene | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| SVOCs(c) | | | | | | | | | | |
| Anthracene | -- | -- | -- | -- | 24 J | 41 J | -- | -- | -- | -- |
| Diethyl phthalate | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) Complete data summary tables are in Appendix B (Tables B-7 and B-8) of this report.

Samples collected March 6 - 22, 1990.

(b) Volatile Organic Compounds.

(c) Semi Volatile Organic Compounds.

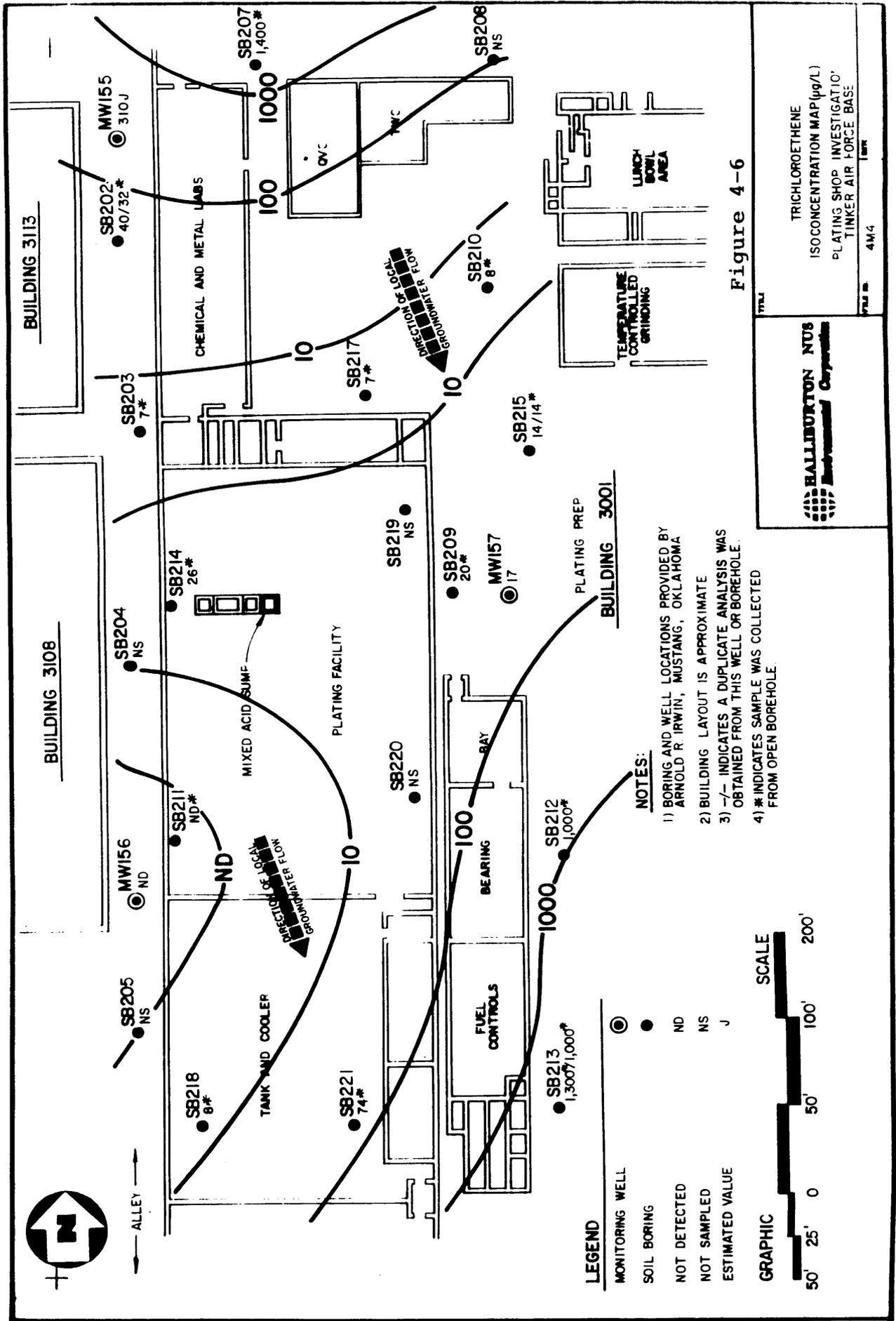
(d) Results obtained from a 10 x dilution.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.



levels occurring in the samples collected from the central areas. PCE concentrations have a maximum concentration of 180 µg/L and show less variation than TCE concentrations. However, the distribution of the two compounds is similar. Two SVOC compounds were detected in the groundwater, diethyl phthalate (maximum concentration 5J µg/L) and anthracene (maximum concentration 41J µg/L).

The source of these compounds in the groundwater is not easily determined from the hydraulic gradient and the distribution of the compounds at the site. A source of organic contaminants within the plating shop soils was not indicated from the analytical results. However, sources of contamination impacting the shallow aquifer are present to the northeast and southwest of the plating shop facility (USACOE 1988). The 1988 study shows a large plume of TCE situated in the perched aquifer beneath Building 3001 and extending under the plating shop facility, with the source existing northeast of the shop. Concentrations of TCE detected in the groundwater by this study compare well with the concentrations found in wells surrounding the plating shop and predicted by the isoconcentration map presented in the 1988 study. This source of chlorinated aliphatic compounds is the most likely source of the contamination detected in the shallow groundwater beneath the plating shop. Additional rounds of groundwater elevation data would be necessary to confirm whether contaminants from northeast of the plating shop migrated southwest, toward the plating shop facility.

4.4.2.2 Inorganic Compounds

Inorganic analytical groundwater results are presented in Table 4-11. Copies of the laboratory analysis data sheets (Form 1s) as well as the data summary table listing all analytes and their qualifiers is included in Appendix B (Table B-9). Data validation letters with their supporting QA/QC data are included in Appendix D. Average background groundwater quality data for the shallow aquifer have been determined by the USACOE (1988) by sampling upgradient perimeter wells at Tinker AFB. Average background groundwater quality analytical results are also presented on Table 4-10. Although data from both filtered monitoring well samples and unfiltered open borehole samples are presented on this table, only the analytical results from the three monitoring wells will be discussed in the text.

Of the three wells sampled, only groundwater from MW-155 and MW-157 contained detectable amounts of inorganics above background levels. The groundwater sample collected from MW-155 contained selenium and zinc at levels exceeding the background levels. In the groundwater sample collected from MW-157, chromium, lead, mercury, and selenium were elevated above background conditions. Of these inorganics, chromium was found in the highest concentrations, 8,620 µg/L, or

TABLE 4-11

INORGANICS DETECTED IN GROUNDWATER(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA

| Sample Number Depth (ft) Units | T-GW-MW155A MW-155 µg/L | T-GW-MW156A MW-156 µg/L | T-GW-MW157A MW-157 µg/L | T-GW-SB201A SB201 mg/kg | T-GW-SB202A SB202 mg/kg | T-GW-SB203A SB203 mg/kg | T-GW-SB207A SB207 mg/kg | T-GW-SB209A SB209 mg/kg | T-GW-SB210A SB210 mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Aluminum | 762 | -- | -- | -- | -- | 67.9 | 390 | 153 | -- |
| Antimony | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | 2.1 | 5.7 | 1.7 | -- | -- | -- | -- | 0.28 | -- |
| Barium | 191 | 130 | -- | -- | -- | -- | -- | 15.4 J | -- |
| Beryllium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Cadmium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 58,300 | 22,900 | -- | -- | -- | -- | -- | -- | -- |
| Chromium | -- | -- | 8,620 | -- | 2.5 J | -- | -- | 6.5 J | -- |
| Cobalt | -- | -- | 29.1 | -- | -- | -- | -- | -- | -- |
| Copper | 8.6 | -- | -- | -- | -- | 1.4 | -- | -- | -- |
| Iron | -- | -- | 262 | -- | -- | 78.5 | 489 | 155 | -- |
| Lead | -- | -- | 1.1 | -- | -- | -- | -- | -- | -- |
| Magnesium | 27,400 | 11,700 | -- | -- | -- | 139 | -- | -- | -- |
| Manganese | 70.8 | 75.6 | 919 | -- | -- | 5.2 J | 8.4 | 15.5 | -- |
| Mercury | -- | -- | 1.2 J | -- | -- | -- | -- | -- | -- |
| Nickel | 10.3 | -- | 90.2 | -- | -- | -- | -- | -- | -- |
| Potassium | 1,240 | 1,390 | -- | -- | -- | -- | 83.1 | 45.5 | -- |
| Selenium | 2.6 | -- | 3.7 | -- | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sodium | 98,100 | 188,000 | 130,000 | -- | -- | -- | -- | -- | -- |
| Thallium | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | 16.5 | 11.3 | -- | -- | 1.7 | -- | -- | -- | -- |
| Zinc | 481 | -- | 41.5 | -- | -- | -- | -- | -- | -- |
| Cyanide | -- | -- | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Table B-9) of this report.
 Samples collected March 6 - 22, 1990.

(b) From USACOE 1988

Data Qualifier Legend
 J - The associated numerical value is an estimated quantity.
 -- Analyte was not detected.
 NA - Not analyzed.

TABLE 4-11

INORGANICS DETECTED IN GROUNDWATER(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE TWO

| Sample Number Depth (ft) Units | T-GW-SB211A SB211 mg/kg | T-GW-SB212A SB212 mg/kg | T-GW-SB213A SB213 mg/kg | T-GW-SB213X SB213 mg/kg | T-GW-SB214A SB214 mg/kg | T-GW-SB215A SB215 mg/kg | T-GW-SB215X SB215 mg/kg |
|--------------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Aluminum | 239 J | 220 | 523 | 462 | 107 | 514 | 346 |
| Antimony | -- | -- | -- | -- | -- | -- | -- |
| Arsenic | -- | -- | -- | -- | -- | -- | -- |
| Barium | 85.5 J | 8.9 J | 27.1 J | 26.1 J | 127 J | 3.8 J | -- |
| Beryllium | -- | -- | -- | -- | -- | -- | -- |
| Cadmium | -- | -- | -- | -- | -- | -- | -- |
| Calcium | 761 | 571 | 232 | 235 | 153 J | 645 J | 584 J |
| Chromium | -- | 283 J | -- | -- | -- | -- | -- |
| Cobalt | 2.7 | -- | -- | -- | -- | -- | -- |
| Copper | 2.4 | -- | 1.5 | 2.8 | -- | -- | -- |
| Iron | 413 | 209 | 423 | 403 | 169 | 836 J | 472 J |
| Lead | 0.48 J | -- | 0.77 J | 0.22 J | -- | 0.34 | 0.28 |
| Magnesium | -- | -- | -- | -- | 177 | 578 | 379 |
| Manganese | 21.2 J | 15.1 J | 20.5 J | 22.3 J | 45.1 J | 38.8 J | 31.6 J |
| Mercury | -- | -- | -- | -- | -- | -- | -- |
| Nickel | -- | -- | -- | -- | -- | 2.0 | -- |
| Potassium | -- | -- | -- | -- | -- | -- | -- |
| Selenium | -- | -- | -- | -- | -- | -- | -- |
| Silver | -- | -- | -- | -- | -- | -- | -- |
| Sodium | -- | -- | -- | -- | -- | -- | -- |
| Thallium | -- | -- | -- | -- | -- | -- | -- |
| Vanadium | -- | -- | -- | -- | -- | -- | -- |
| Zinc | -- | 13.4 J | 11.6 J | 35.7 J | -- | -- | -- |
| Cyanide | -- | -- | -- | -- | -- | -- | -- |

(a) The complete data summary table is in Appendix B (Table B-9) of this report.

(b) Samples collected March 6 - 22, 1990.

(c) From USACOE 1988.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

TABLE 4-11

INORGANICS DETECTED IN GROUNDWATER(a)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 OKLAHOMA CITY, OKLAHOMA
 PAGE THREE

| Sample Number Depth (ft) Date Collected | T-GW-SB217A SB217 mg/kg | T-GW-SB218A SB218 mg/kg | T-GW-SB221A SB221 mg/kg | Background Conditions(b) |
|---|-------------------------------|-------------------------------|-------------------------------|-----------------------------|
| Aluminum | 442 | 464 J | 251 | NA |
| Antimony | -- | -- | -- | NA |
| Arsenic | 0.44 | -- | -- | 10 |
| Barium | 9.6 J | 111 | -- | 1,110 |
| Beryllium | -- | -- | -- | NA |
| Cadmium | -- | -- | -- | 10 |
| Calcium | 853 J | 600 | 428 | NA |
| Chromium | -- | -- | -- | 46 |
| Cobalt | 6.9 | -- | -- | NA |
| Copper | -- | -- | -- | NA |
| Iron | 750 J | 760 J | 398 | NA |
| Lead | 0.52 | 6.7 | 0.32 | 57 |
| Magnesium | 671 | -- | -- | NA |
| Manganese | 27.7 J | 73.1 | 24.2 J | NA |
| Mercury | -- | -- | -- | <0.4 |
| Nickel | -- | -- | 2.0 | 101 |
| Potassium | -- | -- | -- | NA |
| Selenium | 0.40 J | -- | -- | 2.1 |
| Silver | -- | -- | -- | 10 |
| Sodium | -- | -- | -- | NA |
| Thallium | -- | -- | -- | NA |
| Vanadium | 2.2 | -- | -- | NA |
| Zinc | -- | -- | -- | 110 |
| Cyanide | -- | -- | -- | <200 |

(a) The complete data summary table is in Appendix B (Table B-9) of this report.
 Samples collected March 6 - 22, 1990.

(b) From USACOE 1988.

Data Qualifier Legend

J - The associated numerical value is an estimated quantity.

-- Analyte was not detected.

NA - Not analyzed.

187 times the background concentration. Monitoring well MW-157 is located on the eastern portion of the plating shop facility. During the USACOE investigation of Building 3001, elevated levels of dissolved chromium were detected at concentrations up to 900,000 µg/L in the shallow groundwater. These high chromium concentrations were detected northeast of the plating shop facility, where high concentrations of organics were found in the groundwater. Migration of chromium in the groundwater from northeast of the plating shop has probably resulted in the high levels of this metal in the groundwater beneath the plating shop. However, existing data do not show this area to be hydraulically upgradient of the plating shop facility.

It is significant that no other inorganic compounds used extensively in the plating process (cadmium, nickel, and silver) were detected at elevated levels in the groundwater during the plating shop investigation. These data suggest that the mixed-acid sump and the plating shop facility are not sources of inorganic groundwater contamination.

4.5 ANALYTICAL DATA QUALITY ASSURANCE/QUALITY CONTROL SUMMARY

Precision, accuracy, representativeness, comparability, and completeness (PARCC's) are the principal indicators for overall data quality. Each of these parameters is defined and discussed below. Additional discussions of data quality are included in the Precision data package case narratives included in Appendix D.

Precision is a measure of the reproducibility of a set of measurements under a given set of conditions. The precision of laboratory data is measured through the analysis of duplicate samples or MS/MSD analyses. A majority of the MS/MSD VOC results from all data packages show good precision. Field duplicate samples from the mixed-acid sump were not analyzed for BNA and inorganic analytes. This measure of precision for these samples is unavailable from the data obtained during this investigation.

Accuracy

Accuracy is a measure of the agreement of a measurement with a known value and is measured as percent recovery of standards or matrix spikes. The accuracy of analytical instruments is measured by the analysis of initial and continuing calibration or calibration verification standards. Matrix spike recoveries were consistently low for antimony in soils collected from the mixed-acid sump. Several additional analytes were qualified because of low or high percent recoveries of standards or spikes or by being run out while instruments were of calibration.

Representativeness

Representativeness begins with a sampling plan which is designed to accurately portray site conditions. The sampling described in this report has been very successful in that respect. Sample handling is equally important, because collection methods, sample preservation, and holding times may introduce biases into the data. Blank contamination is minor to moderate throughout the data packages. Holding times were missed for a few VOC and SVOC compounds by a few hours to a few days in four of the data packages.

Comparability

Comparability is the degree of confidence with which one set of data can be compared with another. Although the soils from the mixed-acid sump were collected and analyzed approximately one month before the remainder of the plating shop soils any impact on comparability should be small. Groundwater analytical results (VOC's and SVOC's) compare favorably to surrounding shallow wells sampled and analyzed by the USACOE 1988. Inorganic analytical results obtained from the open borehole samples compare poorly with the samples obtained from monitoring wells installed during this investigation and from existing data (USACOE 1988).

Completeness

Completeness is a measure of the amount of valid data obtained relative to the amount expected. All data packages were complete and no data was lost. Analytical results for 2-butanone were rejected in six data packages due to initial and continuing calibration problems. With these exceptions the database is complete.

5.0 CONTAMINANT FATE AND TRANSPORT

Contaminant fate and transport for the plating shop investigation will focus on characterizing whether the soils surrounding the mixed-acid sump are a continuing source of groundwater contamination. Soils from the mixed-acid sump/plating shop are not a significant source of organic compounds. As discussed in Section 4.1, however, relatively high levels of inorganics are present, particularly in the soils surrounding the mixed-acid sump. Further discussions of fate and transport will qualitatively evaluate these soils as a potential source of inorganic groundwater contamination.

5.1 CHEMICAL AND PHYSICAL PROPERTIES OF INORGANIC SITE CONTAMINANTS

The environmental mobility of inorganic elements is a complex issue which cannot be dealt with as readily as the mobility of organic compounds. Site-specific information sufficient to characterize all of the factors affecting inorganic mobility can seldom be obtained short of research-oriented investigations. Some of the various factors affecting the mobility of inorganic species are as follows:

- Valence state and ion size
- Speciation
- Solubility products and precipitation reactions
- Adsorption and cation exchange
- Soil reaction (pH)
- Oxidation-reduction potential (Eh)
- Inorganic complexation
- Organo-metallic complexation
- Common ion effects
- Competing reactions

Two substantive pieces of information regarding the subject were obtained as a result of the sampling and analysis program conducted during this investigation: the analytical results for TCLP testing of drill cuttings and the CEC of selected subsurface soil samples. This information provides some indication of the potential leachability and mobility of inorganic constituents detected at the site.

5.1.1 Toxicity Characteristic Leaching Procedure (TCLP) Data

Grab samples were obtained from 19 drums containing soil boring cuttings and were subjected to TCLP extraction and analysis. The inorganic analytical results for these samples are summarized in the following table:

TCLP DATA FROM DRUMMED SOIL CUTTINGS(a)

| Analyte | Range of Concentrations from Plating Shop Drill Cuttings | T-SU-Sump W (Mixed-Acid Sump) Drill Cuttings | Regulatory Levels |
|----------|--|--|-------------------|
| Arsenic | <10 | 1.7 | 5,000 |
| Barium | 922J-4,180J | 69.2J | 100,000 |
| Cadmium | <5 | 1,200 | 1,000 |
| Chromium | <10-25.0J | 9.2J | 5,000 |
| Lead | <5-11.7 | <5 | 5,000 |
| Mercury | <0.2 | 10.1 | 200 |
| Selenium | <5 | <5 | 1,000 |
| Silver | <10 | 11.4 | 5,000 |
| Cyanide | <0.38 mg/kg | 13 mg/kg | -- |

(a) Results are reported in µg/L, except for cyanide. TCLP data are included in Appendix D.

As shown in this table, only cadmium was detected above the applicable regulatory level. Cadmium was detected in the extract from the mixed-acid sump cuttings at a concentration of 1.2 mg/L, whereas the regulatory limit is 1.0 mg/L (40 CFR 261). Cadmium concentrations in the other samples were below 5 µg/L. Other inorganics, including arsenic, barium, chromium, lead, mercury, silver, and cyanide, were detected in the TCLP extract at levels below regulatory limits. The TCLP regulatory levels are used to assess if a material is a hazardous waste and are designed to be conservative. As promulgated, the TCLP regulatory levels consider both toxicity and potential fate and transport through the use of a dilution/attenuation factor (USEPA 1990).

Because the observed TCLP concentrations do not exceed the regulatory levels at any boring location with the exception of the mixed-acid sump, one may infer that contamination at most locations in the vicinity of the plating shop does not pose a threat of unacceptable environmental releases.

5.1.2 Cation Exchange Capacity Data

The CEC results for the soil boring samples are presented in the following table:

CATION EXCHANGE CAPACITY (CEC) FOR MIXED-ACID SUMP/PLATING SHOP SOILS

| Sample Number | T-SU-SB111A | T-SU-SB205C | T-SU-SB206C | T-SU-SB206D | T-SU-SB208C | T-SU-SB209C | T-SU-SB12A | T-SU-BB001A |
|-----------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|-------------|
| CEC (meq/100 g) | 15.74 | 0.54 | 0.58 | 0.43 | 0.43 | 0.46 | 0.22 | 1.02 |

However, increasing CEC values correspond to greater abilities of a soil to adsorb metals. CEC values for these soils are very low. For comparative purposes, typical clay minerals such as kaolinite and montmorillinite have CEC values ranging from 3 to 150 meq/100 g. Soils rich in fulvic and humic acids typically exhibit CEC values in excess of 200 meq/100 g (Dragun 1988). These data indicate that site-specific natural soils have only a limited ability to hold metals as a result of inorganic adsorption processes. The low CEC of the soils surrounding the mixed-acid sump/plating shop suggest that metals might be leached from the soils and migrate to the groundwater.

5.2 **MIGRATION ROUTES**

This section identifies potential contaminant release mechanisms and migration routes acting on soils surrounding the mixed-acid sump. For soil contaminants to migrate into the groundwater, a source of infiltrating water must exist to transport these compounds to the water table.

A source of water that can interact with these soils is not readily available. Because the mixed-acid sump is inside Building 3001, the soils surrounding the sump are not directly exposed to infiltrating precipitation. A majority of the soils described from the borings drilled in the mixed-acid sump were moist to dry, except those collected from the vertical borings drilled into the sump's floor. In addition, no zones or seams of water or waste acids were detected while drilling these borings.

Potential sources of water that might impact the soils are leaking sewer or water lines under the building. A conclusion in the RI report for Building 3001 (USACOE 1988) suggested that leaking utility lines beneath the building created a groundwater high in the shallow aquifer under Building 3001. However, the localized groundwater flow direction determined during this study describes different flow conditions than were reported in the USACOE study. No other significant sources of water that could mobilize inorganics from the soils are known to exist beneath the building.

5.3 SOURCE CHARACTERIZATION

Only limited amounts of water are available to move through the vadose zone soils at the mixed-acid sump/plating shop. In addition, groundwater analyses did not reveal highly elevated levels of inorganics (see Section 4.3.2). These conditions suggest that the soils at the site have limited ability to contribute to inorganic groundwater contamination. However, results of the TCLP analytical data suggest that inorganics could be leached by interstitial waters moving through the soils. In addition, the soils in the area have a limited ability to adsorb or retard the migration of these inorganics through cation exchange.

6.0 RISK ASSESSMENT

This section provides an overview of the risk assessment methodologies employed for the plating shop at Tinker AFB. It is based on the validated data base summarized in Section 4.0. Complete laboratory analysis data and the supporting QA/QC documents are included in Appendices B, C, and D. Risk assessment calculations are presented in Appendix E. Although significant groundwater contamination was identified during this investigation, it will not be addressed by the risk assessment. Contaminated groundwater contained in the shallow aquifer under Building 3001 is already planned for CERCLA remediation and no domestic or other uses of this groundwater are possible prior to remediation. Therefore, the objectives of the risk assessment for Building 3001 are to define the actual or potential risks to human health or the environment from the presence of hazardous materials in the soil.

To assess public health risks, three major aspects of chemical contamination and environmental fate and transport must be considered: (1) contaminants with toxic characteristics must be found in environmental media and must be released by either natural processes or human action; (2) pathways by which actual or potential exposure occurs must be present; and (3) human or environmental receptors must be present to complete the exposure route. Risk is a function of both toxicity and exposure; without one of the factors listed above, there will be no risk.

A risk assessment contains four components: (1) Data Evaluation, (2) Toxicity Assessment, (3) Exposure Assessment, and (4) Risk Characterization. Each of these components is described below.

Data Evaluation (Section 6.1) is primarily concerned with the selection of chemicals of concern that are representative of the type and magnitude of potential human health and/or environmental effects. Contaminant concentrations are considered relative to background levels, contaminant release and environmental transport mechanisms, exposure routes, and toxicity to develop a list of contaminants used to define the site-associated risks. The list of chemicals of concern is location specific.

The Toxicity Assessment (Section 6.2) presents available human health and environmental criteria for all the indicator chemicals. Quantitative toxicity indices are presented where they are available, including any applicable regulatory standards and criteria. Enforceable standards such as Maximum Contaminant Levels (MCLs), regulatory guidelines such as Ambient Water Quality Criteria (AWQC) and Health Advisories, and dose-response parameters such as Reference Doses (RfDs) and Cancer Slope Factors (CSFs) are presented for each chemical of concern.

The Exposure Assessment (Section 6.3) identifies potential human or environmental exposures at the source area and/or off-site. Exposure routes are developed from information on contaminant release mechanisms, patterns of human activity, and other pertinent information. Section 6.3 presents the equations and relevant input parameters for calculating human intakes.

The Risk Characterization (Section 6.4) compares the predicted exposure concentrations to relevant regulatory standards or guidelines to define the risks associated with threshold (noncarcinogenic) effects of the chemicals of concern. Quantitative estimates of carcinogenic risk are also presented.

6.1 DATA EVALUATION

Both the rationale for selection and the lists of chemicals of concern are presented in this section.

The risk assessment for the site is performed using representative concentrations for each chemical of concern identified in the soils. The representative concentration was calculated using the latest risk assessment guidance from the EPA (USEPA 1989b). The calculation is a two-step process. First, the standard deviation of the sample set must be determined, as follows:

$$S = \left[\frac{\sum X_i^2 - \frac{(\sum X_i)^2}{n}}{n-1} \right]^{1/2}$$

where: S = standard deviation
 X_i = individual sample value
 n = number of samples

The upper bound 95 percent confidence interval; A.K.A. the upper confidence limit (UCL) is then calculated as follows (Gilbert 1987):

$$UCL = \bar{X} + t \left[\frac{S}{n^{1/2}} \right]$$

where: UCL = representative concentration
 \bar{X} = arithmetic average value for the sample set
 t = two-sided t distribution factor, based on degrees of freedom (n-1)
 S = standard deviation
 n = number of samples
 For the UCL, t = $t_{0.975}$

Data evaluation is a site-specific task and uses a variety of information to select a list of chemicals of concern. These chemicals are those that are found at the highest frequency or concentrations, those that are detected at concentrations greater than background, and those for which toxicological data are available. Total chromium values were used in the development of the representative concentrations for the chemicals of concern for this site. All risks are presented on the assumption that the chromium component of the metals detected in the analytical samples is chromium (VI) (USACOE 1988). The rationale for the inclusion or exclusion of a chemical for further consideration follows.

6.1.1 Soils - Mixed-Acid Sump

The mixed-acid sump is located inside the plating shop facility. Soil boring samples were collected from this area at depths of 1 to 1.5 feet, 2 to 2.5 feet, and 3.5 to 4 feet. Inorganic chemicals whose representative concentrations were greater than that of the same chemical identified in the Halliburton NUS background soil sample (T-SU-BB001) and the average base background samples (USACOE 1990) and for which toxicity information is available were retained as chemicals of concern. The following metals and cyanide were detected above base background levels in the soil samples analyzed for the mixed acid sump area.

- Cadmium
- Chromium
- Mercury
- Nickel
- Silver
- Cyanide

Although beryllium, cobalt, copper, manganese, and vanadium were detected in the soil samples from the mixed acid sump, these chemicals were present at concentrations less than those reported in the Halliburton NUS background sample. Arsenic, barium, lead, and zinc were also detected in the mixed acid sump, but were present at concentrations less than those reported in the average base background samples. Both the Halliburton NUS background data and the USACOE's average base background data are presented in Appendix E. Other metals such as calcium, iron, magnesium, potassium, sodium, and aluminum were also detected but were not retained as chemicals of concern because they exhibit low systemic toxicity and are not carcinogenic.

In addition, several volatile and semivolatile organic compounds were also detected in the soil samples from the mixed acid sump. The following organic compounds were retained as chemicals of concern:

- 2-Butanone
- PCE
- Di-n-octyl phthalate
- Di-n-butyl phthalate
- Butyl benzyl phthalate
- Diethyl phthalate
- Acenaphthene
- Anthracene
- Benzo (a) anthracene
- 1,2-DCE
- Benzo (b) fluoranthene
- Benzo (a) pyrene
- Chrysene
- Fluoranthene
- Indeno (1,2,3-cd) pyrene
- Phenanthrene
- Pyrene
- Pentachlorophenol

Chemicals that were detected in low concentrations (less than 1 µg/kg) were not retained as chemicals of concern. A complete list of the chemicals of concern for the mixed-acid sump and their representative concentrations are presented in Table 6-1. Only samples obtained from borings in the sump were used in the calculations.

6.1.2 Soils - Plating Shop

The plating shop comprises the remaining area surrounding the mixed-acid sump. Soil boring samples from this area were collected at depths of 5, 10, and 20 feet. Only soil samples collected from depths of 10 feet or less were considered in determining the chemicals of concern for the plating shop. Since it is assumed that any types of subsurface construction taking place at the plating shop would be no deeper than the existing foundation (1 story or 10 feet) of Building 3001. Several inorganic chemicals were detected in the soil samples from the plating shop. The following were retained as chemicals of concern:

- Arsenic
- Barium
- Cobalt
- Chromium
- Manganese
- Selenium
- Vanadium
- Zinc

TABLE 6-1
CHEMICALS OF CONCERN - MIXED-ACID SUMP⁽¹⁾
BUILDING 3001
TINKER AIR FORCE BASE

| Known or Potential Carcinogens | Representative Concentration ⁽²⁾ (µg/kg) | Noncarcinogens | Representative Concentration ⁽²⁾ (µg/kg) |
|--------------------------------|---|------------------------|---|
| Tetrachloroethene | 3.2 | 2-Butanone | 6.6 |
| Bis(2-ethylhexyl)phthalate* | 180 | 1,2-Dichloroethene | 2.6 |
| Benzo(a)anthracene | 64 | Di-n-butyl phthalate | 170 |
| Benzo(b)fluoranthene | 84 | Di-n-octyl phthalate | 6 |
| Benzo(a)pyrene | 50 | Butyl benzyl phthalate | 25 |
| Chrysene | 100 | Diethyl phthalate | 170 |
| Indeno(1,2,3-cd)pyrene | 37 | Acenaphthene | 27 |
| Pentachlorophenol* | 210 | Anthracene | 30 |
| Chromium (VI)* | 52,500 | Fluoranthene | 170 |
| Nickel* | 416,000 | Phenanthrene | 170 |
| | | Pyrene | 160 |
| | | Cadmium | 24,800 |
| | | Mercury | 140 |
| | | Silver | 2,700 |
| | | Cyanide | 790 |

* Chemical also exhibits noncarcinogenic health effects.

- (1) Includes all T-SU-SB100 sample designations. Results for duplicate samples were averaged and counted as one sample.
- (2) Calculated using 1/2 detection limit for nondetects. If UCL > maximum concentration, maximum was used.

Although lead and nickel were also detected in some of the soil samples from the plating shop, they were present in concentrations less than those in the average base background samples. Beryllium and copper were also detected in some of the soil samples but were present in concentrations less than those of the Halliburton NUS background sample. Calcium, manganese, sodium, iron, and potassium were also detected but were not retained as chemicals of concern because of their low systemic toxicity.

Several volatile and semivolatile organic chemicals were also detected in soil samples from the plating shop. The following organics were retained as chemicals of concern:

- Acetone
- 2-Butanone
- 1,1,1-TCA
- Bis(2-ethylhexyl)phthalate
- Di-n-octyl phthalate
- Di-n-butyl phthalate
- Diethyl phthalate
- TCE
- 1,2-DCE
- Methylene chloride
- Fluoranthene
- Benzoic acid

Organic chemicals that were detected infrequently or in low concentrations were not included as chemicals of concern. For example, chloromethene, vinyl acetate, and phenol were not selected as chemicals of concern for these reasons.

A complete list of chemicals of concern for the area of the plating shop is presented in Table 6-2. The table contains a list of the samples that were used in the risk assessment, as well as the calculated representative concentrations.

6.2 TOXICITY ASSESSMENT

The purpose of this section is to identify the potential health hazards associated with exposure to each of the chemicals of concern. A toxicological evaluation characterizes the inherent toxicity of a compound. The literature indicates that many of the chemicals detected at Building 3001 have carcinogenic and/or noncarcinogenic health effects in humans. In addition, many of the chemicals have adverse effects on environmental receptors. Although the chemicals of concern may cause adverse health effects, dose-response relationships and the potential for exposure must be evaluated before the risks to receptors can be determined. Dose-response relationships correlate the magnitude of the dose with the probability of toxic effects, as discussed below.

TABLE 6-2

CHEMICALS OF CONCERN - PLATING SHOP AREA(1)
 BUILDING 3001
 TINKER AIR FORCE BASE

| Known or Potential Carcinogens | Representative Concentration(2) (µg/kg) | Noncarcinogens | Representative Concentration(2) (µg/kg) |
|--------------------------------|--|-----------------------|--|
| Tetrachloroethene* | 5.8 | Acetone | 11 |
| Trichloroethene | 2.9 | 2-Butanone | 5.6 |
| Methylene chloride* | 4.5 | 1,2-Dichloroethene | 2.8 |
| Bis(2-ethylhexyl)phthalate* | 180 | 1,1,1-Trichloroethane | 2.9 |
| Arsenic* | 2,300 | Di-n-octyl phthalate | 4 |
| Chromium (VI)* | 26,600 | Di-n-butyl phthalate | 44 |
| | | Diethyl phthalate | 7 |
| | | Fluoranthene | 51 |
| | | Benzoic acid | 42 |
| | | Barium | 333,000 |
| | | Cobalt | 8,500 |
| | | Manganese | 465,000 |
| | | Selenium | 250 |
| | | Vanadium | 26,200 |
| | | Zinc | 32,700 |

* Chemical also exhibits noncarcinogenic health effects.

- (1) Includes all T-SU-SB200 sample designations from depths of 10 feet or less. Results for duplicate samples were averaged and counted as one sample.
- (2) Calculated using 1/2 detection limit for nondetects. If UCL > maximum concentration, maximum was used.

6.2.1 Health Effects

An important component of the risk assessment process is the relationship between the dose of a compound (the amount of a chemical that is absorbed by a receptor) and the potential for adverse health effects resulting from that dose. Dose-response relationships provide a means by which potential public health impacts may be quantified. The published information on doses and responses is used in conjunction with information on the nature and magnitude of human exposure to develop an estimate of potential health risks.

Standard Reference Doses and/or Cancer Slope Factors have been developed by the EPA for many chemicals. This section provides a brief description of these parameters.

Reference Dose (RfD) - The RfD is developed by the EPA for chronic and/or subchronic human exposure to hazardous chemicals and is based solely on the noncarcinogenic health effects imparted by a chemical. The RfD is usually expressed as a dose (mg) per unit body weight (kg) per unit time (day). It is generally derived by dividing a no-observed-(adverse)-effect level (NOEL or NOAEL) or a lowest-observed-adverse-effect level (LOAEL) by an appropriate uncertainty factor. NOELs, NOAELs, and LOAELs are determined from laboratory or epidemiological toxicity studies. The uncertainty factor is based on the availability of toxicity data.

Uncertainty factors are generally applied as multiples of 10 to represent specific areas of uncertainty in the available data. A factor of 10 is used to account for variations in the general population (to protect sensitive subpopulations), when extrapolating from animals to humans (to account for interspecies variability), when a NOAEL derived from a subchronic study (instead of a chronic study) is used to develop an RfD, and when a LOAEL is used to develop an RfD instead of a NOAEL. In addition, EPA reserves the use of a modifying factor of up to 10 for professional judgment of uncertainties in the data base not already accounted for. The default value of the modifying factor is 1. For example, the RfDs used for cobalt, selenium, and phenanthrene were calculated by dividing the LOAELs for these chemicals by 10,000 (all of the uncertainty factors combined and a modifying factor of 1.0). The LOAELs used for these chemicals were TD_{LO} values (the lowest dose of a substance introduced by any route other than inhalation reported to produce toxic effects in humans) reported in the Registry of Toxic Effects of Chemical Substances (RTECS, NIOSH, 1989). Calculations for the aforementioned chemical RfDs are presented in Appendix E.

Thus, the RfD incorporates the surety of the evidence for chronic human health effects. Even if applicable human data exist, the RfD (as diminished by the uncertainty factor) still maintains a margin of safety so that chronic human health effects are not underestimated. Thus, the RfD is an acceptable

guideline for evaluation of noncarcinogenic risk, although the associated uncertainties preclude its use for precise risk quantitation.

Cancer Slope Factor (CSF) - CSFs are applicable for estimating the lifetime probability (assuming a 70-year lifetime) of human receptors developing cancer as a result of exposure to known or suspected carcinogens. This factor is generally reported by the EPA in units of (mg/kg/day)⁻¹ and is derived through an assumed low-dosage linear relationship and an extrapolation from high to low dose-responses determined from animal studies. The value used in reporting the CSF is the upper 95 percent confidence limit.

Weight of Evidence - The weight-of-evidence designations indicate the likelihood that a chemical is a human carcinogen, based on both animal and human studies. The classification is as follows:

- A - Known human carcinogen.
- B1 - Limited human data are available. B2 indicates that there is sufficient evidence of carcinogenicity in animals but inadequate or no evidence in humans.
- C - Possible human carcinogen.
- D - Not classifiable as to human carcinogenicity.
- E - Evidence of noncarcinogenicity in humans.

6.2.2 Applicable or Relevant and Appropriate Requirements (ARARs)

This section presents available regulatory standards or guidelines for all of the chemicals of concern at the mixed-acid sump/plating shop. Currently, there are no enforceable Federal regulatory standards for exposures to soil contamination, therefore, other regulatory guidelines may be used for comparative purposes to infer health risks and environmental impacts. Relevant regulatory guidelines include the AWQC, Maximum Contaminant Level Goals (MCLGs), and Health Advisories.

Maximum Contaminant Levels (MCLs) - MCLs are enforceable standards promulgated under the Safe Drinking Water Act and are designed for the protection of human health. MCLs are based on laboratory or epidemiological studies and apply to drinking water supplies consumed by a minimum of 25 persons. They are designed for prevention of human health effects associated with lifetime exposure (70 years) of an average adult (weighing 70 kg) who consumes 2 liters of water per day, but they also reflect the technical feasibility of removing the contaminant from the water. These enforceable standards also reflect the fraction of toxicant expected to be absorbed by the gastrointestinal tract.

Maximum Contaminant Level Goals (MCLGs) - MCLGs are specified as zero for carcinogenic chemicals, based on the assumption of nonthreshold toxicity, and do not consider either the technical or economic feasibility of achieving these goals. MCLGs are nonenforceable guidelines based entirely on health effects. The MCLs are set as close to the MCLGs as is considered technically and economically feasible.

Ambient Water Quality Criteria (AWQC) - AWQCs are unenforceable Federal regulatory guidelines and are of primary utility in assessing the potential for toxic effects in aquatic organisms. They may also be used to identify the potential for human health risks. AWQCs consider the acute and chronic toxic effects in both freshwater and saltwater aquatic life, and the adverse human health effects from ingestion of both water (2 liters per day) and aquatic organisms (6.5 grams per day), and from ingestion of water alone. The AWQCs for protection of human health for carcinogenic substances are based on the EPA's specified incremental cancer risk range of one additional case of cancer in an exposed population of 10,000,000 to 100,000 persons (i.e., the 10^{-7} to 10^{-5} range) and are generally based on older toxicologic data.

Health Advisories - Health Advisories are guidelines developed by the EPA Office of Drinking Water for nonregulated contaminants in drinking water. These guidelines are designed to consider both acute and chronic toxic effects in children (assumed body weight of 10 kg) who consume 1 liter of water per day, or in adults (assumed body weight of 70 kg) who consume 2 liters of water per day. Health Advisories are generally available for acute (1 day), subchronic (10 days), and chronic (long-term or lifetime) exposure scenarios. These guidelines are designed to consider only threshold effects and, as such, are not used to set acceptable levels of known or probable human carcinogens.

Table 6-3 presents values of the available Federal ARARs for chemicals that are known or suspected human carcinogens and for chemicals having only noncarcinogenic effects. All available toxicity information is included in this table. However, if a parameter is not available, previously published values from other EPA sources are used. If the dose of a chemical exceeds these standards or guidelines, there is a good possibility that the receptor may experience adverse health effects. These exceedances will be discussed in Section 6.4.3. Estimated risks associated with each chemical are presented in tabular form following Section 6.4.2.

6.3 EXPOSURE ASSESSMENT

The purpose of this section is to evaluate the potential for human exposure to the hazardous chemicals in the environmental media at the mixed-acid sump/plating shop. This section characterizes the exposed populations, identifies actual or potential exposure routes, and illustrates

TABLE 6-3

REGULATORY REQUIREMENTS AND DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF CONCERN
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE

| Chemical | Safe Drinking Water Act ⁽¹⁾ | | Reference Dose ⁽²⁾ (mg/kg/day) | | Ambient Water Quality Criteria ⁽³⁾ (µg/L) | | Health Advisory ⁽¹⁾ (µg/L) | Cancer Slope Factor ⁽²⁾⁽⁴⁾ (mg/kg/day) ⁻¹ | | EPA Weight of Evidence ⁽¹⁾⁽²⁾ |
|----------------------------|--|-------------|--|----------------------|---|-----------|--|--|------------------------|--|
| | MCL (mg/L) | MCLG (mg/L) | Oral | Inhalation | Drinking Water Only | 10-6 Risk | | Oral | Inhalation | |
| Acenaphthene | | | 6 x 10 ⁻² | | 20 | | | | | D |
| Acetone | | | 1 x 10 ⁻¹ | | | | | | | |
| Anthracene | | | 3 x 10 ⁻¹ | | | | | | | D |
| Benzene | 0.005 | 0 | | | 0 | 0.67 | 1-Day/Child: 10-Day/Child: | 2.9 x 10 ⁻² | 2.9 x 10 ⁻² | A |
| Benzoic acid | | | 4 x 10 ⁰ | | | | | | | D |
| Benzo(a)anthracene | 0.0001(a) | 0(a) | | | 0(b) | 0.0031(b) | | 1.7 x 10 ⁰ | 8.8 x 10 ⁻¹ | B2 |
| Benzo(a)pyrene | 0.0002(a) | 0(a) | | | 0(b) | 0.0031(b) | | 1.15 x 10 ¹ | 6.1 x 10 ⁰ | B2 |
| Benzo(b)fluoranthene | 0.0002(a) | 0(a) | | | 0(b) | 0.0031(b) | | 1.6 x 10 ⁰ | 8.5 x 10 ⁻¹ | B2 |
| Bis(2-ethylhexyl)phthalate | 0.004(a) | 0(a) | 2 x 10 ⁻² | | 21,000 | | 1-Day/Child: 10-Day/Child: Longer-term/Child: Longer-term/Adult: Lifetime/Adult: | 1.4 x 10 ⁻² | | B2 |
| 2-Butanone | | | 5 x 10 ⁻² | 9 x 10 ⁻² | | | 80,000 8,000 3,000 9,000 200 | | | D |
| Butyl benzyl phthalate | 0.004 | 0.1(a) | 2 x 10 ⁻¹ | | | | | | | C |
| Carbon disulfide | | | 1 x 10 ⁻¹ | 3 x 10 ⁻³ | | | | | | D |
| Chrysene | 0.0002(a) | 0(a) | | | 0(b) | 0.0031(b) | | 5.1 x 10 ⁻² | 2.7 x 10 ⁻² | B2 |
| Di-n-butyl phthalate | | | 1 x 10 ⁻¹ | | 44,000 | | | | | D |

(1) USEPA 1991b.
 (2) USEPA 1991a.
 (3) USEPA 1986b.
 (4) ICF-Clement 1988.
 (5) NIOSH 1989.
 (a) Proposed.
 (b) Total PAHs.
 (c) National Interim Primary Drinking Water Regulation.
 (d) An RfD was developed from the current drinking water standard of 1.3 mg/L, assuming consumption of 2 L/day by a 70-kg adult.
 (e) Reference dose has been revoked.
 (f) Calculated from TD_{Lo}.

**TABLE 6-3
REGULATORY REQUIREMENTS AND DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF CONCERN
PLATING SHOP - BUILDING 3001
TINKER AIR FORCE BASE
PAGE TWO**

| Chemical | Safe Drinking Water Act(1) | | Reference Dose(2) | | Ambient Water Quality Criteria(3) | | Health Advisory(1) (µg/L) | Cancer Slope Factor(2)(4) | | EPA Weight of Evidence (1)(2) |
|------------------------|----------------------------|----------------|--------------------------|---------------------------|-----------------------------------|-----------|--|---------------------------|------------------------|--|
| | MCL (mg/L) | MCLG (mg/L) | Oral (mg/kg/day) | Inhalation (mg/kg/day) | Drinking Water Only (µg/L) | 10-6 Risk | | Oral (mg/kg/day)-1 | Inhalation | |
| 1,2-Dichloroethane | 0.005 | 0 | | | 0 | 0.94 | 1-Day/Child: 700 10-Day/Child: 700 Longer-term/Child: 700 Longer-term/Adult: 2,600 Lifetime/Adult: 5,000 | 9.1 x 10 ⁻² | 9.1 x 10 ⁻² | B2 |
| Diethyl phthalate | | | 8 x 10 ⁻¹ | | | | | | | D |
| Di-n-octyl phthalate | | | 2 x 10 ⁻² | | | | | | | D |
| Fluoranthene | | | 4 x 10 ⁻² | | 188 | | | | | D |
| Indeno(1,2,3-cd)pyrene | 0.0002(a) | 0(a) | | | 0(b) | 0.0031(b) | | 2.7 x 10 ⁰ | 1.4 x 10 ⁰ | B2 |
| Methylene chloride | 0.005(a) | 0(a) | 6 x 10 ⁻² | 9 x 10 ⁻¹ | | | 1-Day/Child: 10,000 10-Day/Child: 2,000 | 7.5 x 10 ⁻³ | 1.6 x 10 ⁻³ | B2 |
| 4-Methyl-2-pentanone | | | 5 x 10 ⁻² | 2 x 10 ⁻² | | | 1-Day/Child: 1,000 10-Day/Child: 300 Longer-term/Child: 300 Longer-term/Adult: 1,000 | 1.2 x 10 ⁻¹ | | B2 |
| Pentachlorophenol | | | 3 x 10 ⁻² | | 1,010 | | | | | |
| Phenanthrene | | | 7 x 10 ⁻³ (f) | | 0(b) | 0.0031(b) | | | | |
| Phenol | | | 6 x 10 ⁻¹ | | 3,500 | | 1-Day/Child: 6,000 10-Day/Child: 6,000 Longer-term/Child: 6,000 Longer-term/Adult: 20,000 Lifetime/Adult: 4,000 | | | D |
| Pyrene | | | 3 x 10 ⁻² | | | | | | | D |
| Tetrachloroethene | 0.005 | 0 | 1 x 10 ⁻² | | 0 | 0.88 | 1-Day/Child: 2,000 10-Day/Child: 2,000 Longer-term/Child: 1,000 Longer-term/Adult: 5,000 | 5.1 x 10 ⁻² | 1.8 x 10 ⁻³ | B2 |

(1) USEPA 1991b.
(2) USEPA 1991a.
(3) USEPA 1986b.
(4) ICF-Clement 1988.
(5) NIOSH 1989.
(a) Proposed.
(b) Total PAHs.
(c) National Interim Primary Drinking Water Regulation.
(d) An RfD was developed from the current drinking water standard of 1.3 mg/L, assuming consumption of 2 L/day by a 70-kg adult.
(e) Reference dose has been revoked.
(f) Calculated from TDLo.

TABLE 6-3
 REGULATORY REQUIREMENTS AND DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF CONCERN
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 PAGE THREE

| Chemical | Safe Drinking Water Act(1) | | Reference Dose(2) | | Ambient Water Quality Criteria(3) | | Health Advisory(1) (µg/L) | Cancer Slope Factor(2)(4) | | EPA Weight of Evidence (1)(2) |
|-------------------------|----------------------------|----------------|--------------------|--------------------|-----------------------------------|-----------|--|---------------------------|----------------------|--|
| | MCL (mg/L) | MCLG (mg/L) | Oral | Inhalation | Drinking Water Only | 10-6 Risk | | Oral | Inhalation | |
| 1, 1, 1-Trichloroethane | 0.2 | 0.2 | 9×10^{-2} | 3×10^{-1} | 19,000 | | 100,000 10-Day/Child: 40,000 Longer-term/Child: 40,000 Longer-term/Adult: 100,000 Lifetime/Adult: 200 | | | D |
| Trichloroethene | 0.005 | 0 | | | 0 | 2.8 | | 1.1×10^{-2} | 1.7×10^{-2} | B2 |
| Xylenes | 10 | 10 | 2×10^0 | 9×10^{-2} | | | 40,000 10-Day/Child: 40,000 Longer-term/Child: 40,000 Longer-term/Adult: 100,000 Lifetime/Adult: 10,000 | | | D |
| Arsenic | 0.050(c) | | 1×10^{-3} | | 0 | 0.025 | | | | A |
| Barium | 2(e) | 2(e) | 5×10^{-2} | 1×10^{-4} | | | 2,000 Lifetime/Adult: 40 10-Day/Child: 40 Longer-term/Child: 5 Longer-term/Adult: 20 Lifetime/Adult: 5 | | 5×10^1 | D |
| Cadmium | 0.005 | 0.005 | 5×10^{-4} | | 10 | | | | 6.1×10^0 | D |

(1) USEPA 1991b.
 (2) USEPA 1991a.
 (3) USEPA 1986b.
 (4) ICF-Clement 1988.
 (5) NIOSH 1989.
 (a) Proposed.
 (b) Total PAHs.
 (c) National Interim Primary Drinking Water Regulation.
 (d) An RfD was developed from the current drinking water standard of 1.3 mg/L, assuming consumption of 2 L/day by a 70-kg adult.
 (e) Reference dose has been revoked.
 (f) Calculated from TDLo.

TABLE 6-3
 REGULATORY REQUIREMENTS AND DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF CONCERN
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 PAGE FOUR

| Chemical | Safe Drinking Water Act(1) | | Reference Dose(2) | | Ambient Water Quality Criteria(3) | | Health Advisory(1) (µg/L) | Cancer Slope Factor(2)(4)-1 | | EPA Weight of Evidence (1)(2) |
|----------------|----------------------------|-------------|--------------------------|------------------------|-----------------------------------|------------------------------|--|-----------------------------|------------|-------------------------------|
| | MCL (mg/L) | MCLG (mg/L) | Oral (mg/kg/day) | Inhalation (mg/kg/day) | Drinking Water Only (µg/L) | 10 ⁻⁶ Risk (µg/L) | | Oral | Inhalation | |
| Chromium (III) | 0.100 | 0.100 | 1 x 10 ⁰ | 2 x 10 ⁻⁶ | 179,000 | | 1,000 1,000 200 800 100 1,000 1,000 200 800 100 | | | |
| Chromium (VI) | 0.100 | 0.100 | 5 x 10 ⁻³ | 2 x 10 ⁻⁶ | 50 | | 1,000 1,000 200 800 100 | 4.1 x 10 ¹ | | A |
| Cobalt | | | 8 x 10 ⁻³ (f) | | | | | | | D |
| Manganese | | | 1 x 10 ⁻¹ | 1 x 10 ⁻⁴ | | | | | | D |
| Mercury | 0.002 | 0.002 | 3 x 10 ⁻⁴ | 9 x 10 ⁻⁵ | 10 | | 2 2 | | | D |
| Nickel | 0.1(c) | 0.1(c) | 2 x 10 ⁻² | | 15.4 | | 1,000 1,000 100 600 100 | 8.4 x 10 ⁻¹ | | A |
| Selenium | 0.05 | 0.05 | 1 x 10 ⁻² (f) | | 10 | | | | | |
| Silver | 0.1 | | 3 x 10 ⁻³ | | | | 200 200 200 200 100 | | | D |

(1) USEPA 1991b.
 (2) USEPA 1991a.
 (3) USEPA 1986b.
 (4) ICF-Clement 1988.
 (5) NIOSH 1989.
 (a) Proposed.
 (b) Total PAHs.
 (c) National Interim Primary Drinking Water Regulation.
 (d) An RfD was developed from the current drinking water standard of 1.3 mg/L, assuming consumption of 2 L/day by a 70-kg adult.
 (e) Reference dose has been revoked.
 (f) Calculated from TDLo.

TABLE 6-3
 REGULATORY REQUIREMENTS AND DOSE-RESPONSE PARAMETERS FOR CHEMICALS OF CONCERN
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE
 PAGE FIVE

| Chemical | Safe Drinking Water Act ⁽¹⁾ | | Reference Dose ⁽²⁾ (mg/kg/day) | | Ambient Water Quality Criteria ⁽³⁾ (µg/L) | | Health Advisory ⁽¹⁾ (µg/L) | Cancer Slope Factor ⁽²⁾⁽⁴⁾ (mg/kg/day) ⁻¹ | | EPA Weight of Evidence (1)(2) |
|----------|--|----------------|--|------------|---|-----------------------|--|--|------------|--|
| | MCL (mg/L) | MCLG (mg/L) | Oral | Inhalation | Drinking Water Only | 10 ⁻⁶ Risk | | Oral | Inhalation | |
| Vanadium | | | 7 x 10 ⁻³ | | | | 1-Day/Child: 80 10-Day/Child: 80 Longer-term/Child: 30 Longer-term/Adult: 110 Lifetime/Adult: 20 | | | D |
| Zinc | | | 2 x 10 ⁻¹ | | 5,000 | | 1-Day/Child: 4,000 10-Day/Child: 4,000 Longer-term/Child: 2,000 Longer-term/Adult: 9,000 Lifetime/Adult: 2,000 | | | D |
| Cyanide | 0.2(a) | 0.2(a) | 2 x 10 ⁻² | | 200 | | 1-Day/Child: 200 10-Day/Child: 200 Longer-term/Child: 200 Longer-term/Adult: 800 Lifetime/Adult: 200 | | | D |

(1) USEPA 1991b.

(2) USEPA 1991a.

(3) USEPA 1986b.

(4) ICF-Clement 1988.

(5) NIOSH 1989.

(a) Proposed.

(b) Total PAHs.

(c) National Interim Primary Drinking Water Regulation.

(d) An RfD was developed from the current drinking water standard of 1.3 mg/L, assuming consumption of 2 L/day by a 70-kg adult.

(e) Reference dose has been revoked.

(f) Calculated from TDLo.

how the magnitude of exposure is estimated. The nature and extent of contamination upon which the exposures are based is presented individually for each site.

To determine whether there is an actual exposure or a potential exposure in the future at each site, one must consider the most likely pathways of contaminant release and transport, as well as the human and environmental activity patterns in the area. A complete exposure pathway has three components: (1) a source of chemicals that can be released to the environment; (2) a route of contaminant transport through an environmental medium; and (3) an exposure or contact point for a human or an environmental receptor. These components are addressed in the following subsections.

There are no plans to develop the area of Building 3001 for residential use in the immediate future. Consequently, an exposure scenario that addresses future residential land use will not be addressed in the risk assessment. If such a decision is made in the future, risks should be estimated based on data collected at that time.

6.3.1 Exposure Routes

Soil is the one environmental medium through which identified receptors can be either directly or indirectly exposed to site-related contaminants. This section identifies the receptors at Building 3001 most at risk through this exposure pathway.

Direct contact with contaminated soil can result in a dermal exposure. For example, base personnel can get contaminated soil on their skin while involved in excavation. Organic chemicals in soil are dermally absorbed to some extent, but metals are not generally considered to be absorbed. In addition, incidental ingestion of soil can occur after hand-to-mouth contact by receptors. This exposure route is applicable to adult base personnel only. Receptors are those personnel involved in construction activities (exposure to subsurface soil contaminants) at depths of up to approximately 10 feet. It is assumed that soils deeper than 10 feet will not be exposed during construction activities.

6.3.2 Exposure Estimates

The estimation methods and models used in this section are consistent with current EPA risk assessment guidance (USEPA 1989b, 1991) as well as with informal HAZWRAP guidance. Exposure estimates associated with each exposure route are presented below. All exposure scenarios incorporate the representative contaminant concentrations in the estimates of intakes. Therefore, only one exposure scenario is developed for each exposure route and receptor combination.

Noncarcinogenic risks are estimated using the concept of an average annual exposure. The intake incorporates terms describing the exposure time and/or frequency that represent the number of hours per day and the number of days per year that exposure occurs. This is used with a term known as the averaging time, which annualizes the exposure frequency by dividing by 365 days per year.

Carcinogenic risks, on the other hand, are calculated as an incremental lifetime risk, and therefore incorporate terms to represent the exposure duration (years) over the course of a lifetime (70 years). This factor will subsequently be referred to as a time-weighting factor. These terms are presented in the equations used to calculate potential cancer risks but are not used in the calculation of noncarcinogenic risks.

Physical contact with contaminated soils by base personnel during construction may result in the dermal absorption of chemicals. It was assumed that no one other than adult base personnel will be in these areas. Exposures through this route are estimated as follows (USEPA 1989b):

$$DEX = C \times SA \times AF \times ABS \times EF \times ED / (BW \times LT \times AT \times 10^6)$$

where: DEX = dermally absorbed dose (mg/kg/day)

C = contaminant concentration in soil (mg/kg)

SA = exposed surface area of skin (cm²/day)

AF = soil adherence per unit skin area (mg/cm²)

ABS = absorption factor (decimal fraction)

EF = exposure frequency (days/year)

ED = exposure duration (years)

BW = body weight (kg)

LT = lifetime (years)

AT = averaging time or exposure period (days/year)

10⁶ = conversion factor (mg/kg)

The exposure concentration for the soil contact scenario is the representative concentration calculated as shown in Section 6.1. Subsurface soil (e.g., less than 8 to 10 feet deep) sample results are used in determining the representative concentrations for soil contact.

The approximate exposed skin area of a person wearing a short-sleeved, open-necked shirt, pants, shoes, and no gloves or hat was set at 2,948 cm² (Schaum 1984). The soil adherence factor was set at 1.45 mg/cm² (USEPA 1989b). Absorption factors were set as follows: VOCs, 0.10; BNAs, 0.05; and inorganics, 0.0. These factors account for the resistance to mass transfer from the soil to the skin

surface as well as to transport through the skin. These estimates are considered to be reasonable because studies have shown that less than 10 percent of most chemical substances are percutaneously absorbed even after topical administration (Feldman and Maibach 1970).

Base personnel engaged in construction activities are assumed to be exposed 12 days per year for 20 years. Twenty years is considered to be the working lifetime of either a civilian employee or a career military person. The receptor body weight is set at 70 kg for adults. An averaging time of 365 days/year and a lifetime of 70 years was used.

Exposure to soil can also result in a minor amount of incidental ingestion after hand-to-mouth contact. Surface and shallow subsurface soil sample results are used as input to this scenario. Intakes through this route are estimated as follows (USEPA December 1989b):

$$IEX = C \times IR \times F_i \times EF \times ED / (BW \times LT \times AT \times 10^6)$$

where: IEX = ingestional exposure dose (mg/kg/day)
C = exposure concentration in soil (mg/kg)
IR = soil ingestion rate (mg/day)
F_i = fraction ingested from contaminated source (decimal fraction)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
LT = lifetime (years)
AT = averaging time or period of exposure (days/year)
10⁶ = conversion factor (mg/kg)

The average daily rate of soil ingestion for a short-term construction scenario for adults was set at 480 mg/day, and 10 percent of this amount was assumed to be from the contaminated source (USEPA 1989b). Base personnel engaged in construction activities are assumed to be exposed for 12 days at any given site during their working lifetime (20 years) (i.e., exposure frequency, 12 days/year; exposure duration, 1 year). The receptor body weight is set at 70 kg for adults. An averaging time of 365 days/year and a lifetime of 70 years will be used.

A summary of the soil exposure assessment input parameters for dermal contact and incidental ingestion is presented in Table 6-4 for the construction scenario.

TABLE 6-4

EXPOSURE ASSESSMENT SUMMARY - DIRECT CONTACT WITH SOIL
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE

| Dermal Contact with Subsurface Soil (Employees - Construction) | | | |
|--|-----------------------------------|---|--|
| Input Parameter | Description | Value | Rationale |
| C | Exposure Concentration | UCL ⁽¹⁾ (mg/kg) | HAZWRAP guidance; EPA guidance (USEPA 1989b) |
| AV | Exposed Surface Area of Skin | 2,948 cm ² /day | Adult wearing short-sleeved, open-necked shirt; pants, shoes (Schaum 1984) |
| AF | Soil-to-Skin Adherence Factor | 1.45 mg/cm ² | Value for commercial potting soil (USEPA 1989b) |
| ABS | Absorption Factor (dimensionless) | Volatiles - 0.10 BNAs - 0.05 Metals - 0.0 | Accounts for desorption from soil and percutaneous absorption (Feldman and Maibach 1970) |
| EF | Exposure Frequency | 12 days/year | Professional judgment |
| ED ⁽²⁾ | Exposure Duration | 1 years | One time exposure; professional judgment |
| BW | Body Weight | 70 kg | Adult receptors; convention (USEPA 1989b) |
| LT ⁽²⁾ | Lifetime | 70 years | Convention (USEPA 1989a) |
| AT | Averaging Time | 365 days/year | Average annual exposure |

(1) Upper 95 percent confidence limit (UCL) of arithmetic average, or maximum concentration if UCL exceeds maximum.

(2) ED and LT used only for calculation of lifetime carcinogenic risk.

**TABLE 6-4
EXPOSURE ASSESSMENT SUMMARY - DIRECT CONTACT WITH SOIL
PLATING SHOP - BUILDING 3001
TINKER AIR FORCE BASE
PAGE TWO**

| Incidental Ingestion of Subsurface Soil (Employees - Construction) | | | |
|--|--|----------------------------|---|
| Input Parameter | Description | Value | Rationale |
| C | Exposure Concentration | UCL ⁽¹⁾ (mg/kg) | HAZWRAP guidance; EPA guidance (USEPA 1989b) |
| IR | Ingestion Rate | 480 mg/day | Suggested value; brief exposures only; EPA guidance (USEPA 1989b, 1991) |
| FI | Fraction Ingested from Contaminated Source | 0.10 | Professional judgment |
| EF | Exposure Frequency | 12 days/year | Professional judgment |
| ED ⁽²⁾ | Exposure Duration | 1 years | One time exposure professional judgment |
| BW | Body Weight | 70 kg | Adult receptors; convention (USEPA 1989b) |
| LT ⁽²⁾ | Lifetime | 70 years | Convention (USEPA 1989a) |
| AT | Averaging Time | 365 days/year | Average annual exposure |

- (1) Upper 95 percent confidence limit (UCL) of arithmetic average, or maximum concentration if UCL exceeds maximum.
- (2) ED and LT used only for calculation of lifetime carcinogenic risk.

6.4 RISK CHARACTERIZATION

Potential human health risks resulting from the exposures outlined in the preceding sections are characterized on a quantitative basis in this section. Quantitative risk estimates are generated based on risk assessment methods outlined in EPA guidance (USEPA 1989b, 1991). Noncarcinogenic risk estimates are presented in the form of Hazard Quotients and Hazard Indices that are determined through comparison of estimated doses with published Reference Doses. Incremental cancer risk estimates are provided in the form of dimensionless probabilities based on published Cancer Slope Factors. Estimated human intakes were developed for each of the specific exposure routes discussed previously. Both carcinogenic and noncarcinogenic risks are summarized for each exposure route on a series of tables in each site-specific section of this report. Detailed calculations are provided in Appendix E.

Noncarcinogenic risk is assessed using the concept of Hazard Quotients and Hazard Indices. The Hazard Quotient is the ratio of the estimated dose and the Reference Dose for a selected chemical of concern, as follows:

$$\text{Hazard Quotient} = \text{Dose}/\text{RfD}$$

A Hazard Index is generated by summing the individual Hazard Quotients for the chemicals of concern. If the value of the Hazard Index exceeds unity (1.0), there is a potential noncarcinogenic health risk associated with exposure to that particular chemical mixture (USEPA 1986a). The Hazard Index is not a mathematical prediction of the severity of toxic effects; it is simply a numerical indicator of the possibility of the occurrence of noncarcinogenic (threshold) effects. If the ratio of the dose and the Reference Dose for a selected chemical exceeds unity, it is likely that noncarcinogenic effects would occur as a result of the exposure.

Incremental cancer risk estimates are generated for each of the exposure pathways using the estimated doses and published Cancer Slope Factors, as follows:

$$\text{Risk} = \text{Dose} \times \text{CSF}$$

If the above equation results in a risk greater than 0.1, the following equation is used:

$$\text{Risk} = 1 - [\exp(\text{Dose} \times \text{CSF})]$$

The risk determined using these equations is a unitless expression of an individual's likelihood of developing cancer as a result of exposure to carcinogenic chemicals. An incremental cancer risk of 1×10^{-6} indicates that the exposed receptor has a one in 1 million chance of developing cancer after a lifetime of exposure to the chemical(s) of concern. Alternatively, such a risk may be interpreted as representing one additional case of cancer in an exposed population of 1 million people. The calculated cancer risks should be recognized as upper-limit estimates. Cancer Slope Factors are the upper 95 percent confidence limit of a dose-response curve generally derived from animal studies. Actual human risk, while not identifiable, is not expected to exceed the upper limit based on Cancer Slope Factors and, in fact, may be lower.

The EPA generally considers risks in the range of 10^{-4} to 10^{-6} to be acceptable at Superfund and Resource Conservation and Recovery Act (RCRA) sites. The upper bound (10^{-4}) is more commonly applied when less-than-lifetime exposures are considered.

Carcinogenic and noncarcinogenic health risks are estimated using a number of different assumptions; therefore, the values presented in the following sections contain an inherent amount of uncertainty. The extent to which health risks can be characterized is primarily dependent upon the accuracy with which the toxicity of a chemical can be estimated and the accuracy of the exposure scenario estimates. The toxicological data that form the basis for all risk assessments contain uncertainty in the following areas:

- The extrapolation of nonthreshold (carcinogenic) effects from the high doses administered to laboratory animals to the low doses received under more common exposure scenarios.
- The extrapolation of the results of laboratory animal studies to human or environmental receptors.
- The interspecies variation in toxicological endpoints used in characterizing potential health effects resulting from exposure to a chemical.
- The variations in sensitivity among individuals of any particular species.

In addition to these sources of uncertainty, the exposure estimates presented in Section 6.3 are also based on a number of simplifying assumptions. The assumptions made include the following:

- Receptor characteristics, such as age, body weight, and exposure duration are based on published values, with some attempt at making them more site-specific.

- Land use and activity patterns in the study area are primarily industrial, and direct access is restricted to adult base personnel.
- There are no antagonistic/synergistic effects between chemicals.

The chemical analytical data base also has some limitations in such areas as sample locations, sample representativeness, and accuracy of the analytical results. However, every effort was made to collect samples that reflected actual site conditions.

6.4.1 Mixed-Acid Sump

A summary of the chemical-specific Hazard Quotients for direct dermal contact and incidental ingestion of subsurface soil by personnel engaged in construction activities in the mixed-acid sump area is provided in Table 6-5. The Hazard Indices for dermal contact and incidental ingestion by construction personnel are 5.4×10^{-6} and 1.9×10^{-3} , respectively. Both of these values are less than unity, thereby indicating that no adverse noncarcinogenic health effects are expected from exposure to site subsurface soil during construction in the mixed-acid sump.

The incremental cancer risks for the direct contact scenarios for construction personnel are provided in Table 6-6. The incremental cancer risks calculated for the dermal contact and incidental ingestion exposure scenarios are 4.1×10^{-10} and 9.2×10^{-11} , respectively. Both of these values are well below the EPA risk range goal. Therefore, no adverse carcinogenic health effects are expected under the defined scenario from exposure to subsurface soil in the plating shop during construction activities.

6.4.2 Subsurface Soil Exposure (Construction) - Plating Shop

Table 6-7 presents a summary of the chemical-specific Hazard Quotients for both dermal contact and incidental ingestion of subsurface soil during construction activities in the plating shop area. The total Hazard Indices for both the direct dermal contact (1.3×10^{-6}) and incidental ingestion (5.4×10^{-4}) exposure scenarios are less than 1.0. Therefore, no adverse noncarcinogenic health effects are expected under the defined scenario.

A summary of the incremental cancer risks for the direct contact exposure routes during construction activities in the plating shop is presented in Table 6-8. The incremental cancer risks for both the dermal contact (4.6×10^{-12}) and the incidental ingestion (9.5×10^{-10}) exposure scenarios are well below 10^{-6} . This indicates that no adverse carcinogenic health effects are likely to occur from exposure to subsurface soil in the area of the plating shop during construction activities under the defined scenario.

TABLE 6-5

HAZARD QUOTIENTS - DIRECT CONTACT WITH
 SUBSURFACE SOIL (MIXED-ACID SUMP)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE

| Chemical | Hazard Quotient ⁽¹⁾ Adult Employee | |
|----------------------------|--|------------------------------|
| | Dermal Contact | Incidental Ingestion |
| 2-Butanone | 2.6 x 10 ⁻⁸ | 3.0 x 10 ⁻⁹ |
| Tetrachloroethene | 6.4 x 10 ⁻⁸ | 7.2 x 10 ⁻⁹ |
| 1,2-Dichloroethene | 2.6 x 10 ⁻⁸ | 2.9 x 10 ⁻⁹ |
| Bis(2-ethylhexyl)phthalate | 9.0 x 10 ⁻⁷ | 2.0 x 10 ⁻⁷ |
| Di-n-octyl phthalate | 3.0 x 10 ⁻⁸ | 6.8 x 10 ⁻⁹ |
| Di-n-butyl phthalate | 1.7 x 10 ⁻⁷ | 3.8 x 10 ⁻⁸ |
| Butyl benzyl phthalate | 1.3 x 10 ⁻⁸ | 2.8 x 10 ⁻⁹ |
| Diethyl phthalate | 2.1 x 10 ⁻⁸ | 4.8 x 10 ⁻⁹ |
| Acenaphthene | 4.5 x 10 ⁻⁸ | 1.0 x 10 ⁻⁸ |
| Anthracene | 1.0 x 10 ⁻⁸ | 2.2 x 10 ⁻⁹ |
| Benzo(a)anthracene | (2) | (2) |
| Benzo(b)fluoranthene | (2) | (2) |
| Benzo(a)pyrene | (2) | (2) |
| Chrysene | (2) | (2) |
| Fluoranthene | 4.3 x 10 ⁻⁷ | 9.6 x 10 ⁻⁸ |
| Indeno(1,2,3-cd)pyrene | (2) | (2) |
| Phenanthrene | 2.4 x 10 ⁻⁶ | 5.5 x 10 ⁻⁷ |
| Pyrene | 5.3 x 10 ⁻⁷ | 1.2 x 10 ⁻⁷ |
| Pentachlorophenol | 7.0 x 10 ⁻⁷ | 1.6 x 10 ⁻⁷ |
| Cadmium | NA | 1.1 x 10 ⁻³ |
| Chromium (VI) | NA | 2.4 x 10 ⁻⁴ |
| Mercury | NA | 1.0 x 10 ⁻⁵ |
| Nickel | NA | 4.7 x 10 ⁻⁴ |
| Silver | NA | 2.0 x 10 ⁻⁵ |
| Cyanide | NA | 8.9 x 10 ⁻⁷ |
| Total Hazard Index | 5.4 x 10⁻⁶ | 1.9 x 10⁻³ |

(1) Calculations provided in Appendix E.

(2) No Reference Dose available for this chemical and/or exposure route.

NA Not applicable; inorganics are assumed not to be dermally absorbed.

TABLE 6-6

**INCREMENTAL CANCER RISKS - DIRECT CONTACT WITH
SUBSURFACE SOIL (MIXED-ACID SUMP)
PLATING SHOP - BUILDING 3001
TINKER AIR FORCE BASE**

| Chemical | Incremental Cancer Risk ⁽¹⁾ Adult Employee | |
|----------------------------|--|-------------------------------|
| | Dermal Contact | Incidental Ingestion |
| 2-Butanone | (2) | (2) |
| Tetrachloroethene | 4.7 x 10 ⁻¹³ | 5.3 x 10 ⁻¹³ |
| 1,2-Dichloroethene | (2) | (2) |
| Bis(2-ethylhexyl)phthalate | 3.6 x 10 ⁻¹² | 8.1 x 10 ⁻¹³ |
| Di-n-octyl phthalate | (2) | (2) |
| Di-n-butyl phthalate | (2) | (2) |
| Butyl benzyl phthalate | (2) | (2) |
| Diethyl phthalate | (2) | (2) |
| Acenaphthene | (2) | (2) |
| Anthracene | (2) | (2) |
| Benzo(a)anthracene | 4.3 x 10 ⁻¹¹ | 9.6 x 10 ⁻¹² |
| Benzo(b)fluoranthene | 5.4 x 10 ⁻¹¹ | 1.2 x 10 ⁻¹¹ |
| Benzo(a)pyrene | 2.3 x 10 ⁻¹⁰ | 5.2 x 10 ⁻¹¹ |
| Chrysene | 2.0 x 10 ⁻¹² | 4.6 x 10 ⁻¹³ |
| Fluoranthene | (2) | (2) |
| Indeno(1,2,3-cd)pyrene | 4.0 x 10 ⁻¹¹ | 8.9 x 10 ⁻¹² |
| Phenanthrene | (2) | (2) |
| Pyrene | | (2) |
| Pentachlorophenol | 3.6 x 10 ⁻¹¹ | 8.1 x 10 ⁻¹² |
| Chromium (VI) | NA | (2) |
| Nickel | NA | (2) |
| Mercury | NA | (2) |
| Silver | NA | (2) |
| Zinc | NA | (2) |
| Cyanide | NA | (2) |
| Total Cancer Risk | 4.1 x 10⁻¹⁰ | 9.2 x 10⁻¹¹ |

(1) Calculations provided in Appendix E.

(2) No Cancer Slope Factor available for this chemical and/or exposure route.
NA Not applicable; inorganics are assumed not to be dermally absorbed.

TABLE 6-7

**HAZARD QUOTIENTS - DIRECT CONTACT WITH
SUBSURFACE SOIL (PLATING SHOP AREA)
PLATING SHOP - BUILDING 3001
TINKER AIR FORCE BASE**

| Chemical | Hazard Quotient ⁽¹⁾ Adult Employee | |
|----------------------------|--|--|
| | Dermal Contact | Incidental Ingestion |
| Acetone | 2.2×10^{-8} | 2.5×10^{-9} |
| 2-Butanone | 2.2×10^{-8} | 2.5×10^{-9} |
| 1,1,1-Trichloroethane | 6.5×10^{-9} | 7.3×10^{-10} |
| Tetrachloroethene | 1.2×10^{-7} | 1.3×10^{-8} |
| Trichloroethene | (2) | (2) |
| 1,2-Dichloroethene | 2.8×10^{-8} | 3.1×10^{-9} |
| Methylene chloride | 1.5×10^{-8} | 1.7×10^{-9} |
| Bis(2-ethylhexyl)phthalate | 9.0×10^{-7} | 2.0×10^{-7} |
| Di-n-octyl phthalate | 2.0×10^{-8} | 4.5×10^{-9} |
| Di-n-butyl phthalate | 4.4×10^{-8} | 9.9×10^{-9} |
| Diethyl phthalate | 8.8×10^{-10} | 2.0×10^{-10} |
| Fluoranthene | 1.3×10^{-7} | 2.9×10^{-8} |
| Benzoic acid | (2) | 2.4×10^{-10} |
| Arsenic | NA | 5.2×10^{-5} |
| Barium | NA | 1.5×10^{-4} |
| Chromium (VI) | NA | 1.2×10^{-4} |
| Cobalt | NA | 2.4×10^{-5} |
| Manganese | NA | 1.0×10^{-4} |
| Selenium | NA | 5.6×10^{-6} |
| Vanadium | NA | 8.4×10^{-5} |
| Zinc | NA | 3.7×10^{-6} |
| Total Hazard Index | 1.3×10^{-6} | 5.4×10^{-4} |

(1) Calculations provided in Appendix E.

(2) No Reference Dose available for this chemical and/or exposure route.

NA Not applicable; inorganics are assumed not to be dermally absorbed.

TABLE 6-8

INCREMENTAL CANCER RISKS - DIRECT CONTACT WITH
 SUBSURFACE SOIL (PLATING SHOP AREA)
 PLATING SHOP - BUILDING 3001
 TINKER AIR FORCE BASE

| Chemical | Incremental Cancer Risk ⁽¹⁾ Adult Employee | |
|----------------------------|--|-------------------------------|
| | Dermal Contact | Incidental Ingestion |
| Acetone | (2) | (2) |
| 2-Butanone | (2) | (2) |
| 1,1,1-Trichloroethane | (2) | (2) |
| Tetrachloroethene | 8.5 x 10 ⁻¹³ | 9.5 x 10 ⁻¹⁴ |
| Trichloroethene | 9.1 x 10 ⁻¹⁴ | 1.0 x 10 ⁻¹⁵ |
| 1,2-Dichloroethene | (2) | (2) |
| Methylene chloride | 9.7 x 10 ⁻¹⁴ | 1.1 x 10 ⁻¹⁴ |
| Bis(2-ethylhexyl)phthalate | 3.6 x 10 ⁻¹² | 8.1 x 10 ⁻¹³ |
| Di-n-octyl phthalate | (2) | (2) |
| Di-n-butyl phthalate | (2) | (2) |
| Diethyl phthalate | (2) | (2) |
| Fluoranthene | (2) | (2) |
| Benzoic acid | (2) | (2) |
| Arsenic | NA | (2) |
| Barium | NA | (2) |
| Cadmium | NA | (2) |
| Chromium (VI) | NA | (2) |
| Cobalt | NA | 9.3 x 10 ⁻¹⁰ |
| Manganese | NA | (2) |
| Selenium | NA | 1.9 x 10 ⁻¹¹ |
| Vanadium | NA | (2) |
| Zinc | NA | (2) |
| Total Cancer Risk | 4.6 x 10⁻¹² | 9.5 x 10⁻¹⁰ |

(1) Calculations provided in Appendix E.

(2) No Reference Dose available for this chemical and/or exposure route.

NA Not applicable; inorganics are assumed not to be dermally absorbed.

6.4.3 Summary

This section contains a summary of both the total Hazard Indices and the total incremental cancer risks for the subsurface soil construction scenario for the mixed-acid sump and plating shop areas for Building 3001.

All Hazard Indices for subsurface soil exposures to adult base personnel involved in subsurface construction activities in and around the area of Building 3001 are less than 1.0, as shown in Table 6-9. Therefore, no adverse noncarcinogenic health effects are expected under the defined scenarios.

The total incremental cancer risks for exposure to subsurface soil during construction under the defined scenarios are presented in Table 6-10. The total risk to adult personnel via direct contact with soils (both mixed-acid sump and plating shop areas) is 1.5×10^{-9} . This indicates that no adverse carcinogenic health effects are likely by exposure to subsurface soil in the area of Building 3001, under the defined scenario.

TABLE 6-9
TOTAL HAZARD INDICES
BUILDING 3001
TINKER AIR FORCE BASE

| Exposure Route | Hazard Index |
|---|--|
| | Adult Employee |
| Incidental ingestion of soil contaminants (mixed acid sump) | 1.9×10^{-3} |
| Dermal absorption of soil contaminants (mixed acid sump) | 5.4×10^{-6} |
| Incidental ingestion of soil contaminants (plating shop) | 5.4×10^{-4} |
| Dermal absorption of soil contaminants (plating shop) | 1.3×10^{-6} |
| Total Hazard Index (Soil) | 2.4×10^{-3} |

NA Not applicable; exposure route not evaluated.

TABLE 6-10

**TOTAL INCREMENTAL CANCER RISKS
BUILDING 3001
TINKER AIR FORCE BASE**

| Exposure Route | Cancer Risk |
|---|------------------------------|
| | Adult Employee |
| Incidental ingestion of soil contaminants (mixed-acid sump) | 9.2 x 10 ⁻¹¹ |
| Dermal absorption of soil contaminants (mixed-acid sump) | 4.1 x 10 ⁻¹⁰ |
| Incidental ingestion of soil contaminants (plating shop) | 9.5 x 10 ⁻¹⁰ |
| Dermal absorption of soil contaminants (plating shop) | 4.6 x 10 ⁻¹² |
| Total Cancer Risk (Soil) | 1.5 x 10⁻⁹ |

NA Not applicable; exposure route not evaluated

7.0 FINDINGS AND RECOMMENDATIONS

7.1 FINDINGS

7.1.1 Soils

- VOC and SVOC compounds were detected infrequently and in relatively low concentrations from soil samples collected surrounding the mixed-acid sump.
- Elevated levels of cadmium, cyanide, calcium, chromium, mercury, nickel, silver, and sodium were detected in the soils collected from the mixed-acid sump. Cadmium, mercury and nickel were present at concentrations exceeding background levels in from 30 to 50 percent of the samples analyzed. The most likely source of these inorganics is spent plating shop acids stored in the sump that have been released into the environment.
- Although evidence exists suggesting that fluids have migrated out of the sump, no cracks or cavities within the sump's concrete surface were found that would allow migration of fluids out of the sump. The most likely route for fluids to take when leaving the sump is through the floor joints or wall seams.
- Organic compounds were detected infrequently and at relatively low levels in soil samples obtained to investigate subsurface contamination at the plating shop (excluding the sump).
- When compared to background levels, inorganic analytical results from these same soils reveal relatively low levels of toxic inorganics (maximum 5.7 times background levels).
- The results of the risk assessment performed on the mixed-acid sump and plating shop soils revealed acceptable carcinogenic and noncarcinogenic risks for workers periodically exposed to these soils during construction activities at the facility.

7.1.2 Groundwater

- Groundwater elevation data collected during this investigation reveal that the localized direction of groundwater flow beneath the plating shop varies significantly from the regional flow documented by previous investigations.

- Groundwater samples collected from monitoring wells and borings within the plating shop show relatively high levels of chlorinated aliphatic compounds (TCE, PCE, and 1,2-DCE) and chromium within the shallow groundwater. These chemicals have a complex distribution within the groundwater and probably originate from an area northeast of the plating shop facility.

7.1.3 Source Characterization

- Soils from the mixed-acid sump and plating shop facility are not a source of the organic contamination detected in the groundwater.
- Soils from the mixed-acid sump are a potential source of inorganic groundwater contamination. TCLP tests on drummed cuttings detected arsenic, barium, cadmium, chromium, lead, mercury, silver, and cyanide in the extract. Only cadmium was detected in the sump cuttings at levels above regulatory limits.
- Evidence from the groundwater samples collected during this investigation suggests that inorganics are not migrating from the soils into the groundwater. However, the monitoring well spacing and the complexity of the hydrogeologic regime may have resulted in some inorganics that have migrated from the sump area not being detected.

7.2 RECOMMENDATIONS

- It is recommended that groundwater elevation data be collected on a quarterly basis to detect seasonal fluctuations in the shallow water table.

In addition, a combination of measures should be employed to eliminate leakage of plating shop acids from the sump and/or detect leakage when or if it occurs. Corrective measures that should be used to minimize the potential for leaks include:

- Redesign of the plating operation to eliminate the use of the in-ground sumps. Aboveground tanks with secondary containment could be installed to store the spent plating wastes.

- If the existing mixed-acid sump is to continue to store spent plating wastes it should be made more leak resistant by applying a new waterproof coating to the concrete. Two liners should be installed in the sump with a leak detection system installed between the two linings and between the concrete and the liners.
- In combination with the above process controls, the existing network of shallow monitoring wells should be employed to detect, in a timely manner, the presence of any inorganics leaching from the soils around the sump.

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