

**Final Report  
Phase II RCRA Facility Investigation  
Appendix I Sites**

**Executive Summary**

**Prepared for:**

**Department of the Air Force  
Oklahoma City Air Logistics Center  
Tinker Air Force Base, Oklahoma**

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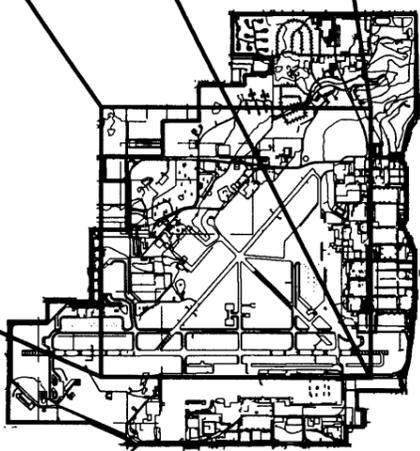
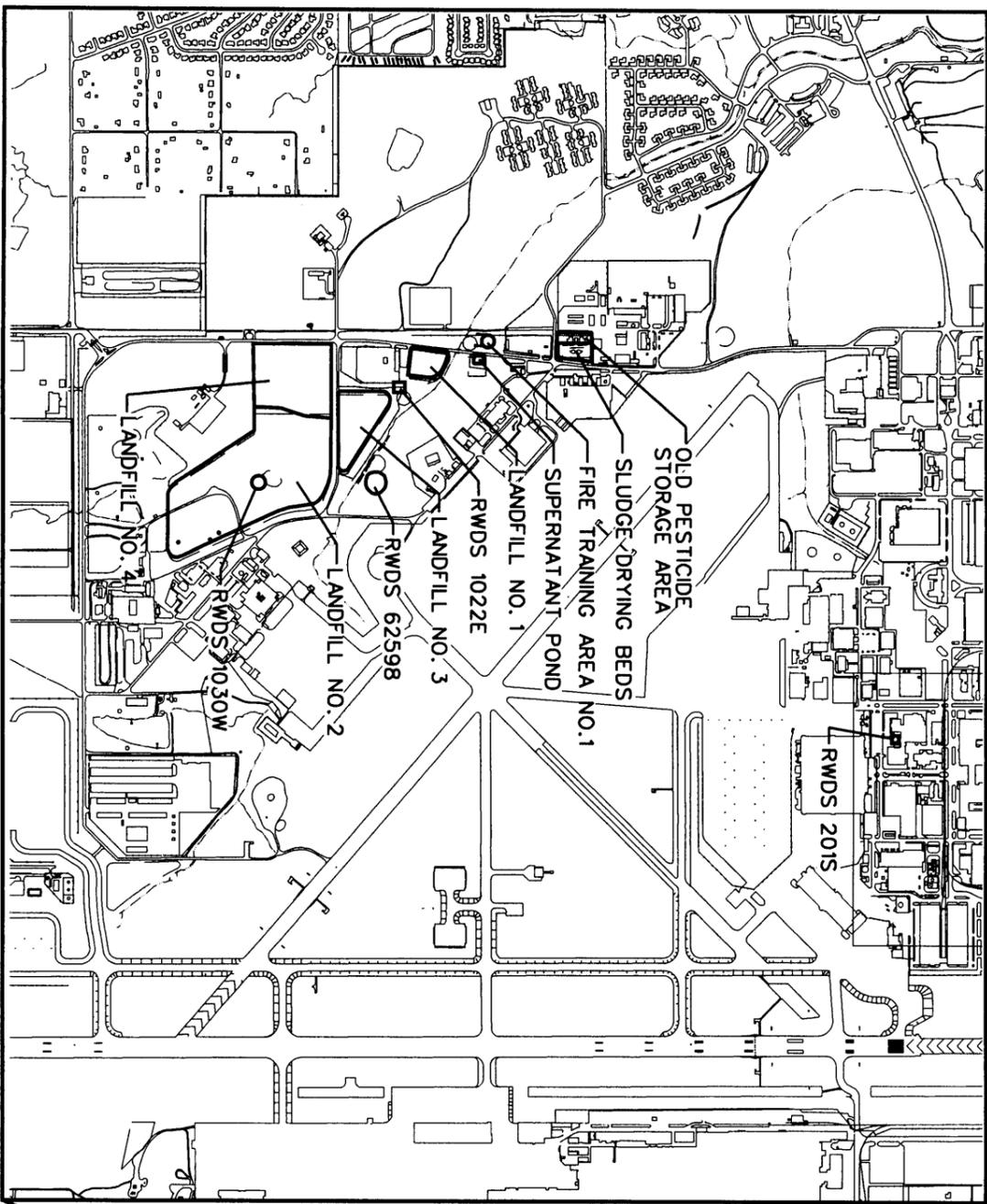
## ***Introduction***

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This summary report provides a brief overview of the results of the investigations that have been conducted at eleven solid waste management units (SWMU) and one area of concern (AOC) at Tinker Air Force Base (AFB), Oklahoma (Figure 1). The investigations were performed as part of the Phase I and II Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for Appendix I Sites, mostly located in the southwest of Tinker AFB (Figure 1). For most sites, the Phase I RFI mainly involved compiling a comprehensive report that summarized the various investigations that had occurred at the subject sites prior the RFI program. The Phase II RFI involved a review of the Phase I recommendations, collection of additional data to fill in identified data gaps, and reporting the findings. Thus the main objective for the Phase II RFI was to collect additional data and complete the site characterization at these sites.

This document presents the executive summaries of the Phase I and II RFI findings along with the results from previous investigations at twelve sites. A more detailed presentation about each site can be found in a separate Phase II RFI report for the site. All reports for the twelve sites only deal with the evaluation of the soil analytical data and do not include the results of groundwater investigations. Evaluation of groundwater contamination at Tinker AFB is addressed under the Basewide groundwater investigation program and reported in a separate report. The twelve sites presented in this summary report include:

- Old Pesticide Storage Area - AOC
- Sludge Drying Beds - (SWMU- 14)
- Fire Training Area 1 - (SWMU-7)
- Supernatant Pond - (SWMU-11)
- Landfill 1 - (SWMU-3)
- Landfill 2 - (SWMU-4)
- Landfill 3 - (SWMU-5)
- Landfill 4 - (SWMU-6)
- Radioactive Waste Disposal Site (RWDS) 201S - (SWMU-20)
- RWDS 1022E - (SWMU-22)
- RWDS 1030W - (SWMU-19)
- RWDS 62598 - (SWMU-21).



TINKER AIR FORCE BASE  
INDEX MAP

FIGURE 1  
SITE LOCATION MAP

TINKER AIR FORCE BASE  
OKLAHOMA CITY, OKLAHOMA



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## ***Executive Summary***

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This report presents the results of investigations conducted at the area of concern (AOC) called the Old Pesticide Storage Area (OPSA) at Tinker Air Force Base (AFB), Oklahoma, in order to meet regulatory requirements as described below. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, that a facility undertake corrective action for any release of hazardous waste or constituents from any solid waste management unit (SWMU) or AOC at a treatment, storage, or disposal facility. On January 12, 1989, Tinker AFB submitted an application for renewal of its RCRA Part B permit to operate its RCRA Hazardous Waste Storage facility. The final RCRA permit issued on July 1, 1991 requires that Tinker AFB investigate all SWMUs and AOCs and perform corrective action at those sites identified as posing a threat to human health or the environment. The permit specifies that a RCRA facility investigation (RFI) be conducted for 43 identified SWMUs and two AOCs on the Base. This document was prepared to report whether sufficient investigations were conducted at the OPSA to provide full characterization of the site and whether the site meets permit requirements.

This document integrates the findings of previous investigations conducted at the adjacent Sludge Drying Bed (SDB) site and those of the investigation conducted at the OPSA as part of the Phase II RFI program. The results of the investigations reported herein form the basis for determining whether additional investigation is warranted at the OPSA site, and if so, what corrective action should be implemented. This report focuses on the evaluation of analytical data for surface and subsurface soils at the OPSA site. It does not cover the results of groundwater investigations at the subject site. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater (BWGW) investigation program as a part of the Phase II RFI. All groundwater sampling results from this site are addressed in the BWGW report (IT Corporation [IT], 1997)<sup>1</sup>.

**Background.** Tinker AFB is located in central Oklahoma in the southeastern portion of the Oklahoma City metropolitan area in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

the south. The Base encompasses approximately 5,000 acres. The OPSA is located in the southwest quadrant of Tinker AFB at Building 1005 adjacent to the SDB site.

**Source Description.** The OPSA (at Building 1005) is located on the west side of the Base west of Patrol Road. Building 1005 was constructed as part of a sanitary waste treatment plant that was operational from the early 1950s until 1971. The building was reportedly used to store and mix pesticides; however, the exact dates of these operations are not known.

**Site Investigations.** No previous investigations have been conducted specifically at the OPSA site. During the Phase I RFI conducted at the adjacent SDB site, three soil borings were drilled around the OPSA site to the top of the first water encountered. The analytical results from soil samples indicated that no significant impacts to the environment were present at the OPSA (IT, 1994)<sup>2</sup>. The OPSA was recently added to the Installation Restoration Program. Previous investigations were conducted at the adjacent SDB site, and this investigation contributes to those activities during this Phase II RFI.

**Findings.** Under the Phase II RFI, site evaluation was performed by installing three additional borings around the perimeter of the OPSA site for the collection of ten surface and subsurface soil samples (Figure ES-1). The soil analytical data were compared to generic soil-screening levels (SSL) developed by the EPA (1996)<sup>3</sup> and with site-specific background data to define areas of potential contamination. The SSLs are presented separately for major pathways of concern in both surface and subsurface soils. The background values were determined to be the 95 percent upper tolerance limit (UTL) established in the BWBG soils report (IT, 1999)<sup>4</sup>. The soils data were divided into surface and subsurface analytical results and were compared to appropriate screening values. Constituents with concentration levels that exceeded the screening values indicate the potential presence of contamination.

**Surface Soil.** Eight metals were detected in the surface soils at the OPSA site: aluminum, barium, beryllium, chromium, iron, mercury, nickel, and zinc. These metals were detected at

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<sup>2</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume VI, Tinker Air Force Base, Oklahoma*, September 1994.

<sup>3</sup>U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

<sup>4</sup>IT Corporation (IT), 1999, *Final Report, Base-Wide Background Screening Levels, Inorganics*, May 1999.

varying concentration levels in the surface soil samples. Beryllium was detected at a concentration level that exceeded its SSL; however, its UTL background concentration level was not exceeded. This indicates that the beryllium does not appear to be indicative of soil contamination. None of the other metals were detected at concentration levels exceeding either their respective 95 percent background UTLs or their risk-based SSLs. No organic constituents (volatile organic compounds [VOC], semivolatile organic compounds [SVOC], polychlorinated biphenyls, pesticides, or herbicides) were detected in any of the surface soil samples.

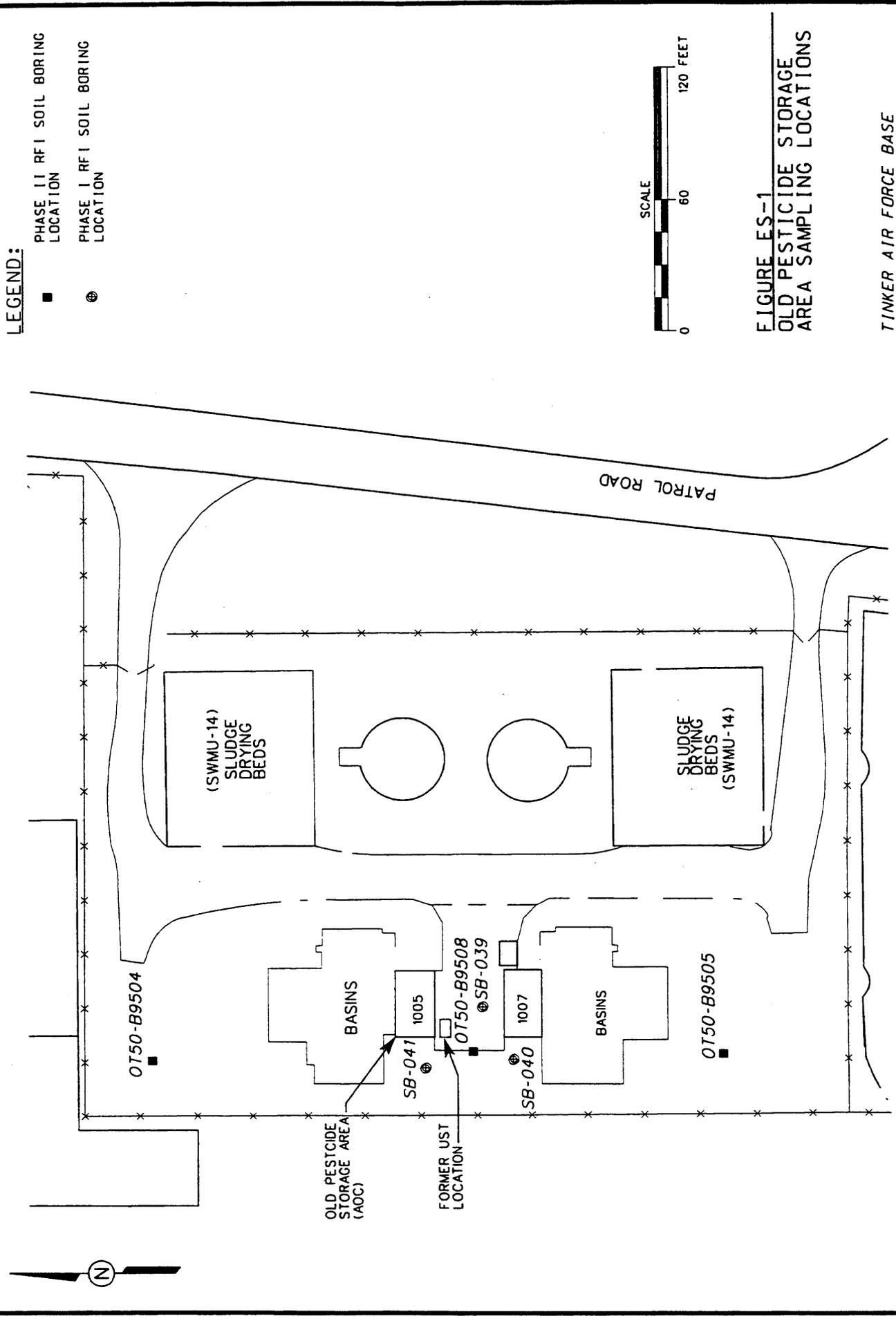
**Subsurface Soil.** The subsurface soil analytical data from soil borings drilled at the site indicate that two herbicides and nine metals were detected in the subsurface soils. SSLs have not been developed for herbicides. The detected metals included aluminum, barium, beryllium, chromium, iron, lead, mercury, nickel, and zinc. Of the metals detected in soil samples collected from soil borings at the OPSA site, none exceeded their SSLs or background UTLs. In addition, subsurface soils were collected from an underground storage tank excavation following removal of the tank. The tank had been buried south of Building 1005. Although VOCs, SVOCs, pesticides, and metals were detected in the soil samples collected from the excavation, neither the organic constituents nor the metals were detected at concentration levels exceeding their respective SSLs or background UTLs.

**Conclusions.** The soils at the OPSA site do not appear to be contaminated with either organic or inorganic constituents, including pesticides. This is consistent with the information provided by the Base personnel involved with the OPSA during its operation. Base personnel did not observe any pesticide releases during their involvement with the OPSA activities. In addition, when the pesticide building and its surrounding area were inspected, there was no evidence or appearance of pesticide spills.

**Recommendations.** In view of these findings, it is recommended that no further characterization be performed at the OPSA site.

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TINKER AIR FORCE BASE  
 OKLAHOMA CITY, OKLAHOMA

## ***Executive Summary***

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This report presents the results of investigations conducted at Solid Waste Management Unit (SWMU) 14, the Sludge Drying Beds (SDB), Tinker Air Force Base (AFB) in order to meet regulatory requirements as described below. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, that a facility undertake corrective action for any release of hazardous waste or constituents from any SWMU at a treatment, storage, and disposal facility. On January 12, 1989, Tinker AFB submitted an application for renewal of its RCRA Part B permit to operate its RCRA Hazardous Waste Storage facility. The final RCRA permit issued on July 1, 1991 requires that Tinker AFB investigate all SWMUs and areas of concern (AOC) and perform corrective action at those sites identified as posing a threat to human health or the environment. The permit specifies that a RCRA facility investigation (RFI) be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document was prepared to determine whether sufficient investigations were conducted at the SDB to provide full characterization of the site and whether the site meets permit requirements.

This document integrates the findings of previous investigations and those conducted as part of the Phase II RFI program. The results of these investigations form the basis for determining whether additional investigation is warranted at this site, and if so, what corrective action should be implemented. This report focuses on the evaluation of analytical data for surface and sub-surface soils at the subject site. It does not cover the results of groundwater investigations at the SDB site. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater (BWGW) investigation program as a part of the Phase II RFI. All groundwater sampling results from this site are addressed in the BWGW report (IT Corporation [IT], 1997)<sup>1</sup>.

**Background.** Tinker AFB is located in central Oklahoma, in the southeast portion of the Oklahoma City metropolitan area in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. The SDB is located in the

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

southwest quadrant of Tinker AFB, next to Building 1005, the Old Pesticide Storage Area (OPSA).

**Source Description.** The SDB site consists of eight sludge drying beds that were used to passively dewater wastewater treatment sludge from the municipal wastewater treatment facility, which is no longer in use. The sludge drying beds are arranged on the opposing ends of two digesters, with four beds on the north side and four to the south. Each bed includes approximately 1,875 square feet and is 75 feet long, 25 feet wide, and 3 feet deep. The area between the two sets of drying beds is occupied by two concrete vessels used as sludge digesters.

**Site Investigations.** An investigation of the soils beneath the SDB site was initially conducted by the U.S. Army Corps of Engineers (USACE, 1989)<sup>2</sup> - Tulsa District to determine whether any residual contamination remained from the previous storage operations. This investigation was conducted as part of the U.S. Air Force Installation Restoration Program. Eleven soil borings were drilled and a total of sixteen samples collected for chemical analysis. The analytical results indicated that the underlying soils did not pose a threat to the environment.

From October through December 1993, IT (1994)<sup>3</sup> conducted an investigation at the SDB site under the Phase I RFI to determine the existence and degree of soil contamination, if any, directly below the SDB. During the investigation, ten soil borings were drilled in the deepest section of the sludge beds (the northern end of the sludge beds on the south and the southern end of the sludge beds on the north) and in the middle and southern end of the earth-lined sludge bed. A total of thirty-nine soil samples were collected from the ten soil borings that had been drilled during the Phase I RFI. In addition, a soil gas survey was performed at the SDB, which consisted of twenty-six vapor gas survey points configured in a rough circle around the boundary of the site.

Analytical data from the investigation were compared to background data obtained from one boring/monitoring well located upgradient of the site. Results of the investigation indicated the presence of soil and groundwater contamination. Volatile organic compounds (VOC) were

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<sup>2</sup>U.S. Army Corps of Engineers (USACE), 1989, *Sludge Drying Beds, I.R.P. Response Action, Final Report, Tinker AFB, Oklahoma*, January, 1989.

<sup>3</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume II, Tinker Air Force Base, Oklahoma*, September 1994.

detected at concentration levels exceeding the reporting limits in soils from well boring 2-67A and from four of ten soil borings drilled through the floors of the SDB. Lead background concentration levels were exceeded in one sample (collected at the 10-foot in depth from one of the deep soil boring/monitoring wells). All other metals were below background levels. Based upon the results, additional data were collected under a Phase II RFI in order to complete site characterization. The Phase II RFI conducted during 1995 is described below.

**Findings.** Under the Phase II RFI conducted by IT, site evaluation was performed by installing eight additional borings around the perimeter of the SDB site and the adjacent OPSA site for the collection of surface and subsurface soil samples. Three of the borings were drilled at the OPSA site, and the remainder were drilled at the SDB site. For this Phase II RFI report, IT focused on the soil sampling results from the five borings drilled at the SDB site (Figure ES-1). A separate Phase II RFI report was prepared that addresses the soil sampling results from the three borings drilled at the OPSA site.

A total of 19 soil samples were collected from the 5 soil borings drilled at the SDB site and were analyzed for VOCs, semivolatile organic compounds (SVOC), metals, pesticides, polychlorinated biphenyls (PCB), and herbicides. The soil analytical data were compared to generic soil-screening levels (SSL) developed by EPA (1996)<sup>4</sup> and with site-specific background data to define areas of potential contamination. The SSLs are presented separately for major pathways of concern in both surface and subsurface soils. The background values were determined to be the 95 percent upper tolerance limit (UTL) established in the BWBG report (IT, 1999)<sup>5</sup>. The soils data were divided into surface and subsurface analytical results and were compared to appropriate screening levels. Constituents with concentration levels that exceeded their SSLs, UTLs, or both indicate potential presence of contamination.

**Surface Soil.** Nine metals and three pesticides were detected in the surface soils at the SDB site. No VOCs, SVOCs, PCBs, or herbicides were detected in any of the surface soil samples. The nine detected metals included aluminum, barium, beryllium, chromium, iron, lead, mercury, nickel, and zinc. Although beryllium was detected in two surface soil samples at concentrations

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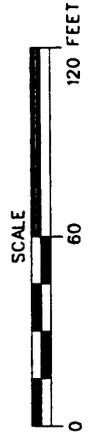
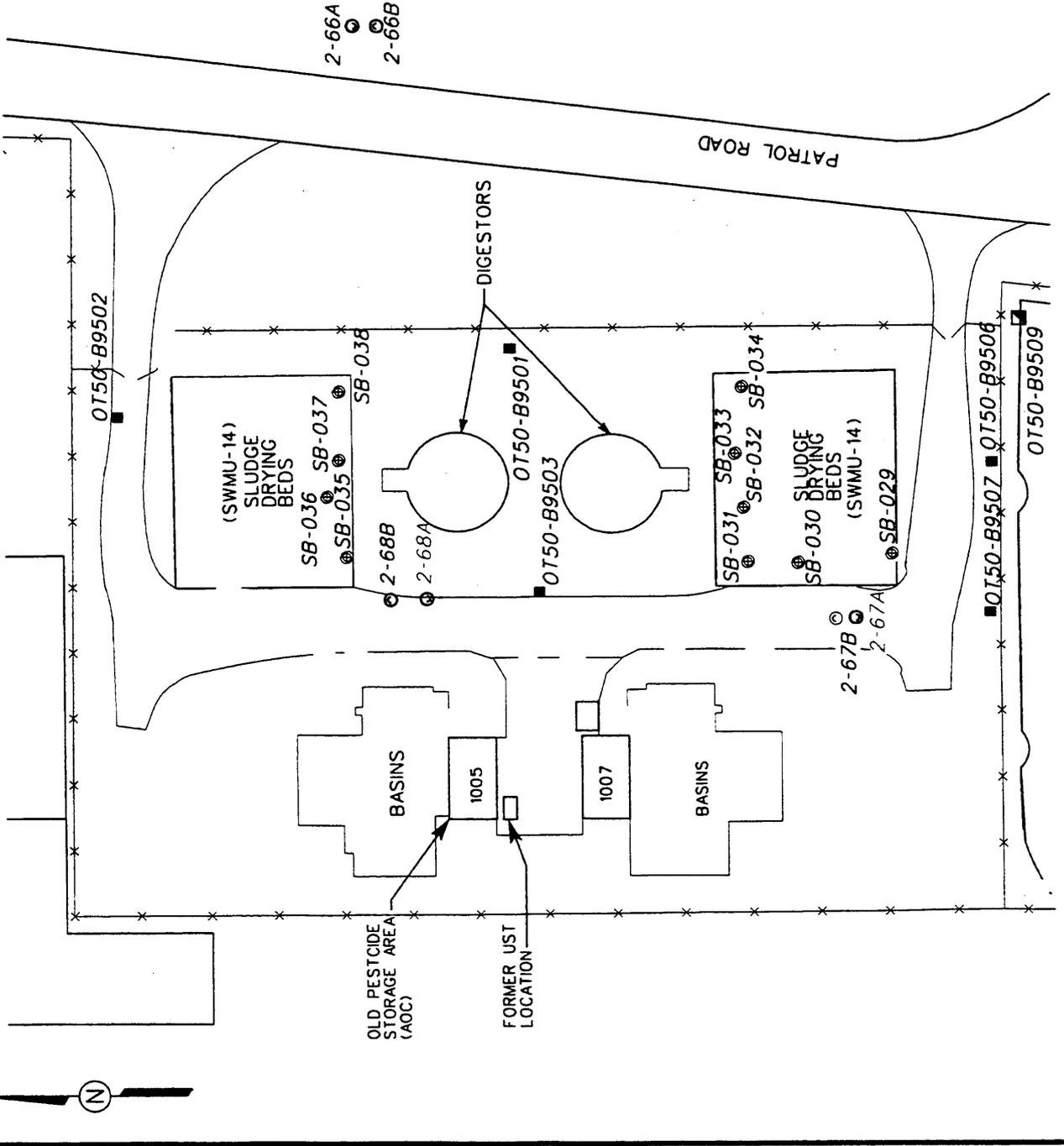
<sup>4</sup>U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

<sup>5</sup>IT Corporation (IT), 1999, *Final Report, Base-Wide Background Screening Levels, Inorganics*, May 1999.

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**LEGEND:**

- PHASE II RFI SOIL BORING LOCATION
- ⊕ PHASE I RFI SOIL BORING LOCATION
- ⊙ DEEP MONITORING WELL LOCATION
- ⊖ SHALLOW MONITORING WELL LOCATION
- ▣ PHASE II RFI SURFACE SOIL SAMPLING LOCATION
- x-x- FENCE



**FIGURE ES-1**  
**SLUDGE DRYING BEDS**  
**SAMPLING LOCATIONS**

TINKER AIR FORCE BASE  
 OKLAHOMA CITY, OKLAHOMA

exceeding its SSL, it did not exceed its background UTL in any of the surface samples. None of the other detected metals were at concentration levels exceeding their respective background UTLs or SSLs.

Detected pesticide compounds included aldrin, chlordane, and heptachlor epoxide. Aldrin and heptachlor epoxide were detected in only one sample, at concentration levels below their respective SSLs. Chlordane was detected in two samples at concentration levels exceeding its SSL. This indicated a potential for chlordane contamination in the surface soil of the SDB site. The chlordane was detected west of the SDB digestors and south of the southernmost SDBs.

**Subsurface Soil.** Fifteen subsurface samples from five soil borings were collected and analyzed during the Phase II RFI. The only organic constituents detected in the subsurface soil samples were VOCs and SVOCs. Acetone and methylene chloride were detected in soil borings located south of the southernmost SDBs. Diethyl phthalate was the only SVOC detected in any of the subsurface soil samples from the SDB site. Of the organic constituents detected, methylene chloride was the only one that exceeded its SSL concentration level of 20 micrograms per kilogram ( $\mu\text{g}/\text{kg}$ ) in soil boring OT50-B9506 at the 17- to 18-foot depth. Methylene chloride was detected in this sampled interval at a concentration level of 23  $\mu\text{g}/\text{kg}$ . Boring OT50-B9506 is located south of the southernmost SDBs.

Of 11 metals detected in subsurface soils during the Phase II RFI, barium and lead were detected at concentration levels exceeding their respective SSLs/UTLs. Barium was detected in two borings at concentration levels exceeding its SSL of 1,600 milligrams per kilogram ( $\text{mg}/\text{kg}$ ) and its background UTL of 1,770.57  $\text{mg}/\text{kg}$ . Iron was also detected at a concentration level exceeding its background UTL of 20,471.53  $\text{mg}/\text{kg}$ . An SSL has not been established for iron. The detections of barium and lead above their screening values occurred south of the southernmost SDBs.

During previous investigations at the SDB site, barium, beryllium, cadmium, chromium, chromium VI, iron, lead, nickel, and silver exceeded either their respective SSLs or their background UTLs or both. Because of the age of the analytical data, they cannot accurately reflect current SDB site conditions.

**Conclusions.** The soils at the SDB site are potentially contaminated with chlordane, methylene chloride, barium, and iron. Potential chlordane contamination is limited to the surface soils only. Methylene chloride, barium, and iron were detected in subsurface soils at

concentration levels exceeding their respective SSLs/UTLs. The elevated concentration levels of methylene chloride, barium, and iron may have resulted from past operations at the SDB sites. Based upon the BWGW report (IT, 1997), none of the constituents exceeding SSLs/UTLs at the SDB site has affected the groundwater at the site.

***Recommendations.*** In view of the findings of this Phase II RFI, it is recommended that no further characterization be performed at the SDB site.

## ***Executive Summary***

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This report presents the results of investigations conducted at Solid Waste Management Unit (SWMU) 7, Fire Training Area (FTA) 1, Tinker Air Force Base (AFB), Oklahoma, in order to meet regulatory requirements. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, a facility to undertake corrective action for any release of hazardous waste or constituents from any SWMU and area of concern (AOC). On January 12, 1989, Tinker AFB submitted its Part B permit application for renewal of its operating RCRA hazardous waste storage facility permit. The final RCRA permit issued on July 1, 1991 requires Tinker AFB to investigate all SWMUs and AOCs and to perform corrective action at those sites identified as posing a threat to human health or the environment. The permit specifies that a RCRA Facility Investigation (RFI) is to be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document has been prepared to determine whether sufficient investigations have been conducted to meet the permit requirements for FTA-1.

This report summarizes interpretations of old aerial photographs of the site, as well as a surface and subsurface site investigation performed at the site in 1995. The results of these investigations form the basis for determining whether or not additional investigation is warranted at this site, and if so, what corrective action should be implemented. The report focuses on surface soil, subsurface soils, analytical data, and geotechnical data. An extensive evaluation of groundwater conditions at Tinker AFB has been addressed under the Basewide groundwater (BWGW) report (IT Corporation [IT], 1997)<sup>1</sup> and as part of the BWGW study conducted under the Phase II RFI.

The report integrates the findings of previous investigations and those conducted as part of the Phase II RFI program. The results of these investigations form the basis for determining whether or not sufficient investigations have been conducted to fully characterize any contamination that may be present, aid in drawing plausible conclusions regarding the nature of contamination at the site, and if needed, form the basis for study and selection of cleanup methods. The report focuses on the evaluation of soil analytical data for all of the soil samples collected at FTA-1. It does not cover the results of groundwater investigations at the subject site. Evaluation of groundwater contamination at Tinker AFB is being addressed under the BWGW investigation program as a

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<sup>1</sup>IT Corporation (IT), 1997, ***Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma***, June 1997.

part of the Phase II RFI. Therefore, no groundwater sampling results from FTA-1 are addressed in this document.

**Background.** Tinker AFB is located in central Oklahoma, in the southeast portion of the Oklahoma City metropolitan area, in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. FTA-1 is located in the southwest quadrant of Tinker AFB. It is bounded by Crutch Creek to the south, Patrol Road to the east, the old municipal sewage treatment plant site to the north, and Air Depot Boulevard to the west.

**Source Description.** FTA-1 was used from 1950 to 1962 as a fire control training area. Prior to exercises, the area was saturated with water to reduce infiltration of flammable liquids into the soil. Fire-fighting exercises consisted of either dousing an old aircraft carcass with flammable liquids, setting the carcass on fire, and then extinguishing the fire; or filling the area with flammable liquids, igniting the liquids, and then extinguishing the fire. No records or documents exist identifying the flammable liquids that were used.

**Site Investigations.** A previous Installation Restoration Program investigation consisted of an initial record search report by Engineering Science (1982)<sup>2</sup>. The records search report identified the site as a potential site for remediation and recommended that soil borings be obtained and analyzed to define the contaminants and to identify the extent of contamination. No remedial investigation (RI) was conducted at the site during the previous investigation.

In November 1985, the U.S. Army Corps of Engineers (USACE) initiated an RI at the site to define the extent of any possible contamination. From 1985 to 1989, 27 soil borings were drilled and 3 monitoring wells were installed. Twenty-four soil borings were drilled at on-site locations, and 3 borings were drilled at off-site locations approximately 200 feet south of the site. The off-site borings were drilled to establish site-specific background levels for contaminants detected in the soil. Two monitoring wells were installed in the upper saturated zone, one upgradient and

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<sup>2</sup>Engineering Science 1982, *Installation Restoration Program, Phase I -Records Search, Tinker AFB, Oklahoma.*

one downgradient of FTA-1. The third monitoring well was installed in the lower saturated zone as part of the RI for Landfills No. 1 and 4 (SWMUs 3 and 6) (USACE, 1993)<sup>3</sup>.

During the Phase II RFI program, three soil borings and two geotechnical borings were installed around the FTA-1 site (Figure ES-1).

**Findings.** Soil and groundwater sampling was conducted throughout the investigation period. As previously mentioned, this report presents only the soil analytical results for all of the soil samples collected at FTA-1. Groundwater analytical data from both the Phase II RFI and previous investigations are presented, respectively, in the BWGW report (IT, 1997) and the Phase I RFI final report for FTA-1 (IT, 1994)<sup>4</sup>.

Site evaluation was performed by comparing the soil analytical data to generic soil screening levels (SSL) developed by EPA (EPA, 1996)<sup>5</sup> and with site-specific background data, to define areas of potential contamination. The SSLs are presented separately for major pathways of concern in both surface and subsurface soils. The inorganics background values were determined to be in the 95 percent upper tolerance limit (UTL) established in the BWBG soils report (IT, May 1999).<sup>6</sup> The soil data were divided into surface and subsurface data and were compared to appropriate screening levels. Constituents with concentrations exceeding the specified screening levels indicate potential presence of contamination.

**Surface Soil.** During the Phase II RFI, no volatile organic compounds or semivolatile organic compounds were detected in the surface soil. TPH, which has neither an established SSL or UTL, was detected in two samples, one of which (at boring location FT21-B9503) exceeded the State of Oklahoma action level of 50,000 micrograms per kilograms ( $\mu\text{g}/\text{kg}$ ) for underground storage tank sites. None of the 10 metals detected in the surface soil exceeded their respective background levels; only two, arsenic and beryllium, exceeded their respective SSL values.

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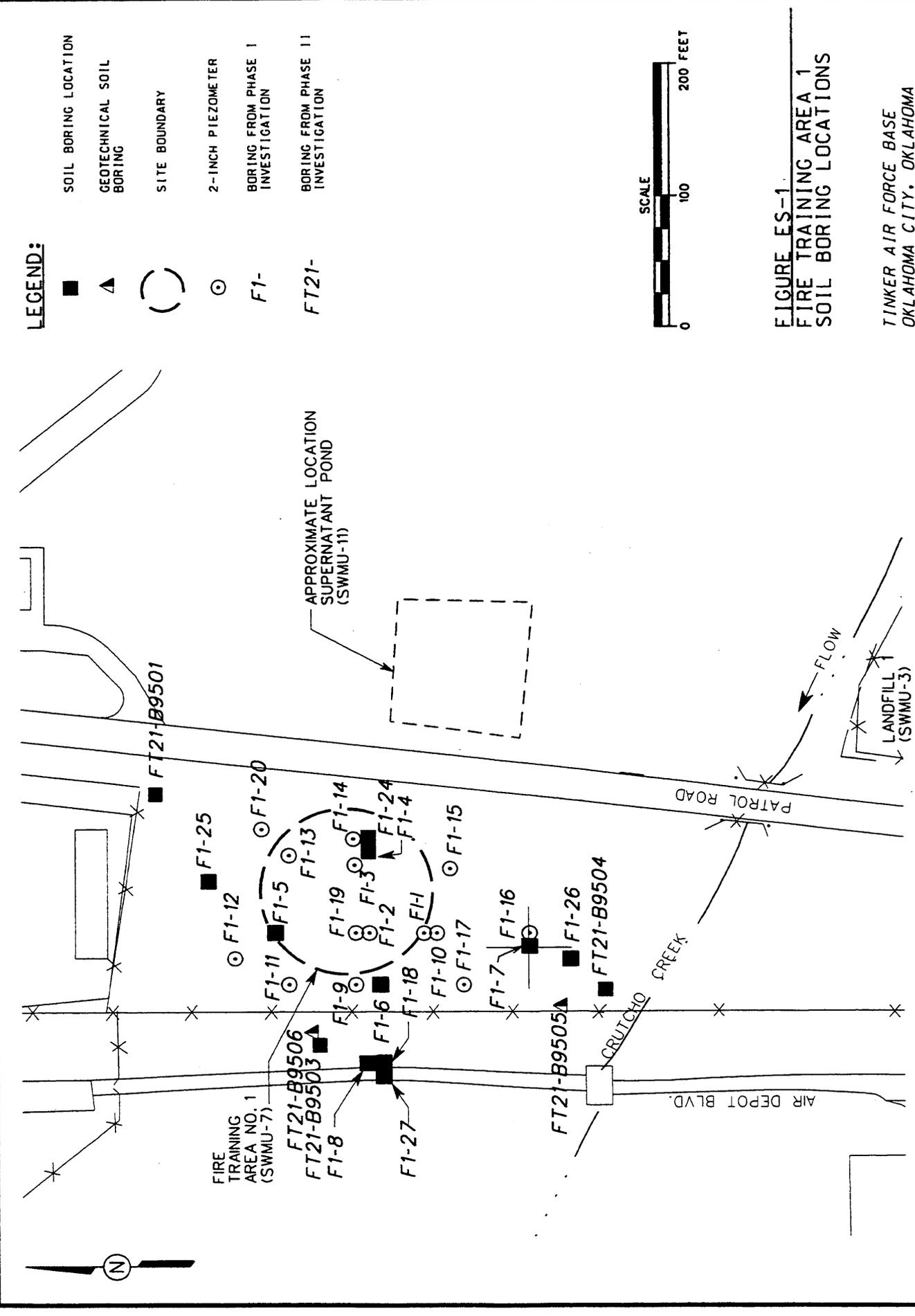
<sup>3</sup>U.S. Army Corps of Engineers (USACE), 1993, *Landfills 1-4 Remedial Investigation Report, Tinker Air Force Base, Oklahoma, Draft Final Report*, October 1993.

<sup>4</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume VIII, Tinker Air Force Base, Oklahoma*, September 1994.

<sup>5</sup>U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

<sup>6</sup>IT Corporation (IT), *Final Report Base-Wide Screening Levels Inorganics*, May 1999.

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During previous investigations, three organic compounds, acetone, methylene chloride, and bis(2-ethylhexyl)phthalate, were detected in the surface soil samples. Acetone was detected in concentrations ranging from 13 µg/kg to 60 µg/kg. Methylene chloride was detected in concentrations ranging from 6 to 29 µg/kg. Bis(2-Ethylhexyl)phthalate was detected in concentrations ranging from 550 to 11,000 µg/kg. None of the organic compounds detected were present in concentrations that exceeded the respective SSL values. Of the ten metals detected in the surface soil, six were present in concentrations that exceeded their respective SSL or UTL.

**Subsurface Soil.** During the Phase II RFI, no organic compounds were detected in the subsurface. None of the eight metals detected in the subsurface soils exceeded their respective background UTL or SSL values.

During previous investigations, five organic compounds (acetone, ethyl benzene, methylene chloride, bis(2-ethylhexyl)phthalate, and trans-1,2-dichloroethene) were detected in subsurface soil samples. Of the five detected organic compounds, the methylene chloride concentration exceeded the SSL value of 20 µg/kg. Methylene chloride was detected in concentrations ranging from 7 to 527 µg/kg. The other four compounds were detected at concentrations less than the SSLs. Potential methylene chloride contamination occurred in an areally discontinuous pattern. There was no obvious vertical trend that correlated concentrations of methylene chloride with depth. Potential contamination occurred approximately within a 4- to 15-foot depth interval at FTA-1. None of the nine metals detected in the subsurface soils exceeded their respective SSLs; only two of the metals, cadmium and silver, exceeded their respective background UTL concentrations.

**Conclusions.** Surface soil data indicate no signs of contamination except for TPH contamination in boring FT21-B9503, located to the west of the fire ring. The location of the fire ring was identified with aerial photographs. No other detected compounds (organic and inorganic) in surface soils during the Phase II investigation were detected at concentrations that exceeded both their SSL and UTL. During the previous investigations, methylene chloride was the only organic compound detected in concentrations exceeding the SSL. It was detected in the subsurface soils and was distributed in an areally discontinuous pattern and occurred only in the unsaturated zone. Methylene chloride is often used in propellants as a common lab contaminant, and may have been present in materials used to extinguish fires at the FTA-1 site, but this cannot be confirmed from site records. The data to date show no evidence of methylene chloride migration to groundwater (IT, 1997). It is probable that any residual methylene chloride in the subsurface soils at FTA-1 has biodegraded or naturally attenuated. During previous investigations, cadmium

and silver were reported in concentrations that exceeded their background UTLs. However, because they were detected at these concentrations in previous investigations only, the data cannot be considered indicative of current site conditions.

***Recommendations.*** Based on the data evaluation, no further characterization is warranted at the FTA-1 site.

## ***Executive Summary***

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This report presents the results of investigations conducted at solid waste management unit (SWMU) 11, the Supernatant Pond, Tinker Air Force Base (AFB), Oklahoma, in order to meet regulatory requirements as described below. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, that a facility undertake corrective action for any release of hazardous waste or constituents from any SWMU or area of concern (AOC). On January 12, 1989, Tinker AFB submitted an application to renew its RCRA Part B permit to operate a RCRA hazardous waste storage facility. The final RCRA permit issued on July 1, 1991, requires that Tinker AFB investigate all SWMUs and AOCs and that corrective action be taken at those sites identified as posing a threat to human health or the environment. The permit specifies that a RCRA Facility Investigation (RFI) be conducted for 43 identified SWMUs and two AOCs on the Base. This document was prepared to report whether sufficient investigations were conducted at the Supernatant Pond to provide full characterization of the site and to meet the RCRA permit requirements.

This report integrates the findings of previous investigations and those conducted as part of the Phase II RFI program. The results of these investigations form the basis for determining whether additional site characterization is warranted at the Supernatant Pond and what corrective action, if any, should be implemented. The report focuses on the evaluation of analytical data for surface and subsurface soils collected at the Supernatant Pond. It does not cover the results of groundwater investigations at the Supernatant Pond site. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater (BWGW) investigation program as a part of the Phase II RFI. Groundwater sampling results from this effort are addressed in the BWGW report (IT Corporation [IT], 1997a)<sup>1</sup>.

***Background.*** Tinker AFB is located in central Oklahoma in the southeast portion of the Oklahoma City metropolitan area in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to

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<sup>1</sup>IT Corporation (IT), 1997a, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

the south. The Base encompasses approximately 5,000 acres. The Supernatant Pond is located in the southwest quadrant of Tinker AFB.

**Source Description.** The Supernatant Pond is located on the west side of Tinker AFB, east of and adjacent to Patrol Road and approximately 200 feet north of the northwest-flowing Crutcho Creek. The site is directly east of the Fire Training Area 1, SWMU-7. Based upon historical information, this site was used as an impoundment for sewage effluent from 1954 to 1979 and as a disposal site for liquid wastes including petroleum hydrocarbon sludge, solvents, and cyanide-contaminated liquids until 1980. From 1980 to 1984, the site was used for disposal of construction rubble and dirt.

**Site Investigations.** Previous site investigations were conducted at the Supernatant Pond at two different times: during the remedial investigation (RI) (U.S. Army Corps of Engineers [USACE], 1991)<sup>2</sup> and during the actual remediation of the site. The RI was conducted by the U.S. Army Corps of Engineers at the Supernatant Pond from July 1989 to July 1990 and included a soil gas survey during which 22 soil gas samples were collected and analyzed; the drilling of 13 soil borings completed as shallow piezometers in the first water-bearing zone encountered; the collection and analysis of seven soil samples obtained from among the 13 soil borings; the installation of 2 pairs of nested monitoring wells in the upper saturated zone and lower saturated zone; and the sampling of the wells and piezometers during October and November 1989 and May 1990. The final RI report (cited above) was published in October 1991.

The soil gas survey conducted by Tracer Research, Inc., allowed a preliminary screening of the site for the presence of volatile organic compounds (VOC) in the vadose zone. The soil gas survey indicated very low concentration levels of 1,1,1-trichloroethane (TCA), tetrachloroethene (PCE), and total petroleum hydrocarbons at several of the 22 sample locations within and adjacent to the Supernatant Pond. Subsequent soil and groundwater sampling and analysis did not detect the presence of TCA or PCE at the locations sampled during the soil gas survey. Soil-sampling results did indicate the presence of VOCs and metals in the subsurface soils within the boundaries of the Supernatant Pond. The RI concluded that the low levels of soil gas contaminants were not indicative of subsurface contamination. The report recommended that a risk assessment be conducted to determine whether future risks exist at the site in the absence of

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<sup>2</sup>U.S. Army Corps of Engineers (USACE), 1991, *Supernatant Pond Remedial Investigation, Tinker AFB, Oklahoma*, Final Report, October, 1991.

remedial action. In addition, the report recommended that a feasibility study be conducted to evaluate remedial alternatives for the soils.

A human health risk assessment and an ecological assessment were performed for the Supernatant Pond site (USACE, 1994)<sup>3</sup>. The risk assessment indicated that the site posed no risk to human health or the environment. However, because the detection of soil contamination was above background levels, it was recommended that additional soil samples be collected to verify the characterization of soil contamination (IT, 1994)<sup>4</sup>.

A focused feasibility study was performed in order to identify, evaluate, and compare alternatives that mitigate or minimize threats to human health and the environment. Because of the limited size of the site and extent of contamination, the Supernatant Pond was selected for demonstrating the innovative technology of soil stabilization/solidification (SS) after several alternatives were reviewed. The SS technology was also considered a cost-effective alternative for the remediation of the soils at the site. The solidification of the soil at the site guaranteed protection of human health and the environment, while demonstrating the effectiveness and applicability of this technology to similar sites. Remediation and sampling activities at the Supernatant Pond took place in 1992 upon completion of the RI (Tinker AFB, 1993)<sup>5</sup>.

A Phase I RFI was conducted (IT, 1994) with the objective of providing Tinker AFB with one comprehensive report that summarized the various investigations that have occurred at the Supernatant Pond site since 1981. The purpose of the comprehensive report was to characterize the site and to identify actual or potential receptors and the action levels for protecting human health and the environment. The Phase I RFI for this site involved reviewing data collected from previous investigations and compiling them into one report. Upon completion of the review, IT recommended that site-specific background data and additional site data be collected as part of a Phase II RFI program, to further define the extent of contamination at the site.

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<sup>3</sup> U.S. Army Corps of Engineers (USACE), 1994, *Supernatant Pond Baseline Risk Assessment Report, Tinker AFB, Oklahoma*, Final Report, February 1994.

<sup>4</sup> IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume VIII, Tinker Air Force Base, Oklahoma*, September 1994.

<sup>5</sup> Tinker AFB, 1993, *Final Decision Document for Supernatant Pond, Tinker AFB, Oklahoma*, September, 1993.

**Findings.** Under the Phase II RFI conducted by IT, a site evaluation was performed by drilling three additional soil borings at the Supernatant Pond site for the collection of surface and subsurface soil samples (Figure ES-1). In addition to the three soil borings, a separate surface sample was collected at a site location dedicated to surface sampling. The soil analytical data were compared to generic soil screening levels (SSL) developed by EPA, (1996)<sup>6</sup> and to site-specific background data to define areas of potential contamination. SSLs are risk-based values that are derived from such factors as pathways of concern and dilution attenuation factors. The SSLs, for surface and subsurface soils, are presented separately for major pathways of concern. The background values were determined to be in the 95-percent upper tolerance limit (UTL) established in the Basewide background soils report (IT, 1997b)<sup>7</sup>. The soil data were divided into surface and subsurface analytical results and were compared to the applicable screening values. Constituents with concentration levels exceeding the screening values revealed the potential contamination at the site.

**Surface Soil.** Surface soil samples were not collected during previous investigations; therefore, analytical data is available from the Phase II RFI, only. Of the target parameters, semivolatile organic compounds (SVOC), pesticides, polychlorinated biphenyls (PCB), and metals were detected. There were no detectable concentration levels of VOCs or cyanide in the surface soils.

Sixteen SVOCs were detected in soil boring WP17-B9502, located at the southeastern corner of the Supernatant pond. Five SVOCs were detected at concentration levels exceeding their respective SSLs: benzo[a]anthracene at 23 micrograms per kilogram ( $\mu\text{g}/\text{kg}$ ), benzo[a]pyrene at 17  $\mu\text{g}/\text{kg}$ , benzo[b]fluoranthene at 16  $\mu\text{g}/\text{kg}$ , benzo[k]fluoranthene at 12  $\mu\text{g}/\text{kg}$ , and indeno(1,2,3-cd)pyrene at 11  $\mu\text{g}/\text{kg}$ .

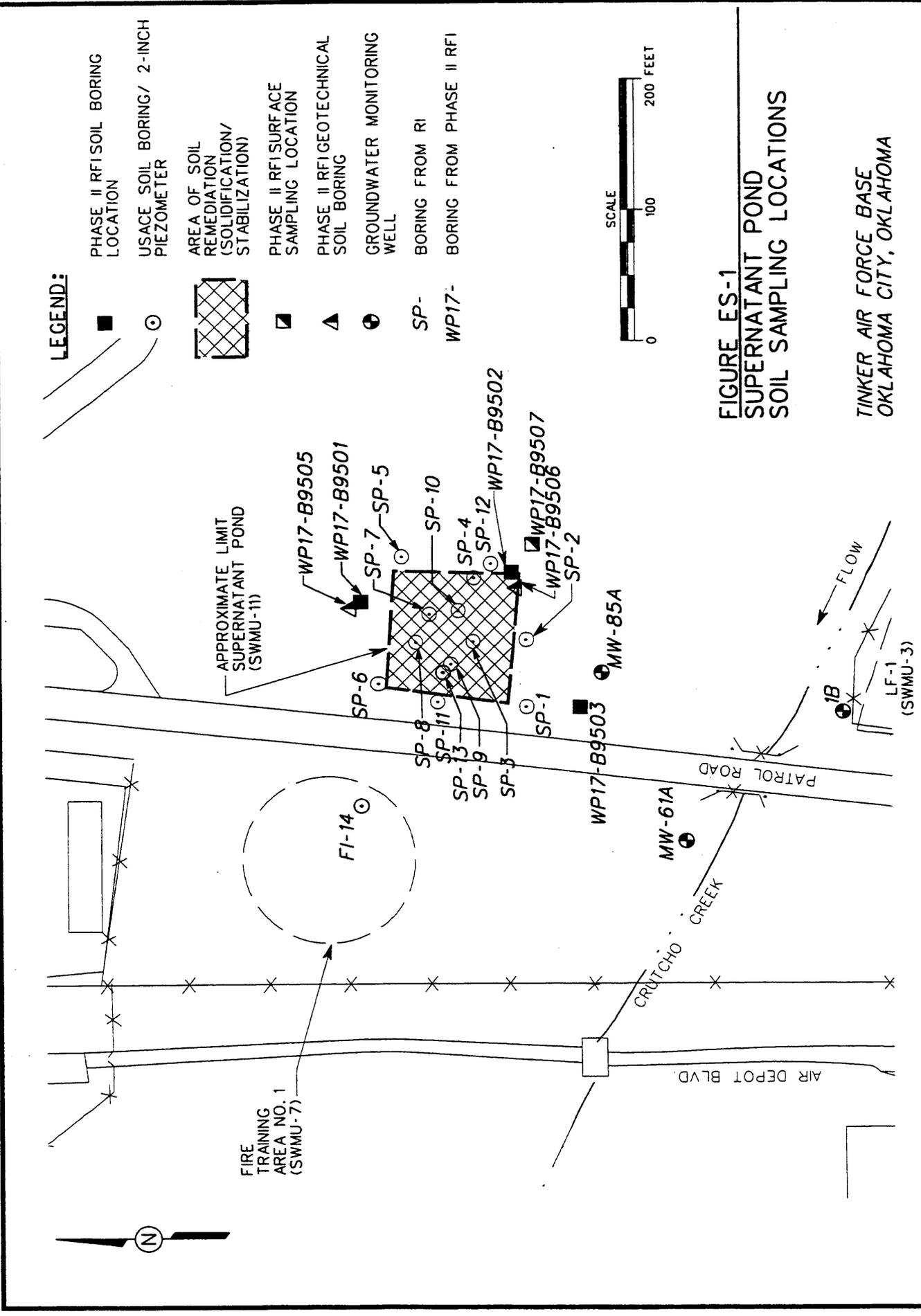
Pesticide and PCB compounds that were detected included 4,4'-dichlorodiphenyldichloroethene (DDE); 4,4'-dichlorodiphenyltrichloroethane (DDT); chlordane; and aroclor-1260. 4,4'-DDE was detected in two samples from borings WP17-B9502 and WP17-B9503 at concentration levels of 36 and 21  $\mu\text{g}/\text{kg}$ , respectively. Boring WP17-B9503 contained 4,4'-DDT at a concentration level of 12  $\mu\text{g}/\text{kg}$ . Chlordane and Aroclor-1260 were detected at 430 and 100  $\mu\text{g}/\text{kg}$ , respectively, in

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<sup>6</sup>U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

<sup>7</sup>IT Corporation (IT), 1999, *Final Report, Base-Wide Background Screening Levels, Inorganics*, May 1999.

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boring WP17-B9502. All detected pesticide/PCB concentration levels were below their respective SSLs, indicating that there does not appear to be potential contamination from pesticide and PCB constituents at the site.

Twelve metals were detected among the surface soil samples collected at the Supernatant Pond site: aluminum, arsenic, barium, beryllium, cadmium, chromium, iron, lead, mercury, nickel, selenium, and zinc. Arsenic and beryllium were detected at concentration levels exceeding their SSLs but not their UTLs. Since arsenic and beryllium concentration levels did not exceed background levels, they are probably not indicative of site contamination. Cadmium, lead, and zinc were detected in surface samples from soil borings WP17-B9502 and WP17-B9503 at concentration levels that did not exceed their respective SSLs but did exceed UTLs. Possible site contamination could be indicated by the metal concentration levels that exceed background levels. However, since these concentration levels were below their respective SSLs, the potential contamination may not present a risk to human health. None of the other metals that were detected occurred at concentration levels exceeding their SSLs or UTLs.

***Subsurface Soil.*** During the Phase II RFI, a total of six subsurface soil samples were collected and analyzed. No VOCs, SVOCs, pesticides, or PCBs were detected in the subsurface soil samples. Ten metals were detected in the subsurface. Of the ten metals, only barium exceeded either of its background UTL or SSL values at a concentration level of 2,400 milligrams per kilogram (mg/kg) in soil boring WP17-B9502, which is located at the southeastern corner of the remediated area of the Supernatant Pond site. Cyanide was detected in one soil boring sample at a concentration level of 0.63 mg/kg, but no SSL for cyanide is indicated.

During previous investigations, the subsurface soil analytical data indicated that five VOCs, four SVOCs, PCB, nine metals, cyanide, and total recoverable petroleum hydrocarbons (TRPH) were detected in the soils at the Supernatant Pond site. Only two of the organic compounds detected in the subsurface soils, methylene chloride and TRPH, were detected at concentration levels that indicated potential site contamination. Methylene chloride exceeded its SSL value in four samples (SP-4, SP-5, SP-7, and SP-9), with concentration levels ranging from 31 µg/kg in SP-4 and SP-5 to 420 µg/kg in boring SP-7. However, methylene chloride was also detected in the corresponding laboratory blanks. This indicates possible laboratory contamination of the samples. TRPH was detected in surface samples from borings SP-4, SP-7, and SP-9, with concentration levels of 68 mg/kg, 78 mg/kg, and 59 mg/kg, respectively. Although TRPH does not have associated SSL or UTL values, all three concentration levels exceed the State of

Oklahoma total petroleum hydrocarbon action level of 50,000  $\mu\text{g}/\text{kg}$  (50  $\text{mg}/\text{kg}$ ) for underground storage tank sites. Boring locations SP-4, SP-7, and SP-9 were located within the Supernatant Pond, which was later remediated using SS technology.

An unspecified PCB was detected in subsurface samples at a concentration level of 100  $\mu\text{g}/\text{kg}$  in soil borings SP-7 and SP-9. This level was below the SSL for the PCB constituent.

The nine metals detected among the subsurface soil samples were, arsenic, barium, cadmium, chromium, lead, nickel, selenium, silver, and zinc. Cadmium, chromium, and lead were detected among three samples, from borings SP-4, SP-7, and SP-9, at concentration levels exceeding both their respective SSLs and their respective UTLs. Additionally, chromium, silver, and zinc were also detected in subsurface soil samples among borings SP-4, SP-7, and SP-9 at concentration levels that did not exceed their respective SSLs but did exceed their UTL background concentration levels. However, samples from borings SP-4, SP-7, and SP-9 were taken from an area that was later remediated by the SS technology. Cyanide was detected in soil borings SP-4 and SP-7 at concentration levels of 0.31  $\text{mg}/\text{kg}$  and 1.64  $\text{mg}/\text{kg}$ , respectively, but no SSL for cyanide is indicated.

**Conclusions.** Based upon historical information, this site was used as an impoundment for sewage effluent; as a disposal site for liquid wastes including petroleum hydrocarbon sludge, solvents, and cyanide-contaminated liquids; and as a disposal site for construction rubble and dirt. The site was later remediated using SS technology.

During the Phase II investigation, the SVOCs identified as exceeding their respective SSLs in surface soils at the site were likely a result of past site operations. Likewise, cadmium, lead, and zinc that were detected above background levels in surface soil and the barium concentration level detected in the subsurface soil was also probably related to past site history.

**Recommendations.** Potential contamination in the form of metals and SVOCs at the Supernatant Pond site appears to have been delineated. It is recommended that no further site characterization be performed at the Supernatant Pond.

## ***Executive Summary***

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This report presents the results of investigations conducted at Solid Waste Management Unit (SWMU) 3 (Landfill 1) at Tinker Air Force Base (AFB), Oklahoma, in order to meet regulatory requirements. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, that a facility undertake corrective action for any release of hazardous waste or constituents from any SWMU or area of concern (AOC) at a treatment, storage, and disposal facility. On January 12, 1989, Tinker AFB submitted an application for renewal of its Part B permit to operate its RCRA hazardous waste storage facility. The final RCRA permit issued on July 1, 1991 requires that Tinker AFB investigate all SWMUs and AOCs and perform corrective action at those sites identified as posing a threat to human health or the environment. The permit specifies that a RCRA Facility Investigation (RFI) be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document was prepared to determine whether sufficient investigations were conducted at Landfill 1 to provide full characterization of the site and whether the site meets permit requirements.

This document integrates the findings of previous investigations performed by the U.S. Army Corps of Engineers (USACE) and a more recent investigation conducted as part of the Phase II RFI program. The results of these investigations form the basis for determining whether additional investigation is warranted at the Landfill 1 site, and if so, what corrective action should be implemented. This report focuses on the evaluation of analytical data for surface and subsurface soils at the Landfill 1 site, particularly the area surrounding the perimeter of the landfill. It does not cover the results of groundwater investigations at Landfill 1. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater (BWGW) investigation program as a part of the Phase II RFI. All groundwater sampling data are presented in the BWGW report (IT Corporation [IT], 1997)<sup>1</sup>.

**Background.** Tinker AFB is located in central Oklahoma in the southeastern portion of the Oklahoma City metropolitan area in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. Landfill 1 occupies approximately

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

1.5 acres in the southwestern part of the Base and is bordered by Crutch Creek to the north and east, Patrol Road to the west, and Building 1022 to the south.

**Source Description.** During its operation from 1942 to 1945, Landfill 1 received any solid and liquid waste, including general refuse and industrial waste, generated at Tinker AFB and may have received waste solids from the domestic waste treatment plant (Radian Corporation [Radian], 1985)<sup>2</sup>. The waste was placed in unlined trenches running east to west across the site, and was typically burned to reduce the volume. The trenches extended to a depth of 10 to 25 feet. The waste was covered daily with several inches of soil excavated during the landfill construction. Approximately 21,780 cubic yards of waste was placed in Landfill 1 (USACE, 1993)<sup>3</sup>.

**Site Investigation.** Previous Installation Restoration Program (IRP) investigations included an initial records search report by Engineering Science (1982)<sup>4</sup>. This investigation found that general refuse placed in Landfill 1 was burned in order to reduce the volume. It is suspected that only small amounts of chemicals and industrial waste were disposed of in the landfill. Radian (1985) conducted the second phase of investigations from 1983 to 1985, which included the additional installation of three monitoring wells to the five previously existing wells and the collection of sediment samples. At one of the monitoring wells west of Landfill 1 there was evidence of contaminant migration to deeper strata.

Between 1986 and 1990 Tinker AFB employed the USACE to conduct a remedial investigation (RI) of Landfill 1 as part of the U.S. Air Force IRP. Waste material indicative of general refuse was encountered in two borings drilled into landfill trenches in 1987. Analytical results of soil and water samples collected from the trench borings indicated contamination from volatile organic compounds (VOC), and metals.

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<sup>2</sup>Radian Corporation, 1985, *Installation Restoration Program, Phase II, Stage 1, Confirmation/Quantification Report, Tinker AFB, Oklahoma*, Final Report, September 1985.

<sup>3</sup>U.S. Army Corps of Engineers (USACE), 1993, *Landfills 1-4 Remedial Investigation Report, Tinker Air Force Base, Oklahoma, Draft Final Report*, October 1993.

<sup>4</sup>Engineering Science (ES), 1982, *Installation Restoration Program, Phase I -Records Search, Tinker AFB, Oklahoma*.

During the course of the RI, the USACE installed five additional monitoring wells to characterize groundwater around Landfill 1. Four of the five wells were placed in both the upper saturated zone and the lower saturated zone. The wells were sampled during the RI and continue to be sampled as part of the ongoing groundwater monitoring program for the site. Soil samples collected during the RI detected no VOCs, semivolatile organic compounds (SVOC), pesticides, or polychlorinated biphenyls (PCB) exceeding health- and environment-based action levels. Two metals (cadmium and silver) were detected at concentration levels exceeding their respective 95-percent upper tolerance limits (UTL).

The Phase I RFI for Landfill 1 was conducted by IT (1994)<sup>5</sup>. Data were collected from previous investigations at the site and compiled together with data from this investigation into one comprehensive report. Upon completion of this review, it was recommended that site-specific background data and additional site data be collected in order to provide a more complete delineation at the extent of contamination at this site. The Phase II RFI was initiated to fill in the data gaps that had been identified in the previous investigation in order to complete the site characterization of Landfill 1. Under the Phase II RFI program, IT was retained by Tinker AFB to collect the additional data required to provide full characterization of the subject site. Figure ES-1 shows the soil boring locations from previous investigations and Phase II RFI.

**Findings.** Soil and groundwater sampling was conducted throughout the investigation period. This report presents only the soil analytical results for all of the soil samples collected at Landfill 1. Groundwater analytical data from both the Phase II RFI and previous investigations are presented in the BWGW report (IT, 1997).

To define areas of potential contamination, the site was evaluated through a comparison of the analytical data from surface and subsurface soils to generic soil-screening levels (SSL) developed by the EPA (1996)<sup>6</sup> and to site-specific background UTLs. The SSLs are presented separately for major pathways of concern in both surface and subsurface soil. The background values were

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<sup>5</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume VII, Tinker Air Force Base, Oklahoma*, September 1994.

<sup>6</sup>U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

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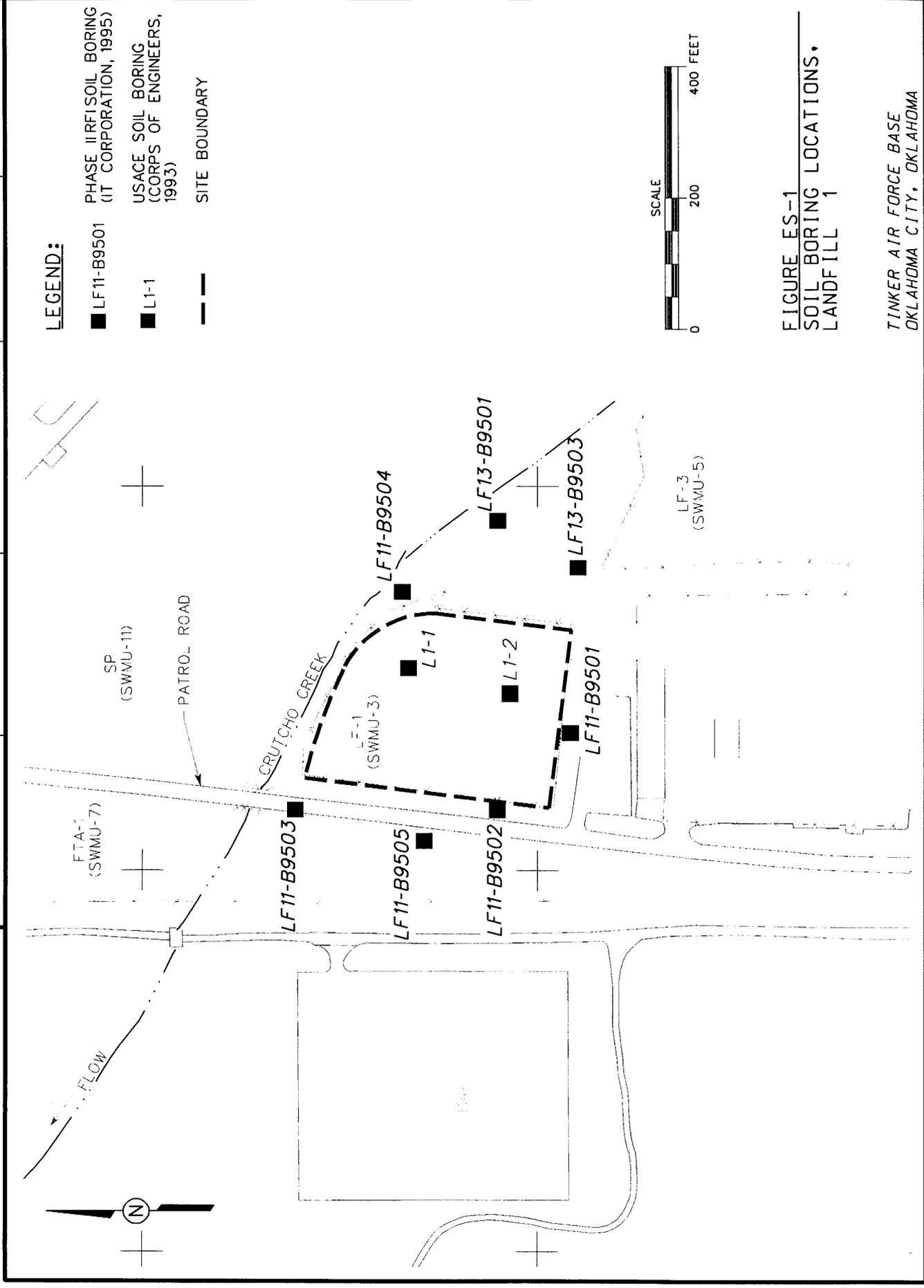
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INITIATOR: F. MAYILA

PROJ. MGR.: R. DUBISKAS

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determined to be the 95-percent UTLs established in the BWBG inorganics report (IT, 1999)<sup>7</sup> and the BWBG radionuclides report (IT, October 1999). The soil data were divided into surface and subsurface results and were compared to appropriate SSLs. Constituents with concentration levels exceeding the SSLs indicated the potential presence of contamination.

**Surface Soil.** One VOC was detected in a surface soil sample located outside of the landfill boundary. The PCB Aroclor 1260 was detected in one soil boring sample at a concentration level of 55 micrograms per kilogram ( $\mu\text{g}/\text{kg}$ ), below the screening level of 1,000  $\mu\text{g}/\text{kg}$ . Eleven metals were detected in the surface soil samples that had been collected from outside of the landfill. Beryllium and arsenic were detected in surface soil samples at concentration levels exceeding their SSLs but not their background UTLs. Lead, mercury, cadmium, and zinc were detected in soil samples at concentration levels exceeding their background UTLs but not their SSLs. Six radionuclides were detected in the surface soil samples from the area surrounding the landfill, but only two samples contained radionuclides exceeding UTLs. Potassium-40 was detected at 16.1 picocuries per gram ( $\text{pCi}/\text{g}$ ) in one soil sample and thorium-234 was detected at 2.50  $\text{pCi}/\text{g}$  in another soil sample.

**Subsurface Soil.** Six radiological parameters, including alpha and beta radiation, potassium-40, radium-226, radium-228, and thorium-234, were detected in the subsurface soil samples from Landfill 1 during the Phase II RFI. However, none of the detected radionuclides were at concentration levels above the screening criteria. Toluene and one SVOC (di-n-butyl phthalate) were detected in the subsurface soil samples at Landfill 1. None of the detected VOCs were at concentration levels above the SSLs. No pesticides or PCBs were detected in the subsurface soils at Landfill 1. Eleven metals were detected at various concentration levels in the samples from Landfill 1. Of the eleven metals detected, barium, chromium, and selenium were at concentration levels exceeding both their SSLs and their UTLs. Additionally, mercury was detected at concentration levels exceeding its background UTL.

**Conclusions.** Evaluation of the collected soil analytical data shows that six metals (beryllium, arsenic, lead, mercury, zinc, and cadmium) and two radiological constituents (potassium-40 and thorium-234) were detected at concentration levels exceeding SSLs and/or UTLs in surface soil samples at Landfill 1. These constituents were detected in samples from around the perimeter of the landfill. Beryllium and arsenic were detected at concentration levels exceeding only their

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<sup>7</sup>IT Corporation (IT), 1999, *Final Report, Base-Wide Background Screening Levels, Inorganics*, May 1999.

SSLs but not their background UTLs; therefore, their detected concentration levels appear to be within the normal range of background concentration for these constituents and probably do not reflect surface soil contamination. Lead, mercury, zinc, and cadmium were detected at concentration levels that exceeded their respective background UTLs but not their SSLs. Their exceeded background UTL concentration levels may reflect surface soil contamination. Of the detected radiological parameters in surface soils at the landfill, potassium-40 is not regulated and the concentration level of thorium-234 is below the Nuclear Regulatory Commission regulatory criteria of 5.0 pCi/g for surface soils.

Only metals were detected in subsurface soils at concentration levels exceeding their respective SSLs and/or background UTLs. Barium, chromium, and selenium were detected in samples from around the perimeter of the landfill at concentration levels exceeding both their SSLs and their UTLs, indicating potential subsurface soil contamination from these constituents. Additionally, mercury was detected in samples from the outside perimeter of the landfill at a concentration level exceeding its background UTL, indicating possible surface soil contamination from mercury.

**Recommendations.** Evaluation of the surface and subsurface soil data collected from Landfill 1 shows that the site has been fully characterized and that the lateral and vertical extents of contamination in surface and subsurface soils has been delineated. Therefore, based upon this evaluation, it is recommended that no further characterization be undertaken at this site.

## ***Executive Summary***

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This report presents the results of investigations conducted at solid waste management unit (SWMU) 4, Landfill 2, Tinker Air Force Base (AFB), Oklahoma, in order to meet regulatory requirements. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, a facility to undertake corrective action for any release of hazardous waste or constituents from any SWMU or area of concern (AOC) at a treatment, storage, and disposal (TSD) facility. On January 12, 1989, Tinker AFB submitted its Part B permit application for renewal of its operating RCRA hazardous waste storage facility permit. The final RCRA permit issued on July 1, 1991 requires Tinker AFB to investigate all SWMUs and AOCs and to perform corrective action at those identified as posing a threat to human health or the environment. The permit specifies that a RCRA Facility Investigation (RFI) be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document has been prepared to determine whether sufficient investigations have been conducted at Landfill 2 to fully characterize the site and to meet the permit requirements.

This report integrates the findings of previous investigations and those conducted as part of the Phase II, RFI program. The results of these investigations form the basis for determining whether or not additional investigation is warranted at Landfill 2, and if so, what corrective action should be implemented. This report focuses on the evaluation of analytical data for surface and subsurface soils collected at Landfill 2, including the area surrounding the perimeter of the landfill. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater investigation program as part of the Phase II RFI. All groundwater sampling data are presented in the Basewide groundwater report (IT Corporation [IT], 1997)<sup>1</sup>.

***Background.*** Tinker AFB is located in central Oklahoma, in the southeast portion of the Oklahoma City metropolitan area, in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. Landfill 2 is the largest of the four landfills in the Landfills 1 through 4 (SWMUs 3 through 6) group, which is located in the southwest corner of the Base. The landfill has a surface area of approximately 27.5 acres and is

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

bordered by Rapcon Road and Reserve Road to the east, Vanaman Road to the north, Landfill 4 to the west, and the Family Camp recreation area to the south. Landfill 2 was closed to landfill operations in 1952, and the completed trenches were covered with 3 to 4 feet of excavated native soil. Underground gas, water, and sanitary sewer lines are located near the southern section of the landfill.

**Source Description.** Landfill 2 was operated from 1945 to 1952. This landfill was used primarily for disposal of general refuse from the Base, including sanitary and industrial waste, along with unknown quantities of paints and solvents. The waste was disposed of in trenches approximately 20 feet in depth and 35 to 40 feet wide, in an east-west orientation. The refuse was covered daily with several inches of excavated native soil and completed trenches were covered with 3 to 4 feet of soil. The trash found in the landfill was composed primarily of wood, metal, paper, rubber, and plastic materials. The quantity of waste placed in Landfill 2 was estimated to be approximately 600,000 cubic yards. In addition, the inactive Radioactive Waste Disposal Site 1030W is located in the central part of the landfill. The site was used as a burial ground for burned radium dial waste including rags and solvent solution.

**Site Investigations.** Previous Installation Restoration Program (IRP) investigations included an initial records search report (Engineering Science [ES], 1982)<sup>2</sup> and a confirmation/quantitation report (Radian Corporation [Radian], 1985a,b)<sup>3,4</sup>. The purpose of the search was to identify past waste disposal activities to evaluate potential sources of contamination. It was concluded that Landfill 2 has a high potential for migration of contaminants; the site received a hazard assessment rating methodology score of 65. ES recommended that Pistol Pond be drained to reduce the potential pathways for contaminant migration. For monitoring purposes, it was recommended that a geophysical survey be conducted; four lysimeters be installed on each side of the landfill; existing groundwater monitoring wells be sampled; and a background monitoring well be constructed.

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<sup>2</sup>Engineering Science (ES), 1982, *Installation Restoration Program, Phase I -Records Search, Tinker AFB, Oklahoma.*

<sup>3</sup>Radian Corporation, 1985a, *Installation Restoration Program, Phase II, Stage 1, Confirmation/Quantification Report, Tinker AFB, Oklahoma*, Final Report, September 1985.

<sup>4</sup>Radian Corporation, 1985b, *Installation Restoration Program, Phase II, Stage 2, Confirmation/Quantification Report, Tinker AFB, Oklahoma*, Final Report, October 1985.

IRP Phase II, Stage 1 field activities were performed in 1983 by Radian (1985a). The purpose of these activities was to determine if environmental contamination had occurred due to disposal and management practices at Landfill 2. Activities included an estimate of the magnitude and extent of contamination; the identification of environmental consequences of migrating pollutants; and the recommendation of additional investigations necessary to identify the magnitude, extent, and direction of movement of discovered contaminants. As part of the Stage 1 investigation, Radian installed three monitoring wells (1-A, 1-B, and 1-C) in the vicinity of Landfills 1 and 4. Radian's Phase II, Stage 2 (Radian, 1985b) field activities conducted from June through October 1984 focused on areas of contamination discovered during the Phase II, Stage 1 field work and, therefore, did not involve any additional groundwater testing or soil borings at Landfill 2.

Tinker AFB employed the U.S. Army Corps of Engineers (USACE) between 1986 and 1990 to conduct a remedial investigation (RI) of Landfill 2 as part of the U.S. Air Force IRP. The USACE assessed the magnitude and extent of contamination originating in the Landfill 2 trenches. Investigations on Landfill 2 involved trench waste characterization, a sludge dump investigation, investigations to establish both the southeast and southwest boundaries of the landfill, and a soil gas survey. From December 1986 to February 1987, ten soil borings (boring L2-1 through L2-10) were drilled across the trench areas. Soil samples of the cover material were collected from the borings with split-spoons or Shelby tubes, and composited samples of the waste were collected from the auger flights. The consolidated shales, siltstones, and sandstones underlying the overburden material were sampled using a 4-inch core barrel in selected locations. Polyvinyl chloride screens were installed in the boreholes where water was encountered.

In June 1989, four additional soil borings (borings L2-11 through L2-14) were drilled along the eastern edge of Landfill 2 to better define the landfill boundary. A specific-use sludge dump was discovered at boring L2-11, in the northeastern corner of the landfill. Borings L2-12, L2-13, and L2-14 were drilled in the southeastern edge of the landfill. No wastes were encountered in these three borings, so the landfill boundary was revised to exclude this area. This modification placed the southeast corner of Landfill 2 approximately 300 feet west of Reserve Road; previously the corner had been immediately adjacent to the road. The area surrounding boring L2-9 was not excluded from the landfill because of evidence of trenches in the area on historical aerial photographs.

As previously discussed, boring L2-11 indicated a specific-use sludge dump located in the northeastern corner of the landfill. High concentrations of industrial solvents and hydrocarbons were detected in the collected samples. Records were not available on the type of material deposited in this area; an investigation was performed to characterize the sludge material encountered. A truck-mounted, auger-type drilling rig was utilized to collect soil and sludge samples in the vicinity of the sludge material. Borings in this area revealed a black, sludge-like material. A follow-up investigation was conducted in the vicinity of the sludge dump to determine the lateral and vertical limits of the sludge dump and to further characterize the contaminants present.

An investigation was conducted in April 1990 on Landfills 2 and 4 to provide definition of the southwest boundary of Landfill 2. The boundary investigation was conducted in connection with the design of landfill cover system for Landfill 2. A series of 42 soil borings (borings L4-12A to L4-29C) were drilled along the southwestern edge of Landfill 2 and the southern edge of Landfill 4. References provided in the USACE RI report (USACE, 1993; Drawing No. 1, Map of Explorations, and Appendix B, Geologic Logs) do not provide adequate information to determine the association of the borings to the respective landfill. Soil samples were collected and placed in one-half quart glass jars for ambient head space analysis. Field screening of the samples was accomplished with Draeger tubes and a photoionization detector for detection of contamination originating from Landfill 2 in the shallow subsurface soils. The Draeger tubes were utilized for analysis of vinyl chloride, acetone, and trichloroethane (TCA).

Tinker AFB employed B&V Waste Science and Technology Corporation (B&V) in 1989 to evaluate alternative cover systems for Landfill 2 and investigate the need to relocate utility systems within the vicinity of the landfill. B&V recommended a natural soil cover with synthetic water barrier and gas control layers. In 1992, B&V issued a prefinal design analysis and construction specifications for the selected cover at Landfill 2. However, the cover was not constructed at that time.

The USACE employed Tracer Research Corporation to conduct a shallow soil gas investigation at Landfills 2 and 4 in July 1989 and March 1990. The purpose of the investigation was to define the nature and extent of volatiles present in the subsurface, and to assist in determining the placement of borings for additional soil and groundwater investigations. A total of 114 soil/gas samples were collected for the two landfills. The samples were analyzed for the following target compounds:

- 1,1,1-TCA
- Trichloroethene
- Tetrachloroethane
- Methane
- Benzene, toluene, ethyl benzene, and xylene
- Total petroleum hydrocarbons (TPH).

The 1989 results of the soil gas investigation in the vicinity of L2-11 showed only benzene, toluene, and TPH at significant levels. A soil gas investigation was conducted on the landfill in March 1990 to obtain qualitative information on the gases evident on the landfill surface. The results of the soil gas investigation indicated areas of localized contamination on Landfill 2 for all of the screened compounds, except for methane. Methane was detected consistently across the landfill area, with concentrations decreasing rapidly at the Landfill 2 boundaries.

The U.S. Air Force employed Applied Research Associates, Inc. (ARA) in 1992 to demonstrate the effectiveness of a prototype Laser Induced Fluorescence-Electronic Cone Penetrometer Test (LIF-CPT) system in site characterization at Tinker AFB. From March to November, ARA investigated 8 test areas, including Landfill 2. CPT soundings were completed at 112 locations and the LIF sensor was used at 81 locations. Eleven CPT profiles were performed in Landfill 2 near the sludge dump boring L2-11. Eight soil samples and 5 groundwater samples were collected for on-site analysis. Four soil samples and 5 groundwater samples were collected for off-site analysis. The soil samples were void of any volatile organic compounds (VOC) and semivolatile organic compounds (SVOC). Heavy metals were found in high concentrations in all soil samples. LIF profiling was conducted at seven CPT locations. The LIF became inoperable after the seventh profile and was not used further at Landfill 2. None of the profiles had LIF values above baseline values.

The Phase I RFI was conducted (IT, 1994)<sup>5</sup> with the objective of providing Tinker AFB with one comprehensive report that summarizes the various investigations that have occurred at a SWMU or AOC since 1981. The purpose of the comprehensive report was to characterize a site, and identify actual or potential receptors and the action levels for protecting human health and the environment. Essentially, the Phase I RFI involved a review of data collected from various investigations and compiling it into one report. Upon completion of the review, IT made recommendations to collect additional site data as part of a Phase II RFI, to complete the site

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<sup>5</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume VII, Tinker Air Force Base, Oklahoma*, September 1994.

characterization. Thus, the Phase II RFI was designed to implement the recommendations made under the Phase I RFI program.

**Findings.** Soil and groundwater sampling was conducted at Landfill 2 throughout the investigative period. As previously mentioned, this report presents only the analytical results for the soil samples collected at Landfill 2. Groundwater analytical data from both the Phase II RFI and previous investigations are presented respectively, in the Basewide groundwater report (IT, 1997) and the Phase I RFI final report for Landfill 2 (IT, 1994).

Site evaluation was performed by comparing the soil analytical data to generic soil screening levels (SSL) developed by EPA (EPA, 1996)<sup>6</sup> and with site-specific background data, to define areas of potential contamination. The SSLs are presented separately for major pathways of concern in both surface and subsurface soils. The background values were determined to be the 95 percent upper tolerance limit (UTL) established in the Basewide background inorganics report (IT, 1999)<sup>7</sup> and the Basewide groundwater radionuclides report (IT, 1999). The soil data were divided into surface and subsurface results and were compared to appropriate screening levels. Constituents with concentrations exceeding the screening levels were interpreted to indicate potential presence of contamination.

**Surface Soil.** Of the target parameters, six radionuclides, seventeen SVOCs, three pesticides, and twelve metals were detected in the surface soils at Landfill 2 during the Phase II investigation. VOCs, TPH, and polychlorinated biphenyls (PCB) were not detected in any of the surface soil samples. Of the six radiological parameters detected, alpha radiation, beta radiation, and K-40 were each detected at activity concentrations exceeding their respective background UTLs in borings LF12-B9504, LF12-B9523, and LF12-B9526. Soil boring LF12-B9504 is located in the northeast portion of the landfill, north of the former sludge dump, almost at the boundary line. Soil borings LF12-B9523 and LF12-B9526 are located in the south-central portion of the landfill and in the northwest portion of the landfill, respectively (Figure ES-1).

Seventeen SVOCs were detected in two of the surface soil samples. Five of the seventeen

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<sup>6</sup>U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

<sup>7</sup>IT Corporation (IT), 1999, *Final Report, Base-Wide Background Screening Levels, Inorganics*, May 1999.

compounds were detected at concentrations above their respective SSLs. The five compounds included benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. All five constituents were detected in a surface sample from soil boring LF12-B9514, located at the southwest corner of the landfill where, according to historical information, re-drumming of leaky drums took place. Other soil borings in the immediate vicinity of LF12-B9514 did not exhibit potential surficial SVOC contamination. The SVOC contamination detected in boring LF12-B9514 appears to be an isolated occurrence limited to only one boring location and not a widespread phenomenon at the Landfill 2 site. Pesticides, the only other organic constituents detected in the surface soils at Landfill 2, were not detected at concentrations that exceeded their respective SSLs.

Twelve metals were detected in the surface soil samples at Landfill 2. Ten of the metals were detected at concentrations exceeding either their respective SSLs, UTLs, or both. Arsenic and beryllium were detected at concentrations exceeding their SSLs, although their background UTLs were not exceeded except for one beryllium detection in boring LF12-B9523. As their background UTLs were not exceeded, it could be assumed that their occurrence in the surface soils of Landfill 2 is a natural phenomenon, and not indicative of potential contamination. As previously mentioned, one beryllium detection in a surface sample in boring LF12-B9523 did exceed both the beryllium SSL and UTL, indicating potential contamination in the vicinity of that boring. LF12-B9523 is located in the south central portion of the landfill. Aluminum, cadmium, chromium, iron, lead, mercury, nickel, and zinc were detected in surface soils at Landfill 2 at concentrations exceeding their respective background UTLs, although not their SSLs. Iron and aluminum are widespread in nature and have no risk-based SSL criteria to compare with their detected concentrations. However, as these metals were detected at concentrations exceeding their background UTLs, potential metals contamination at the Landfill 2 site could be indicated.

**Subsurface Soil.** During the Phase II investigation at Landfill 2, six radiological constituents, eight VOCs, twenty SVOCs, six pesticides, three PCB constituents, and fourteen metals were detected in the subsurface soil samples. Of the six radiological parameters detected, total alpha radiation, potassium (K)-40, radium (Ra)-226, Ra-228, and thorium (Th)-234 were detected at concentrations exceeding their respective UTL background levels. The maximum activity concentrations of Ra-226 and Ra-228 were well below the Nuclear Regulatory Commission regulatory level of 15 picoCuries per gram (pCi/g) for subsurface soils. The concentrations of Th-234, which is regulated as a progeny of uranium-238, were detected below the regulatory level of 10 pCi/g for subsurface soils. The soil borings in which radiological constituents were

detected exceeding UTL background concentrations were distributed in a somewhat random fashion around the north, south, east, and west boundaries of Landfill 2.

One VOC, two SVOCs, and three PCB constituents were detected at concentrations exceeding their respective SSLs in the subsurface soils of Landfill 2 during the Phase II RFI. Benzene was detected in soil boring LF12-B9525, located in the northern portion of Landfill 2. The detected benzene at a concentration exceeding its SSL appeared to be both laterally and vertically isolated and not indicative of widespread subsurface soil contamination. In addition to benzene, two SVOCs, benzo(a)anthracene and N-nitrosodiphenylamine, were detected at concentrations exceeding their respective SSLs in soil borings LF12-B9522 and LF12-B9525, located in the north-central portion of the landfill and in the northern portion of the landfill, respectively. Three PCB constituents (Aroclor 1242, Aroclor 1248, and Aroclor 1254) were detected at concentrations exceeding their respective SSLs, also in soil borings LF12-B9522 and LF12-B9525. Soil samples from borings located adjacent to LF12-B9522 and LF12-B9525 did not exhibit the presence of PCBs. Subsurface soils potentially contaminated with PCBs do not appear to be widespread, but rather appear limited to two locations.

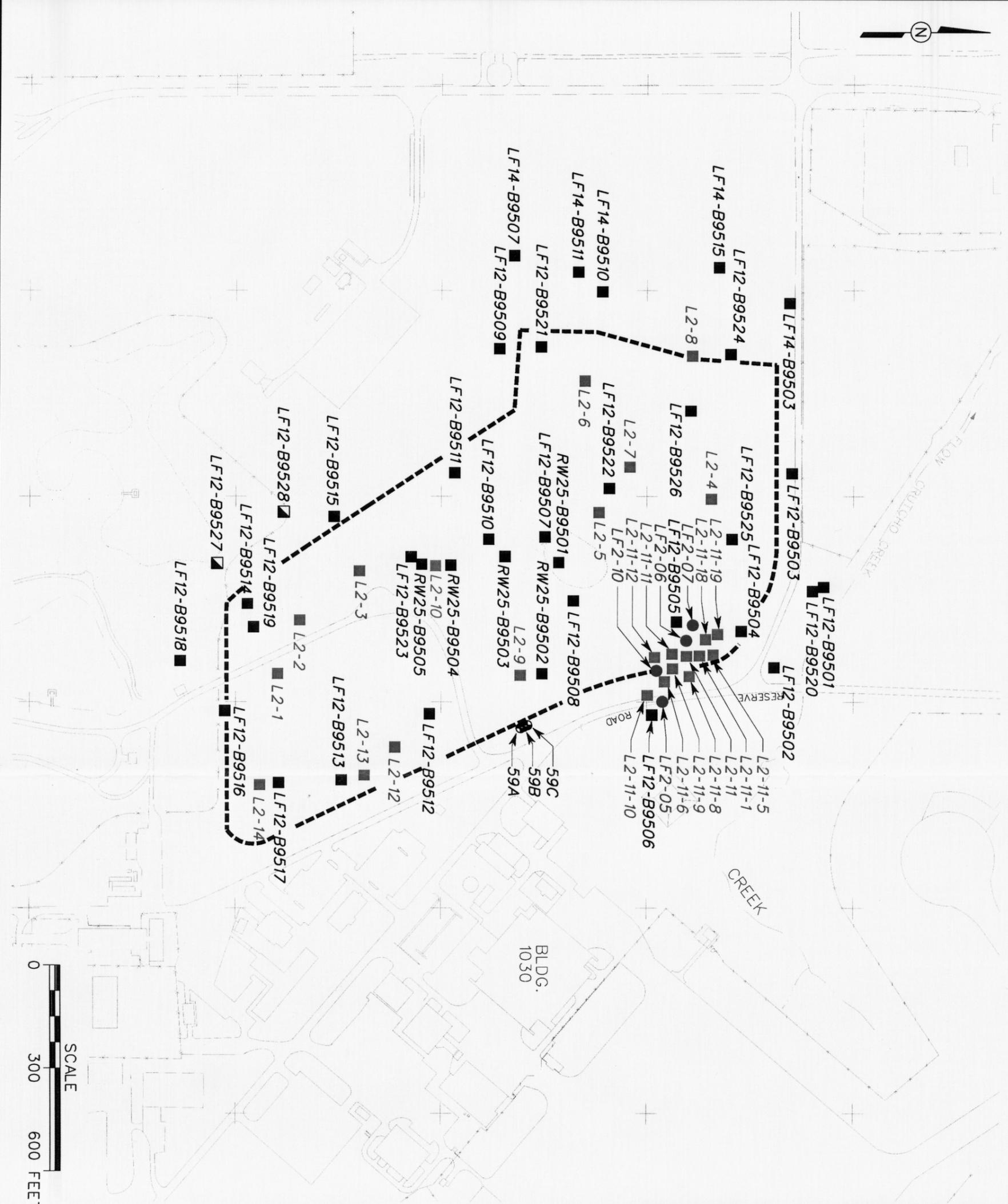
Out of 14 metals detected in the subsurface soils at Landfill 2 during the Phase II investigation, 11 were detected at concentrations exceeding their respective SSLs, background UTLs, or both. Barium was detected in boring LF12-B9524 at a concentration exceeding its SSL. As the background UTL for barium was not exceeded, it could be assumed that its occurrence in the subsurface soils of Landfill 2 is a natural phenomenon, and not indicative of potential contamination. Barium was also detected in a subsurface sample in boring LF12-B9505 at a concentration that did exceed both the barium SSL and UTL, indicating potential contamination in the vicinity of that boring. LF12-B9505 is located in the northeast portion of the landfill in the vicinity of the former sludge dump area. Beryllium, cadmium, chromium, iron, lead, nickel, silver, and zinc were detected in subsurface soils at Landfill 2 at concentrations exceeding their respective background UTLs, although not their SSLs. Iron is widespread in nature and has no risk-based SSL criteria to compare with its detected concentrations. However, as the previously mentioned metals were detected at concentrations exceeding their background UTLs, potential metals contamination at the Landfill 2 site could be indicated. In addition to the metals detected at concentrations exceeding only their respective UTLs but not SSLs, cadmium, chromium, iron, mercury, lead, nickel, silver, and zinc were detected in the subsurface soils of Landfill 2 at concentrations exceeding both their respective background UTLs and SSLs. As indicated by the metals exceeding their UTLs only, the metals exceeding both background UTLs and SSLs indicate potential metals contamination in the subsurface soils at the landfill. The metals

exceeding background UTLs or both UTLs and SSLs were detected in soil borings LF12-B9510 through LF12-B9505, LF12-B9509, LF12-B9511 through LF12-B9513, LF12-B9516, and LF12-B9521 through LF12-B9525. Borings LF12-B9501 through LF12-B9503, LF12-B9509, LF12-B9516, and LF12-B9524 were located either on or outside of the perimeter of Landfill 2. Borings LF12-B9504 and LF12-B9505, LF12-B9511 through LF12-B9513, LF12-B9521, and LF12-B9525 were located inside the perimeter of Landfill 2, with borings LF12-B9522 and LF12-B9523 located in the north-central portion of the landfill and south-central portion of the landfill near the radioactive waste disposal site. Based on the locations of the soil borings, potential subsurface soil contamination from metals appeared to be fairly widespread about the landfill site.

During 1997, a drive-over radiological survey was conducted at Landfill 2 to ensure that the landfill was free of surface and near-surface radioactive contamination after Radioactive Waste Disposal Site 1030W had been remediated. The results of the survey indicated that there were no surface or near-surface areas that exhibited count rates exceeding background except for the southeast corner of Landfill 2, where roll-off bins containing the soils from the former radioactive waste disposal site were staged for shipping.

**Conclusions.** VOCs, SVOCs, and PCBs have been detected in the soils of Landfill 2 at concentrations exceeding their respective screening values. However, their areal distribution around the site is limited and not indicative of widespread contamination. Radionuclides were detected in both surface and subsurface soils at the landfill in 1995; however, a drive-over radiological survey performed in 1997 after the radioactive waste disposal site was remediated indicated that no radionuclides were detectable in the surface and near surface soils. Metals were also detected in both surface and subsurface soils at concentrations exceeding background, indicating potential metal contamination across the site. However, a RCRA cap has since been installed at Landfill 2, minimizing the infiltration of surface water through the landfill.

**Recommendations.** Based on the data evaluation and the presence of the landfill cap, it is recommended that no further soil investigation be conducted at this site.



- LEGEND:**
- LF12-B9501 PHASE II/RFSI SOIL BORING (IT CORPORATION, 1995)
  - ▣ LF12-B9527 PHASE II/RFSI SURFACE SOIL SAMPLING LOCATION (IT CORPORATION, 1997)
  - L2-1 USACE SOIL BORING (CORPS OF ENGINEERS, 1987, 1989 AND 1990)
  - L2-05 ARA SOIL BORING (APPLIED RESEARCH ASSOCIATES, 1992)
  - LANDFILL 2 BOUNDARY

**FIGURE ES-1**  
**LANDFILL 2**  
**SOIL BORING LOCATIONS**  
**TINKER AIR FORCE BASE**  
**OKLAHOMA CITY, OKLAHOMA**

## ***Executive Summary***

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This report presents the results of investigations conducted at solid waste management unit (SWMU) 5, Landfill 3, Tinker Air Force Base (AFB), Oklahoma, in order to meet regulatory requirements. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, a facility to undertake corrective action for any release of hazardous waste or constituents from any SWMU or area of concern (AOC) at a treatment, storage, and disposal facility. On January 12, 1989, Tinker AFB submitted its Part B permit application for renewal of its operating RCRA hazardous waste storage facility permit. The final RCRA permit, issued on July 1, 1991 requires Tinker AFB to investigate all SWMUs and AOCs and to perform corrective action at those sites identified as posing a threat to human health or the environment. The permit specifies that a RCRA Facility Investigation (RFI) be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document has been prepared to determine whether sufficient investigations have been conducted at Landfill 3 to fully characterize the site and meet permit requirements.

The report integrates the findings of previous investigations performed by the U.S. Army Corps of Engineers (USACE) and those conducted as part of the Phase II RFI program. The results of these investigations form the basis for determining whether or not additional investigation is warranted at Landfill 3, and, what corrective measures should be implemented, if any. This report focuses on the evaluation of analytical data for surface and subsurface soils collected at Landfill 3, particularly the area surrounding the perimeter of the landfill. This report does not cover the results of groundwater investigations at Landfill 3. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater (BWGW) investigation program as a part of the Phase II RFI. All groundwater sampling data are presented in the BWGW report (IT Corporation [IT], 1997)<sup>1</sup>.

***Background.*** Tinker AFB is located in central Oklahoma in the southeast portion of the Oklahoma City metropolitan area in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. Landfill 3 occupies approximately

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

8.25 acres in the southwest part of Tinker AFB. It is bounded by Crutch Creek to the north and east, Building 1022 to the west, and Landfill Road to the south.

**Source Description.** Landfill 3 was used for the disposal of an estimated 180,000 cubic yards of general refuse generated by Tinker AFB from 1952 to 1961. Industrial wastes such as paint buckets, insecticide cans, and barrels were also disposed in the landfill. Waste was disposed in a series of trenches oriented east to west across the site. Several inches of excavated, native soil was used as cover over the waste daily, and a final cover of 3 to 4 feet of soil was placed over the completed trench cells.

Two specific-use dump areas are located within the boundaries of Landfill 3. A sludge dump in the south-central area of the landfill was in use from 1961 to 1968. This dump was reported to contain waste fuels and sludge from the Petroleum, Oil, and Lubricant Facility (USACE, 1989)<sup>2</sup>. An area reportedly containing lead-contaminated soil is located in the northern portion of the landfill (USACE, 1993)<sup>3</sup>. The suspected source of this contamination was not documented in the prior reports.

**Site Investigations.** Previous Installation Restoration Program (IRP) investigations included an initial records search report (Engineering Science, 1982)<sup>4</sup>. This investigation found that Landfill 3 had a moderate potential for contaminant migration. Radian Corporation (Radian) conducted the second phase of IRP investigations from 1983 to 1984. During the Radian study, groundwater was sampled at one existing monitoring well within the landfill, but no significant contamination was detected (Radian, 1985a,b)<sup>5,6</sup>. In 1987, the USACE drilled five borings into

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<sup>2</sup>U.S. Army Corps of Engineers (USACE), 1989, *Landfill 3 Sludge Dump Contaminated Soil, Information for Removal and Decontamination, Tinker AFB, Oklahoma*, Final Report, January, 1989.

<sup>3</sup>U.S. Army Corps of Engineers (USACE), 1993, *Landfills 1-4 Remedial Investigation Report, Tinker Air Force Base, Oklahoma, Draft Final Report*, October 1993.

<sup>4</sup>Engineering Science, 1982, *Installation Restoration Program, Phase I -Records Search, Tinker AFB, Oklahoma*.

<sup>5</sup>Radian Corporation, 1985a, *Installation Restoration Program, Phase II, Stage 1, Confirmation/Quantification Report, Tinker AFB, Oklahoma*, Final Report, September 1985.

<sup>6</sup>Radian Corporation, 1985b, *Installation Restoration Program, Phase II, Stage 2, Confirmation/Quantification Report, Tinker AFB, Oklahoma*, Final Report, October 1985.

areas of suspected contamination within Landfill 3. Analytical results of soil samples collected from the borings indicated contamination from volatile organic compounds (VOC), semivolatile organic compounds (SVOC), and metals. The highest concentration of organic contaminants was detected in the area of the former sludge dump.

In 1988, the USACE collected eight soil samples from 15 borings to delineate the extent of organic contamination at the sludge dump. Based on the results of this investigation, the USACE contracted with Roy F. Weston, Inc. (Weston) to perform a full-scale test of a low-temperature thermal treatment system (Weston, 1990a,b)<sup>7,8</sup>. During the test, polychlorinated biphenyls (PCB) were discovered in the feed and process soil. Additional sampling and analysis confirmed the presence of the PCB Aroclor 1260 in the excavated soil. The test was discontinued due to the presence of the PCBs, and all excavated soil was placed back in the excavation. The USACE conducted a follow-up investigation in 1990 at the landfill. Three soil samples were collected from five borings; VOCs, SVOCs, and Aroclor 1254 were detected in the soil.

Prior to the Phase I RFI program, PRC Environmental Management Inc. (PRC) performed a RCRA Facility Assessment at Tinker AFB, which included the Landfill 3 site (PRC, 1989)<sup>9</sup>. The assessment of Landfill 3 concluded that there was a high potential for releases of hazardous waste or hazardous constituents to soil and groundwater; a low potential for releases to surface water; a moderate potential for releases to air; and high potential for the generation of subsurface gas.

Tinker AFB employed Black and Veatch Waste Science, Inc. (B&V) in 1989 to evaluate alternative cover systems for Landfill 3 and investigate the need to relocate utility systems in the vicinity of the landfill. B&V recommended a natural soil cover with a synthetic water barrier and gas control layers. The study indicated that no utilities were located in the immediate vicinity of Landfill 3. In 1990, B&V issued a design analysis report and construction specifications for the

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<sup>7</sup>Weston, R. F., Inc., 1990a, *Task Order 4, Demonstration of Thermal Stripping of JP-4 and Other VOCs from Soils at Tinker AFB, Oklahoma City, Oklahoma*, Final Report, March 1990.

<sup>8</sup>Weston, R. F., Inc., 1990b, *Decontamination Certification for Low Temperature Thermal Treatment (LT<sup>3</sup><sub>SM</sub>) Process Equipment Contaminated During a Demonstration at Tinker AFB*, April 1990.

<sup>9</sup>PRC Environmental Management, Inc. (PRC), 1989, *RCRA Facility Assessment, Tinker AFB, Oklahoma*.

selected cover at Landfill 3 (B&V, 1990a,b)<sup>10,11</sup>. The cover system was modified by USACE prior to its construction to meet RCRA requirements.

The Phase I RFI for Landfill 3 was conducted (IT, 1994)<sup>12</sup>. This investigation included a review of data collected from previous investigations at the site and compiled the data into one comprehensive report. Upon completion of the review, IT recommended the collection of additional site data to further define the extent of contamination at the site and the execution of a baseline risk assessment. The Phase II RFI program was implemented by IT with the objective of collecting additional data to fully characterize the site. Figure ES-1 shows soil boring locations from previous investigations and Phase II RFI.

**Findings.** Soil and groundwater sampling was conducted throughout the investigation period. As previously mentioned, this report presents only the soil analytical results for all the soil samples collected at Landfill 3. Groundwater analytical data from both the Phase II RFI and previous investigations are presented in the BWGW report (IT, 1997).

Site evaluation was performed by comparing the soil analytical data to generic soil screening levels (SSL) developed by EPA (1996) and with site-specific background data, to define areas of potential contamination. The SSLs are presented separately for major pathways of concern in both surface and subsurface soil. The background values were determined to be the 95 percent upper tolerance limit (UTL) established in the Basewide background (BWBG) inorganics report (IT, 1999)<sup>13</sup> and the BWBG radionuclides report (IT, 1999). The soil data were divided into surface and subsurface results and were compared to appropriate screening levels.

**Surface Soils.** Of the target parameters, six radiological constituents, twelve metals, one pesticide, and one PCB constituent were detected in the surface soils at Landfill 3. VOCs, SVOCs,

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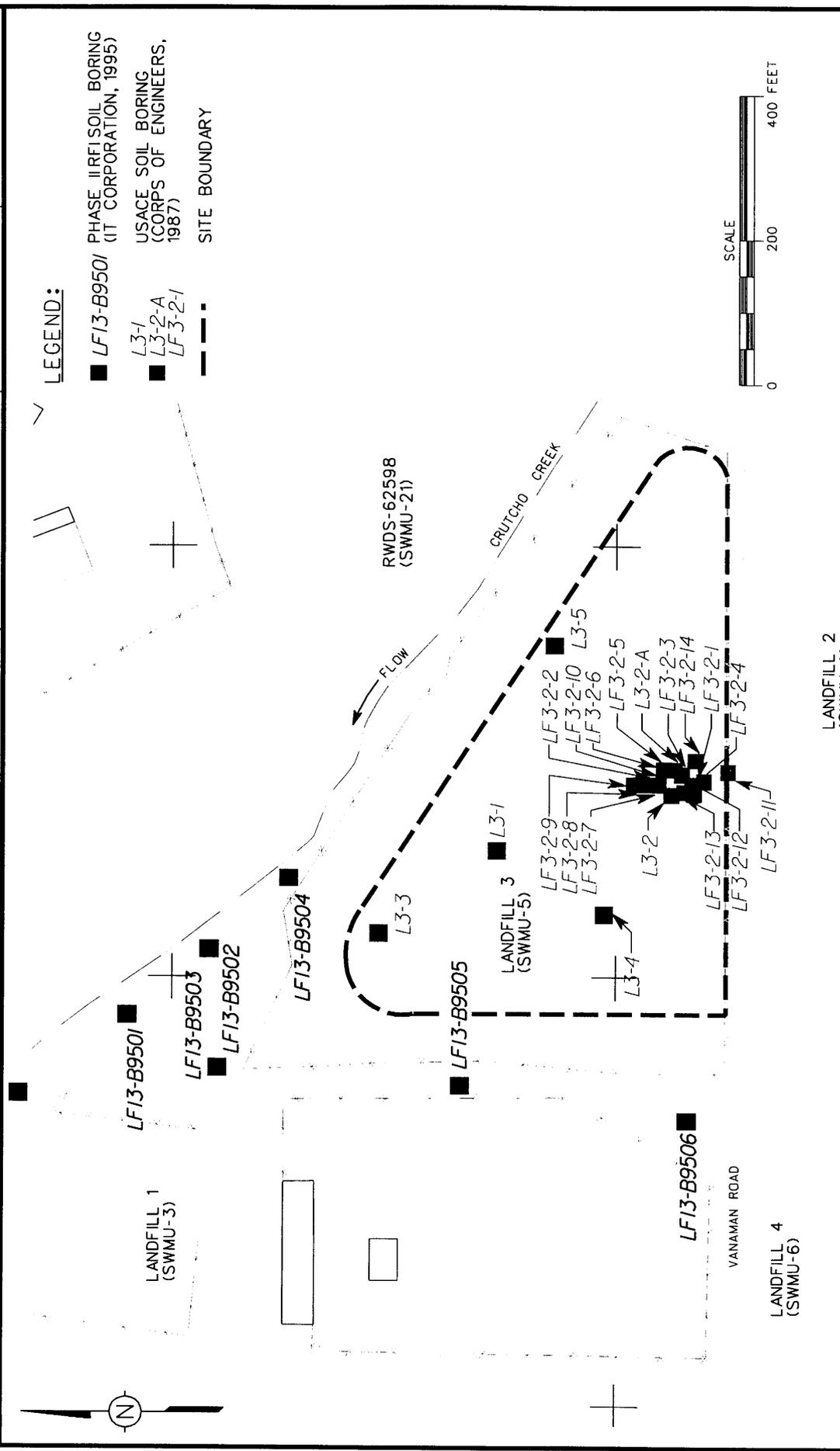
<sup>10</sup>Black and Veatch Waste Science and Technology Corporation (B&V), 1990a, *Landfill 3 Cover Design, Design Analysis, Tinker AFB, Oklahoma*, June 1990.

<sup>11</sup>Black and Veatch Waste Science and Technology Corporation (B&V), 1990b, *Landfill 3 Cover System Specifications, Tinker AFB, Oklahoma*, July 1990.

<sup>12</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume VII, Tinker Air Force Base, Oklahoma*, September 1994.

<sup>13</sup>IT Corporation (IT), 1999, *Final Report, Base-Wide Background Screening Levels, Inorganics*, May 1999.

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and TPH were not detected in any of the surface soil samples. Of the six radionuclides detected, thorium (Th)-234 was detected in two samples at concentrations exceeding the background UTL of 1.99 picoCuries per gram (pCi/g) for Th-234. Th-234 was detected in soil boring LF13-B9501 at a concentration of 2.7 pCi/g, and in soil boring LF13-B9502 at a concentration of 2.56 pCi/g.

The detected pesticide and PCB compounds were 4,4'-dichlorodiphenyltrichloroethane (DDT) and Aroclor 1260, respectively. DDT was detected in soil boring LF13-B9501, at a concentration of 45 micrograms per kilogram ( $\mu\text{g}/\text{kg}$ ). Aroclor 1260 was detected in soil boring LF13-B9504 at a concentration of 92  $\mu\text{g}/\text{kg}$ . A comparison of these data with their respective SSLs indicated that neither of these compounds were at concentrations exceeding their screening criteria.

Twelve metals were detected in the surface soil samples during the Phase II RFI. Four of the metals, cadmium, chromium, lead, and mercury, were detected at concentrations exceeding their respective background UTLs, but were below the SSLs. The metals were detected in soil borings LF13-B9501, LF13-B9502, LF13-B9504, and LF13-B9506. Cadmium concentrations ranged from 0.9 milligrams per kilogram ( $\text{mg}/\text{kg}$ ) to 1.4  $\text{mg}/\text{kg}$ . Chromium concentrations ranged from 11 to 93  $\text{mg}/\text{kg}$ . Lead concentrations ranged from 9.3 to 38  $\text{mg}/\text{kg}$ , and mercury concentrations ranged from 0.098 to 2.1  $\text{mg}/\text{kg}$ .

**Subsurface Soils.** The subsurface soil analytical data indicated that radionuclides, VOCs, SVOCs, PCBs, and metals were detected in the subsurface soil samples at Landfill 3. During the Phase II investigation, only metals and radionuclides were detected in the subsurface samples. None of the radionuclides exceeded their respective background UTL concentrations. Several metals were detected at concentrations exceeding their respective SSLs or UTLs or both. Barium, beryllium, iron, lead, nickel, and selenium were detected at concentrations above their screening levels in soil boring LF13-B9502 from 6 to 7 feet of depth. Barium was detected at a concentration of 1,770  $\text{mg}/\text{kg}$ , while beryllium was detected at a concentration of 1.9  $\text{mg}/\text{kg}$ . Iron was detected at a concentration of 27,600  $\text{mg}/\text{kg}$  and lead was detected at a concentration of 36  $\text{mg}/\text{kg}$ . Nickel was detected at a concentration of 39.9  $\text{mg}/\text{kg}$ , and selenium was detected at a concentration of 12.7  $\text{mg}/\text{kg}$ . No other constituents were detected at concentrations above screening values in any of the subsurface soil samples collected during the Phase II RFI. During the previous investigations conducted at Landfill 3, VOCs, SVOCs, PCBs, and metals were detected in the subsurface samples. All of the soil borings from the previous investigations were located in the interior of Landfill 3 (Figure ES-1). Of the VOCs detected, seven were detected at concentrations exceeding their respective SSLs. They included chlorobenzene, trans-1,2-

dichloroethene, ethyl benzene, methylene chloride, tetrachloroethane, toluene, and trichloroethene. Four out of nine SVOCs were detected at concentrations exceeding their respective SSLs, including 1,2-dichlorobenzene, 4-dichlorobenzene, 2,4-dimethylphenol, and 1,2,4-trichlorobenzene. One PCB constituent, Aroclor 1254, was detected above its SSL. Six metals were detected at concentrations exceeding SSLs and/or background UTL concentrations. The metals included cadmium, chromium, lead, nickel, silver, and zinc. Organic constituents tended to be detected at their highest concentrations in the south central portion of Landfill 3, in the vicinity of the former sludge dump. Recent data from the RFI Phase II studies at Landfill 2 and Landfill 4, located immediately to the south of Landfill 3, indicated that no VOCs or SVOCs were detected at the northern edges of these landfills, adjacent to the former sludge dump area of Landfill 3. Metals at concentrations exceeding their screening levels were detected in all of the subsurface soils analyzed for metals during the previous investigations.

**Conclusions.** Evaluation of analytical data indicates that potential contamination in the form of Th-234 and metals is present in the soils outside of the perimeter of the site. Although the detected concentrations of Th-234 exceeded its UTL value of 1.99 pCi/g, the detected concentrations were less than the Nuclear Regulatory Commission standard of 5.0 pCi/g. Historical data has indicated the presence of organic constituents and metals in the interior of the landfill, although the present condition of soils within the interior of the landfill is unknown due to lack of recent analytical data. The detection of organic constituents during previous investigations in the south central region of the landfill correlates with the historic use of this area, which included disposal of petroleum hydrocarbon waste. Recent investigations conducted at Landfills 2 and 4, immediately to the south of Landfill 3, did not indicate the presence of VOCs or SVOCs at the northern boundary of these landfills, adjacent to the former sludge dump area at Landfill 3. VOCs and SVOCs of Landfill 3 apparently have not migrated off site. The landfill has since been covered with a landfill cap to prevent the spread of any near surface contamination that may pose a threat to human health and the environment. The cap minimizes the migration of potentially contaminated leachate into groundwater.

**Recommendations.** Contamination at Landfill 3 appears to have been laterally contained and delineated and no further characterization is recommended at this site.

## ***Executive Summary***

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This report presents the results of investigations conducted at the Solid Waste Management Unit (SWMU) 6, Landfill 4, Tinker Air Force Base (AFB), Oklahoma in order to meet regulatory requirements. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, a facility to undertake corrective action for any release of hazardous waste or constituents from any SWMU at a treatment, storage, and disposal facility. On January 12, 1989, Tinker AFB submitted its RCRA Part B permit application for renewal of its operating RCRA hazardous waste storage facility permit. The final RCRA permit issued on July 1, 1991 requires Tinker AFB to investigate all SWMUs and areas of concern (AOC) and to perform corrective action at those identified as posing a threat to human health or the environment. The permit currently specifies that a RCRA Facility Investigation (RFI) be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document has been prepared to determine whether sufficient investigations have been conducted to characterize the extent of contamination at the site and to determine whether corrective action is warranted, thus meeting the permit requirements for this site.

The report integrates the findings of previous investigations and those conducted as part of the Phase II RCRA RFI program. The results of these investigations form the basis for determining whether or not sufficient investigations have been conducted to fully characterize the extent of contamination at the site, and aids in assessing the nature of corrective action that may be required at the site. The report focuses on the evaluation of soil analytical data for all samples collected during previous investigations and the recent Phase II investigation at Landfill 4.

***Background.*** Tinker AFB is located in central Oklahoma, in the southeast portion of the Oklahoma City metropolitan area, in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. Landfill 4 is located south of Vanaman Road and east of Patrol Road, adjacent to Landfill 2.

***Source Description.*** Landfill 4 was used for the disposal of an estimated 320,000 cubic yards of waste generated at Tinker AFB from 1961 to 1968. The landfill was used primarily for the disposal of general refuse, but drummed materials of solidified solvents and metal shavings were also disposed of in the landfill area. One specific-use sludge dump was located in the central portion of the landfill. This area was used for landfarming of sludges taken from the bottom of

petroleum and solvent storage tanks. The sludges were spread on top of the landfill and periodically disked to aerate the soil/sludge mixture to promote biodegradation. Borings drilled at the site revealed a mixed layer of trash just under the landfill surface composed primarily of wood, metal, paper, rubber, plastic, asphalt, and cement.

**Site Investigations.** The initial phase of the investigations conducted at Tinker AFB was conducted by Engineering Science, Inc. (ES) (1982)<sup>1</sup>. The purpose of this study was to conduct a literature search for the various potentially contaminated sites to determine from records what was actually disposed of at these sites. ES concluded that Landfill 4 had a high potential for contaminant migration.

The second phase involved investigations to confirm the presence of contamination and determine the nature and the extent of contamination at the different sites. In 1983 and 1984, Radian Corporation (Radian) was retained to perform these investigations. Field activities conducted during the Radian study involved the drilling of two new monitoring wells, one to the west and one to the south of Landfill 4 (Radian, 1985a,b)<sup>2,3</sup>. A surface leachate sample was collected from the west bank of the landfill. The report concluded that the analytical data showed only a limited impact of the landfill on groundwater quality. Total organic halogens (TOX) were detected in both monitoring wells. The leachate sample was typical of sanitary landfill leachate, high in total organic carbon and iron, but with a TOX value of 1,500 micrograms per liter, suggesting the presence of chlorinated organic compounds.

The U.S. Army Corps of Engineers (USACE) conducted a remedial investigation (RI) at Landfills 1 through 4 from 1986 to 1990. In 1987, six soil borings were advanced into the trench areas and sludge dump of Landfill 4. One sample was collected from each boring. In addition, surface soils were sampled at two locations within the landfill. Elevated levels of volatile organic compounds (VOC), semivolatile organic compounds (SVOC), and metals were detected in the subsurface soil samples, with the highest contaminant concentrations detected in borings

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<sup>1</sup>Engineering Science (ES), 1982, *Installation Restoration Program, Phase I -Records Search, Tinker AFB, Oklahoma*.

<sup>2</sup>Radian Corporation, 1985a, *Installation Restoration Program, Phase II, Stage 1, Confirmation/Quantification Report, Tinker AFB, Oklahoma*, Final Report, September 1985.

<sup>3</sup>Radian Corporation, 1985b, *Installation Restoration Program, Phase II, Stage 2, Confirmation/Quantification Report, Tinker AFB, Oklahoma*, Final Report, October 1985.

within the sludge dump and west of the sludge dump. Surface soil samples were significantly less contaminated than subsurface samples.

During the RI, groundwater encountered in borings drilled through trench areas was collected from the soil borings advanced into the landfill. Elevated concentrations of VOCs, SVOCs, metals, and radiological parameters were detected in the groundwater samples. The highest concentrations of contaminants were found in groundwater samples taken from borings within the sludge dump and west of the sludge dump.

The USACE sampled groundwater from monitoring wells in the vicinity of the landfill during RI activities from 1986 to 1990. Since 1990, selected monitoring wells have been sampled as part of an on-going groundwater monitoring program. VOCs, SVOCs, metals, and radionuclides were detected in some samples, but at concentrations significantly below those in groundwater sampled from monitor wells installed at trench locations at the landfill.

An exposure assessment was performed to determine the potential human receptors and analyze the potential exposure pathways at Landfills 1 through 4 (USACE, 1993)<sup>4</sup>. Potentially exposed human populations were limited to industrial workers associated with Base operations. The only complete exposure pathways identified during the exposure assessment were inhalation of contaminated soil particles and inhalation of organic vapors from contaminated soil. No federal threatened or endangered species have been reported at the Base.

Ten additional soil samples were collected in the vicinity of the sludge dump during a 1992 study performed by Applied Research Associates, Inc. (ARA, 1993)<sup>5</sup>. Elevated concentrations of VOCs, polynuclear aromatic hydrocarbons (PAH), and metals were detected.

PRC Environmental Management, Inc. performed a RCRA Facility Assessment (RFA) in 1989 to identify and assess the potential for release of hazardous waste or hazardous constituents from SWMUs and other AOCs, as well as to evaluate the need for further investigations under the authority of Section 3004 (u) of RCRA, as amended by the Hazardous and Solid Waste

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<sup>4</sup>U.S. Army Corps of Engineers (USACE), 1993, *Landfills 1-4 Remedial Investigation Report, Tinker Air Force Base, Oklahoma, Draft Final Report*, October 1993.

<sup>5</sup>Applied Research Associates, Inc. (ARA), 1993, *AF Site Characterization and Analysis Penetrometer System; Laser Induced Fluorescence Cone Penetrometer, Tinker AFB, Oklahoma*, prepared with North Dakota State University, February 1993.

Amendments of 1984. The RFA report incorporated the results of a review of the file materials available from EPA Region VI and a visual site inspection performed May 15 to 19, 1989. The assessment of Landfill 4 concluded that a high potential existed for release of hazardous waste or hazardous constituents to soil, groundwater, and surface water; a moderate potential existed for release of hazardous constituents to air; and high potential existed for the generation of sub-surface gas.

A soil gas investigation was conducted at Landfill 4 in 1990 (Tracer Research Corporation, 1990)<sup>6</sup>. Soil gas samples were analyzed for methane, fuel components (benzene, toluene, ethyl benzene, and xylene), three chlorinated VOCs (1,1,1-trichloroethane, trichloroethene, and tetrachloroethene), and total petroleum hydrocarbon (TPH). Elevated concentrations of methane were detected across most of the landfill. Smaller soil gas plumes of fuel components and chlorinated hydrocarbons were also detected.

Applied Research Associates, Inc. (ARA) performed a Laser-Induced Fluorescence-Electronic Cone Penetrometer Test at Landfill 4. Soil and groundwater samples were collected; soils were analyzed for VOCs, PAHs, and metals. Groundwater was analyzed for VOCs. Soil samples were found to be high in TPHs. PAHs, chlorobenzene, and trace amounts of ethyl benzene and xylenes were detected, as were numerous metals. Groundwater samples were found to contain benzene, toluene, ethyl benzene, and xylenes and chlorinated hydrocarbons.

Tinker AFB employed Black & Veatch Waste Science and Technology Corporation (B&V) in 1989 to evaluate alternative cover systems for Landfill 4 and investigate the need to relocate utility systems within the vicinity of the landfill. B&V recommended a natural soil cover with synthetic water barrier and gas control layers. In 1992, B&V issued a prefinal design analysis and construction specifications for the selected cover at Landfill 4. However, the landfill cover was not installed at that time.

IT Corporation (IT) conducted a geophysical survey at Landfill 4 (October 1995) to delineate the lateral extent of source material within the landfill trenches, verify landfill features depicted on aerial photographs, and identify any geophysical anomalies from buried drums. Although the buried drum survey was not successful due to the large amount of buried metal at the site, the

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<sup>6</sup>Tracer Research Corporation, 1990, *Shallow Soil Gas Investigation, Landfill No. 2 and 4, Tinker Air Force Base, Oklahoma.*

survey did verify surface features depicted on aerial photographs, including numerous scattered pits and surface metallic objects.

IT also conducted a radiation survey of Landfill 4 in March 1995 because the landfill was suspected to have been used for the disposal of radioactive materials. Results indicated that five areas in Landfill 4 had elevated count rates, indicating possible radionuclide contamination at the site.

The Phase I RFI was conducted (IT, 1994)<sup>7</sup> with the objective of providing Tinker AFB with one comprehensive report that summarized the various investigations which have occurred at the Landfill 4 site since 1981. The purpose of the comprehensive report was to characterize the site and identify actual or potential receptors and the action levels for protecting human health and the environment. Essentially, the Phase I RFI for this site involved reviewing of data collected from various investigations and compiling it into one report. Upon completion of the review, IT made recommendations that site-specific background data and additional site data be collected to further define the extent of contamination at the site. Thus, the Phase II RFI was designed to collect additional data in order to complete the site characterization. Figure ES-1 shows the soil boring locations from previous investigations and the Phase II RFI.

**Findings.** Site soil evaluation was performed by comparing the soil analytical data to generic soil screening levels (SSL) developed by EPA (1996)<sup>8</sup> and, with site-specific background data, to define areas of potential contamination. The SSLs are presented separately for major pathways of concern in both surface and subsurface soils. The background values were determined to be the 95 percent upper tolerance limit (UTL) established in the Basewide background soils reports (IT, 1999)<sup>9</sup>. The soil data were divided into surface and subsurface and were compared to appropriate screening levels. Constituents with concentrations exceeding the screening levels indicate potential presence of contamination. Site groundwater evaluation was performed by comparing the groundwater data to the maximum contaminant limits as defined in the Safe

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<sup>7</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume VII, Tinker Air Force Base, Oklahoma*, September 1994.

<sup>8</sup>U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

<sup>9</sup>IT Corporation (IT), 1999, *Final Report, Base-Wide Background Screening Levels, Inorganics*, May 1999.

Drinking Water Act. Detailed information on groundwater sampling results can be found in the Basewide groundwaterreport (IT, 1999).

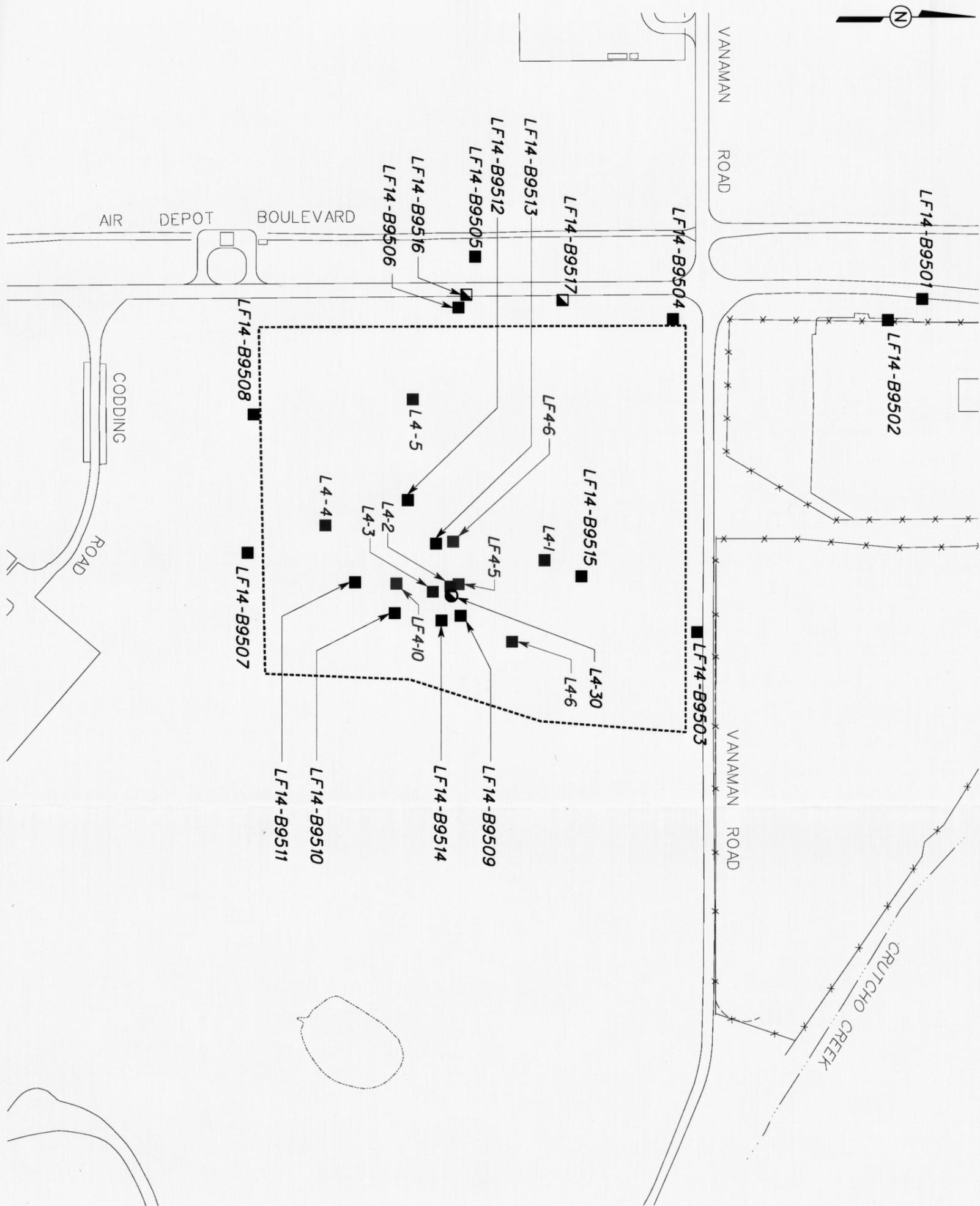
**Surface Soils.** Of the target parameters, one SVOC (benzo[a]pyrene) and four metals (cadmium, chromium, iron, and lead) were reported at concentrations exceeding the SSLs. Five detected radiological parameters (alpha and beta radiation, and radium [Ra]-226, Ra-228, and thorium [Th]-234) exceeded the 95 percent UTL for background concentrations. Pesticides and polychlorinated biphenyls (PCB) were rarely detected in surface soils and never exceeded screening levels.

**Subsurface Soils.** During the Phase I investigation, two VOCs (acetone and methylene chloride) and three SVOCs (benzo[a]anthracene, benzo[b]fluoranthene, and N-nitrosodiphenylamine) were detected in subsurface soils at concentrations exceeding the SSLs. Radionuclides were detected in the subsurface soils during the Phase II RFI, while these parameters were not tested for in Phase I samples. The detected radionuclide concentrations were compared to their corresponding 95 percent UTL background concentrations. The comparison indicated that there was only one occurrence each of Ra-226, Ra-228, and Th-234 exceeding the 95 percent UTL in the subsurface soil samples. No pesticides or PCBs exceeded screening criteria. Of the fifteen detected metals, cadmium, mercury, chromium, nickel, barium, arsenic, lead, and silver exceed SSLs/UTLs.

**Conclusions.** Based on the historical use of this site as a landfill for the disposal of general refuse and other materials, including solidified solvent and metal shavings, it is expected that soils at this site would be contaminated with metals and organic constituents. Previous investigations as well as this Phase II RFI indicated the presence of radionuclides in the soils and the groundwater of Landfill 4. Groundwater appears to be contaminated with a similar suite of metals and radionuclides as found in the soils, possibly due to downward migration of dissolved chemicals over the years.

The analytical data indicate that radionuclide compounds and metals were widely detected in the soil samples. The metal detections frequently exceeded screening levels, suggesting the site soil might have been adversely impacted by the past land use. VOCs and SVOCs were also present in some soil samples. Surface soils exhibited less impact from VOCs, SVOCs, and metals than in the subsurface. No pesticides or PCB compounds were detected at concentrations exceeding the screening levels in either surface or subsurface soils.

**Recommendations.** Currently, Landfill 4 is covered with a RCRA cap. The cap is expected to eliminate or significantly reduce the amount of vertical infiltration of surface drainage through the waste material in the trench areas. In addition, the landfill cover will prevent the spread of any surface or near-surface contamination through surface runoff into Crutch Creek. The cap has eliminated the surface depressions across the site that held surface water, thus reducing vertical infiltration of any accumulated surface water through the waste material or leachate that would potentially contaminate groundwater in the underlying aquifers. The long-term monitoring of groundwater for the southwest quadrant of Tinker AFB is currently being conducted on an annual basis. Therefore, in view of the findings and the installation of the landfill cover, further soil investigation is not warranted.



- LEGEND:**
- LF14-B9501 PHASE II RFI SOIL BORING (IT CORPORATION, 1995)
  - ▣ LF14-B9516 PHASE II RFI SURFACE SOIL SAMPLING LOCATION (IT CORPORATION, 1997)
  - L4-30 PHASE II RFI, NESTED PIEZOMETER LOCATION (IT CORPORATION, 1995)
  - L4-1 USACE SOIL BORING (CORPS OF ENGINEERS, 1987)
  - LF4-6 ARA SOIL BORING (APPLIED RESEARCH ASSOCIATES, 1992)
  - SITE BOUNDARY

**FIGURE ES-1**  
**SOIL BORING LOCATIONS**  
**LANDFILL 4**  
**TINKER AIR FORCE BASE**  
**OKLAHOMA CITY, OKLAHOMA**

## ***Executive Summary***

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This report presents the results of investigations and the soil removal action conducted at solid waste management unit (SWMU) 20, Radioactive Waste Disposal Site (RWDS) 201S, Tinker Air Force Base (AFB), in order to meet regulatory requirements. The report summarizes the findings of previous investigations and the results of the interim corrective measure (ICM) implemented at the subject site. The report was prepared as part of the Phase II, Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) program. The results of these investigations form the basis for determining whether sufficient investigations have been conducted and whether the ICM adequately removed potential contamination at the subject site. The report focuses on the evaluation of soils analytical data collected at RWDS 201S. It does not cover the results of groundwater investigations at the subject site. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater investigation program as a part of the Phase II RFI. Therefore, groundwater sampling results from this site are not addressed in this document. All groundwater data are located in the Phase II RFI report (IT Corporation [IT], 1997)<sup>1</sup>.

***Background.*** Tinker AFB is located in central Oklahoma, in the southeast portion of the Oklahoma City metropolitan area, in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. RWDS 201S is located in the north-central portion of Tinker AFB. This site is located in a grass-covered area that is surrounded on three sides by various portions of Building 201. The site is evenly graded and appears to be moderately drained. The site measures approximately 50 feet in the east to west direction and 60 feet in the north to south direction, covering a total area of approximately 3,000 square feet.

In accordance with the RCRA and the Hazardous and Solid Waste Amendments, U.S. Environmental Protection Agency (EPA) requires, as a permit condition, a facility to undertake corrective action for any release of hazardous waste or constituents from any SWMU at a treatment, storage, and disposal facility. On January 12, 1989, Tinker AFB submitted its Part B permit application for renewal of its operating RCRA hazardous waste storage facility permit.

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

The final RCRA permit issued on July 1, 1991, requires Tinker AFB to investigate all SWMUs and areas of concern (AOC) and to perform corrective action at those sites identified as posing a threat to human health or the environment. The permit specifies that an RFI be conducted for 43 identified SWMUs and 2 AOCs on the Base. This report has been prepared to document investigations which have been conducted at RWDS 201S and the ICM conducted at the subject site.

**Source Description.** RWDS 201S is located in the grass covered area south of Building 201. Prior to implementation of the interim corrective measures, the site had several man-made features. The features included an L-shaped concrete pad and three piezometers. In proximity to RWDS 201 (SWMU 20) was an underground storage tank (UST) and an above ground pump pad associated with SWMU 15. This site was reported to contain radium paint solids and dials from the radium paint room previously located in Building 201. The estimated volume of waste at the site is less than 10 cubic yards (yd<sup>3</sup>). The depth of burial was reported to be less than 10 feet.

**Site Investigation History.** Phase I of the RWDS investigation effort was conducted by U.S. Army Corps of Engineers (USACE [1989])<sup>2</sup>. This investigation consisted of a records search and personnel interviews to collect information pertaining to the disposal of radioactive waste generated by U.S. Air Force (USAF) activities on or near Tinker AFB. The USACE report provides a summary of information from various documents and interviews with key personnel who formerly worked at these sites. The report covers five radioactive waste disposal sites, including site 201S. Based on the report, it was determined that the painting of radium dials occurred within Building 201S and that occasional disposal of radium paint waste did occur at this site.

Phase II of the RWDS investigation effort was conducted by Chem-Nuclear Environmental Services (Chem-Nuclear) and Battelle Pacific Northwest Laboratories (Battelle). The work performed by Chem-Nuclear had two major objectives. The first was to conduct extensive nonintrusive radiation and geophysical surveys of the five radioactive waste disposal sites, including the Building 201 site. The second objective was to develop a proposed remediation plan for the five sites, based on the results of the surveys, and derive an approximate cost for the

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<sup>2</sup> U.S. Army Corps of Engineers (USACE), 1989, *Radiological Waste Disposal Sites, Tinker AFB, Oklahoma City, Oklahoma, Report of Records Search*, Tulsa District.

proposed plan. Volume I of the Chem-Nuclear report (1990)<sup>3</sup> contains the results of the extensive surveys, as well as recommendations for future RWDS remediation.

More recently, a site investigation at RWDS 201S was performed by Battelle (1994)<sup>4</sup> to determine the nature and extent of contamination at the subject site. An intrusive survey of the site was performed by installing six soil borings across the site (Figure ES-1). Soils that exhibited a relatively higher activity underwent RCRA metals, total petroleum hydrocarbons, and total organic carbon analyses, in addition to radiochemical analysis. The results from the intrusive survey were used in a risk assessment evaluating the threat to human health caused by the presence of radioactive contamination. The intrusive survey indicated that no radium-contaminated materials are buried at the site. However, a nonintrusive radiological survey, a limited surficial soil sampling, and gamma logging of soil cores and hand-augered holes indicated that radium dial waste may have spilled on the ground at the site. The surface radiological survey delineated a potentially contaminated source area of 560 square feet at the site. Hand augering and profile gamma-ray logging within this area of higher concentration implied that potential contamination is limited to the shallow soil, extending no more than 0.8 foot below ground surface (bgs). These data were modeled using the U.S. Department of Energy's Residual Radioactive Material Guidelines (RESRAD) code to assess the risk to human health posed by the potential contamination.

**Risk Assessment.** As discussed in the Battelle report (1994), the RESRAD code was used to perform pathway analysis and risk assessment, and to determine dose restricting levels for soil cleanup. Output from RESRAD indicated that the input surficial contamination caused a maximum dose of 190 millirems per year (mrem/yr), which occurred at time zero (time of the investigation). The report identified the primary pathway as direct external exposure to humans living on site (the model assumes a family farm scenario). The report showed that the dose dropped as time progressed and reached approximately 11 mrem/yr after 300 years. The reduction in dose was primarily due to removal of much of the source by erosion (assuming a 0.0005 meter per year erosion rate). However, after 1,000 years, radium leachate broke through into the saturated zone, elevating the total dose to 40 mrem/yr via the ingestion pathway. The report also

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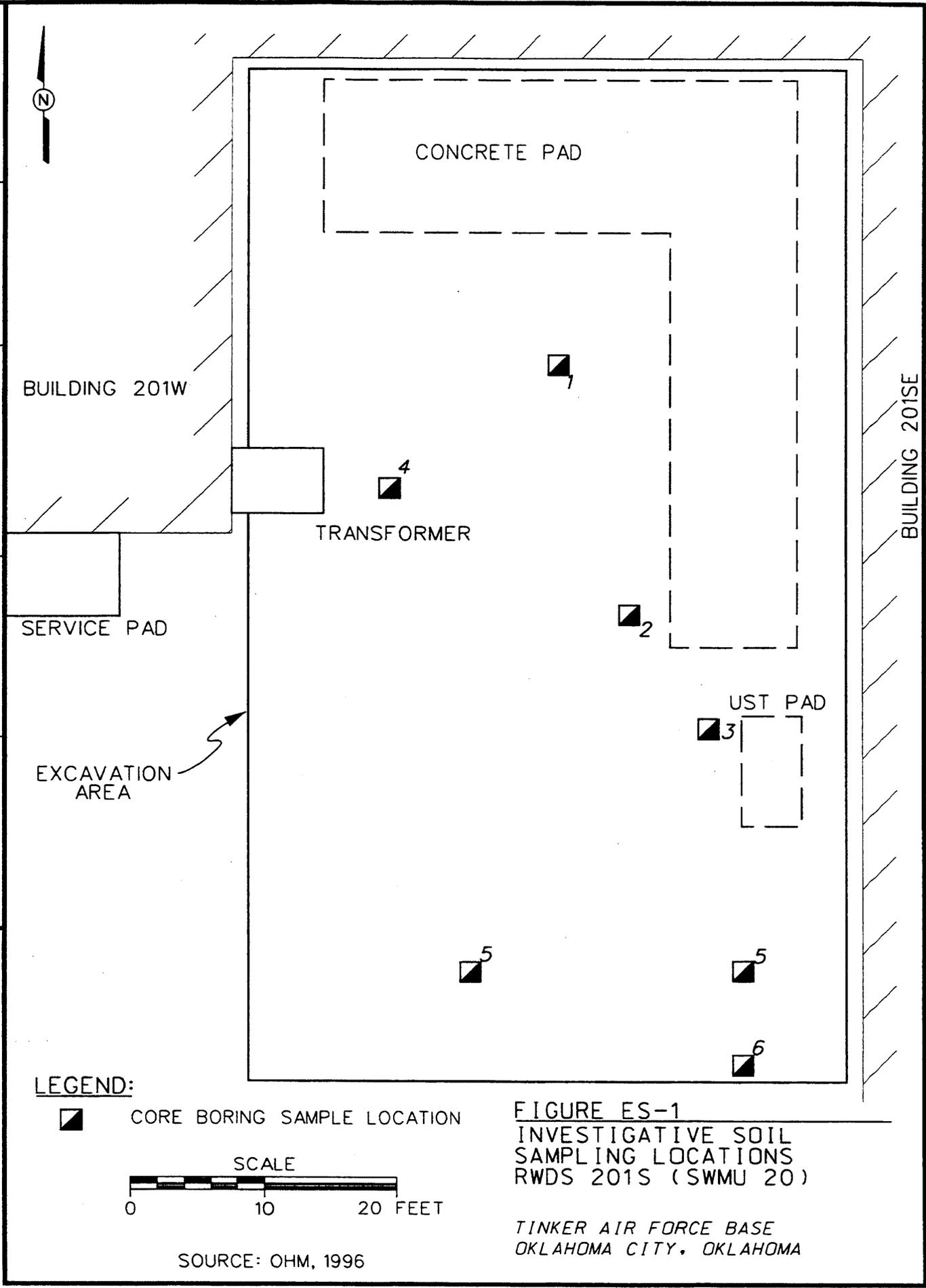
<sup>3</sup>Chem-Nuclear Environmental Services, 1990, *Investigation of the Tinker AFB Radioactive Waste Disposal Sites, Phase II*, Final Report, Vol. I, December 1990.

<sup>4</sup>Battelle Pacific Northwest Laboratories, 1994, *Intrusive Survey and Risk Assessment for Radioactive Waste Disposal Site (RWDS) 201S, Tinker AFB, Oklahoma*, Draft Report, February 1994.

STARTING DATE: 07/13/98	DATE LAST REV: 4 JUL 98	DRAFT. CHCK. BY: C. TUMLIN	INITIATOR: F. MAYILA	DWG. NO.: V762360ES.139
DRAWN BY: T. BRADSHAW	TBRADSHA	ENGR. CHCK. BY: F. MAYILA	PROJ. MGR.: R. DUBISKAS	PROJ. NO.: 762360

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**LEGEND:**

■ CORE BORING SAMPLE LOCATION



**FIGURE ES-1**  
INVESTIGATIVE SOIL  
SAMPLING LOCATIONS  
RWDS 2015 (SWMU 20)

TINKER AIR FORCE BASE  
OKLAHOMA CITY, OKLAHOMA

showed that soil removal or dilution would lower the soil concentration to 8 picoCuries per gram (pCi/g), which would result in a dose less than the 25 mrem/yr limit.

The EPA regulatory limit for radium (Ra)-226 concentration in surficial soil (0 to 15 centimeters [0 to 6 inches] bgs) is 5 pCi/g. The Battelle report indicated that if sufficient radium-contaminated soil was removed from the site to reach this EPA level, the total dose would drop below 25 mrem/yr, meeting the USAF Radioisotope Committee dose standard. Risk values calculated by RESRAD showed that the excess cancer rate from all exposure pathways at the time of the survey (t=0) amounts to  $2.180 \times 10^{-3}$ . The model showed that exposure risk drops to a total  $1.175 \times 10^{-4}$  after 1,000 years.

The primary pathway, direct exposure to humans living on site, was based on a family farm scenario. Risk values calculated by RESRAD showed excess cancer rate from all exposure pathways at the time of the survey. However, the risk values were thought to be conservative because they were based on a source term that was assumed to be contaminated as the highest level of contamination detected during the survey. The risk values also were based on the assumption that humans live at the site and are exposed to contamination throughout their lifetimes.

The Battelle study (1994) recommended removal of surficial soils with elevated concentrations of Ra-226 above 5 pCi/g. In addition, the report recommended that: (1) prior to the implementation of the surficial soil removal action, additional radiochemical analyses of the surficial soil for the presence of Ra-226 be conducted to verify that significant amounts actually are present, and (2) after establishing the presence of Ra-226 in the surface soils, a surficial survey using an alpha sensitive device should be conducted to better delineate the extent of contamination.

**Soil Removal Action.** OHM Remediation Services Corporation (OHM) performed remedial work that involved demolition of concrete pads, UST removal (SWMU 15), soil excavation, disposal of demolition and excavated materials, and site restoration. The volume of excavated soil was approximately 430 yd<sup>3</sup>. The concrete was determined clean by swipe sample results and was disposed of at a construction debris landfill. In addition, an 800-gallon UST was removed, demolished, and disposed of in accordance with the appropriate regulations. Confirmation samples were collected to determine the effectiveness of the removal action. The samples were analyzed for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals, and radionuclides.

**Analytical Results.** Analytical results for the soil samples collected prior to, during, and after the surficial soil removal action are presented in the RFI report. Analytical data collected by both Battelle and OHM were compared to risk-based soil screening levels (EPA, 1996)<sup>5</sup>. Results of the intrusive survey by Battelle (1994) showed Ra-226 was the most frequently detected radionuclide. Of the surface soil samples collected, one sample contained Ra-226 at a maximum concentration of 45.4 pCi/g, well above the EPA regulatory limit of 5 pCi/g for the first upper 15 centimeters or 6 inches of the soil. Other radionuclides were detected at concentrations below background levels and regulatory limits. Only Ra-226 and thallium-208 were detected at concentrations above background levels in seven of fifteen samples. However, all the detected concentrations were below screening levels. Barium was the only metal detected above the screening levels. It was detected in one of fifteen samples at a concentration of 2,160 milligrams per kilogram (mg/kg) above the screening criteria. Total petroleum hydrocarbons were detected in only one sample at a concentration of 627 mg/kg, and was above the regulatory limit of 50 mg/kg.

Forty-two soil samples were collected from the floor of the excavated area during the soil removal action. Samples were analyzed for radionuclides, VOCs, SVOCs, and metals. Samples were collected from a grid that was divided into five columns and eight rows. A sample was collected from the center of each grid. Ra-226 was the only radionuclide detected above the screening levels. It was detected at concentrations ranging from 0.48 to 2.34 pCi/g. However, the detected concentrations were well below the EPA regulatory limit of 15 pCi/g for subsurface soils. Arsenic was the only metal detected above the screening criteria. Only four out of forty-two samples had concentrations above the screening levels, ranging from 30 to 36 mg/kg. None of the detected organic compounds were at concentrations above the screening levels.

Three composite samples were collected from the UST excavation. Of the target compounds detected, only trichloroethene was detected at concentrations above the screening criteria. The rest of the detected compounds were not detected at significant concentrations.

After removal of 378 cubic yards of contaminated soil, six soil borings were drilled and eighteen confirmation samples collected from depths of 5, 10, and 15 feet bgs. The confirmation samples were collected by OHM and analyzed for VOCs, SVOCs, metals, and radiological parameters. Of the target parameters, six VOCs, one SVOC, eight metals, and four radiological parameters

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<sup>5</sup> U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

were reported. All the reported constituents, except Ra-226, were below the screening criteria. One sample contained Ra-226 at a concentration of 3.09 pCi/g above the screening criteria at 5 feet bgs. However, the reported radium concentration was below the EPA regulatory limit of 15 pCi/g for subsurface soils.

**Conclusions.** OHM collected samples during and after the soil removal action. Samples collected at the floor of the excavated area during the soil excavation indicated no sign of contamination. In addition, confirmation samples collected after the soil removal action at depths below the excavated surface indicate no signs of contamination. Furthermore, the results of the nonintrusive radiological survey performed after the remediation of the site confirm that radioactive contamination in the surface and near-surface soils has been removed. Therefore, it is recommended that no further action be undertaken at this site.

## ***Executive Summary***

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This report presents the results of investigations conducted at solid waste management unit (SWMU) 22, Radioactive Waste Disposal Site (RWDS) 1022E, Tinker Air Force Base (AFB), Oklahoma in order to meet regulatory requirements. The report summarizes, the findings of previous investigations conducted at the subject site. The report was prepared as part of the Phase II, Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) program. The results of the previous investigations and the Phase II RFI form the basis for determining whether or not sufficient investigations have been conducted. In addition, they also form a basis for conducting a corrective measures study if needed. This report focuses on the evaluation of soils analytical data for the soil samples collected at the site. It does not cover the results of groundwater investigations at the subject site. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater investigation program as a part of the Phase II RFI. Therefore, groundwater sampling results from this site are not addressed in this document. All groundwater data are located in the, basewide groundwater, report (IT Corporation [IT], 1997a)<sup>1</sup>.

***Background.*** Tinker AFB is located in central Oklahoma, in the southeast portion of the Oklahoma City metropolitan area, in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. RWDS 1022E is located northwest of Landfill 3 (SWMU-5), on the southwest part of the Base. The site is located directly east of a fence that surrounds Building 1022 and its outside storage area. The site is covered with grass and lies on the boundary of a depression created for the construction of Building 1022.

In accordance with the RCRA and the Hazardous and Solid Waste Amendments, the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, a facility to undertake corrective action for any release of hazardous waste or constituents from any SWMU or area of concern (AOC) at a treatment, storage, and disposal facility. On January 12, 1989, Tinker AFB submitted its Part B permit application for renewal of its operating RCRA hazardous waste storage facility permit.

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

The final RCRA hazardous waste storage permit issued on July 1, 1991 requires Tinker AFB to investigate all SWMUs and AOC and to perform corrective action at those identified as posing a threat to human health of the environment. The permit specifies that an RFI be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document has been prepared to determine whether sufficient investigations have been conducted at RWDS 1022E.

**Source Description.** Verbal and record reports obtained during Phase I of the RWDS investigation indicate that as many as eight to ten containers of radioactive material generated in Building 230 were buried at this site at a speculated depth of 30 feet. Other reports, uncovered during the same investigation, indicate this waste consisted of boxes of vacuum tubes filled with 1 milliCurie (mCi) of radon gas.

**Site Investigation.** Phase I of the RWDS investigation efforts was conducted by Engineering Science (1982)<sup>2</sup>. The efforts consisted of a record search and personal interviews to collect information pertaining to the disposal of radioactive waste generated by U.S. Air Force activities on or near Tinker AFB.

The U.S. Army Corps of Engineers (USACE) also performed a record search in 1989. The USACE report (1989)<sup>3</sup> indicates that a red reflector on a metal rod with two pieces of angle iron stuck in the ground at either side of the reflector existed at the approximate site location. Through verbal reports, it is believed that a site marker was installed at the time of the burial but was later destroyed. The USACE report stated that other reports have indicated that the materials disposed at this site probably consisted of boxes of blocking tubes (or vacuum tubes) that contained 1 mCi of radon gas (Feightner, 1989<sup>4</sup>; Burris, 1989)<sup>5</sup>.

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<sup>2</sup>Engineering Science, 1982, *Installation Restoration Program, Phase I - Records Search, Tinker AFB, Oklahoma*, April 1982.

<sup>3</sup>U.S. Army Corps of Engineers (USACE), 1989, *Radiological Waste Disposal Sites, Tinker AFB, Oklahoma City, Oklahoma, Report of Records Search*, Tulsa District.

<sup>4</sup>Feightner, C., Personal Interview with Mr. Feightner pertaining to radioactive waste disposal practice at Tinker AFB when he was Chief of Bioengineering and Base Radiological Monitor, 1950-1956 (military) and 1967-1971 (civilian), Midwest City, Oklahoma, February 1989.

<sup>5</sup>Burris D., Personal Interview with Mr. Burris, Chief of Base Civil Engineering, pertaining to radioactive waste disposal practice on Tinker AFB, Base CE Building 405 Tinker AFB, February 1989.

Phase II of the RWDS effort was conducted by Chem-Nuclear Environmental Services (Chem-Nuclear) and CDM Federal Programs Corporation (CDM). The work performed by Chem-Nuclear had two major objectives. The first was to conduct extensive nonintrusive radiation and geophysical surveys of the five radioactive waste disposal sites. The second objective was to develop a proposed remediation plan for the five sites, based on the results of the surveys, and derive an approximate cost for the proposed plan. Results of the nonintrusive radiological survey show that site radiation measurements were at or below background with the exception of one isolated spot. The spot exhibited radiation readings of 14.2 microRoentgens per hour ( $\mu\text{R/hr}$ ) above background readings that ranged from 6.5 to 7.0  $\mu\text{R/hr}$ . However, the geophysical survey results indicated several anomalies that might have been a result of various metallic objects buried at the site. Volume I of the Chem-Nuclear report (1990)<sup>6</sup> contains more details on the results of the extensive surveys, as well as recommendations for remediation of the RWDS.

The Chem-Nuclear report recommended further investigation at the site. The investigation was to involve intrusive radiological surveys in the immediate vicinity of the buried metal objects, starting in the area with elevated radiation level.

**Removal Action.** CDM was retained by Tinker AFB to conduct a removal action at the subject site. The reason for conducting the removal action was that historical records indicated that radium-contaminated objects were buried at the site in metal containers. In addition, results of the geophysical survey conducted by Chem-Nuclear indicated potential presence of buried metallic objects. Thus, the removal action was to be accomplished by excavating the site until the buried objects and the associated contaminated soils were removed or until the anomalies identified in previous investigations were resolved (CDM, 1992)<sup>7</sup>. Several objects were excavated as a result of the soil removal action. The excavated objects included three small chunks of metallic objects, large sheets of "foil," and a crushed 55-gallon drum. Two of the small chunks of metallic objects were identified as magnesium-thorium and the third chunk was a compass with radium paint on the dial. A final survey of the excavation using a hand-held instrument found no radiation contamination. Based on the findings of the removal action, the

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<sup>6</sup>Chem-Nuclear Environmental Services, 1990, *Investigation of the Tinker AFB Radioactive Waste Disposal Sites, Phase II*, Final Report, Vol.

<sup>7</sup>CDM Federal Programs Corporation (CDM), 1992, *Closure Report for Radioactive Waste Disposal Sites (RWDS) 1022E and 62598 Removal Action, Tinker AFB, Oklahoma*, January 1992.

CDM report (1992) concluded that no radioactive waste exists at the subject site. The report recommended site closure.

The Phase I RFI (IT, 1994)<sup>8</sup> provided a comprehensive report summarizing the various investigations that have occurred at the subject site since 1981. The report recommended that additional site data be collected as part of the Phase II RFI to complete site characterization. Due to the close proximity of RWDS 1022E to Landfill 3, the additional data were collected as part of the Landfill 3 investigation.

**Phase II RFI Findings.** Soil samples from four soil borings were collected at RWDS 1022E site as part of Landfill 3 site characterization (Figure ES-1). Collected samples were analyzed for the following target parameters: volatile organic compounds (VOC), semivolatile organic compounds (SVOC), total petroleum hydrocarbons, metals, pesticides/polychlorinated biphenyls (PCB), and radionuclides. Some target parameters were detected at various concentrations; others were not detected at all. Analytical data obtained were compared to site-specific background levels, upper 95 percent upper tolerance limits, and risk-based soil screening limits. Compounds with concentrations exceeding the screening criteria indicate the potential presence of contamination at the site.

No VOCs and SVOCs were detected in any of the samples. Of the target parameters, some radionuclides, pesticides/PCBs, and metals were detected. Thorium-234 was the only radionuclide detected at concentrations above the background of 1.99 picoCuries/gram (pCi/g). However, the highest concentration (2.7 pCi/g) was well below the regulatory level of 10 pCi/g. None of the pesticides/PCBs exceeded screening levels. Of the metals, only iron and selenium (detected in only one sample) were detected at concentrations exceeding the screening levels.

**Conclusions.** Evaluation of the Phase II RFI analytical data indicates no signs of soil contamination at the site or in its vicinity. These findings are consistent with the results obtained during the removal action (CDM, 1992). It is recommended, therefore, that no further action be undertaken at this site.

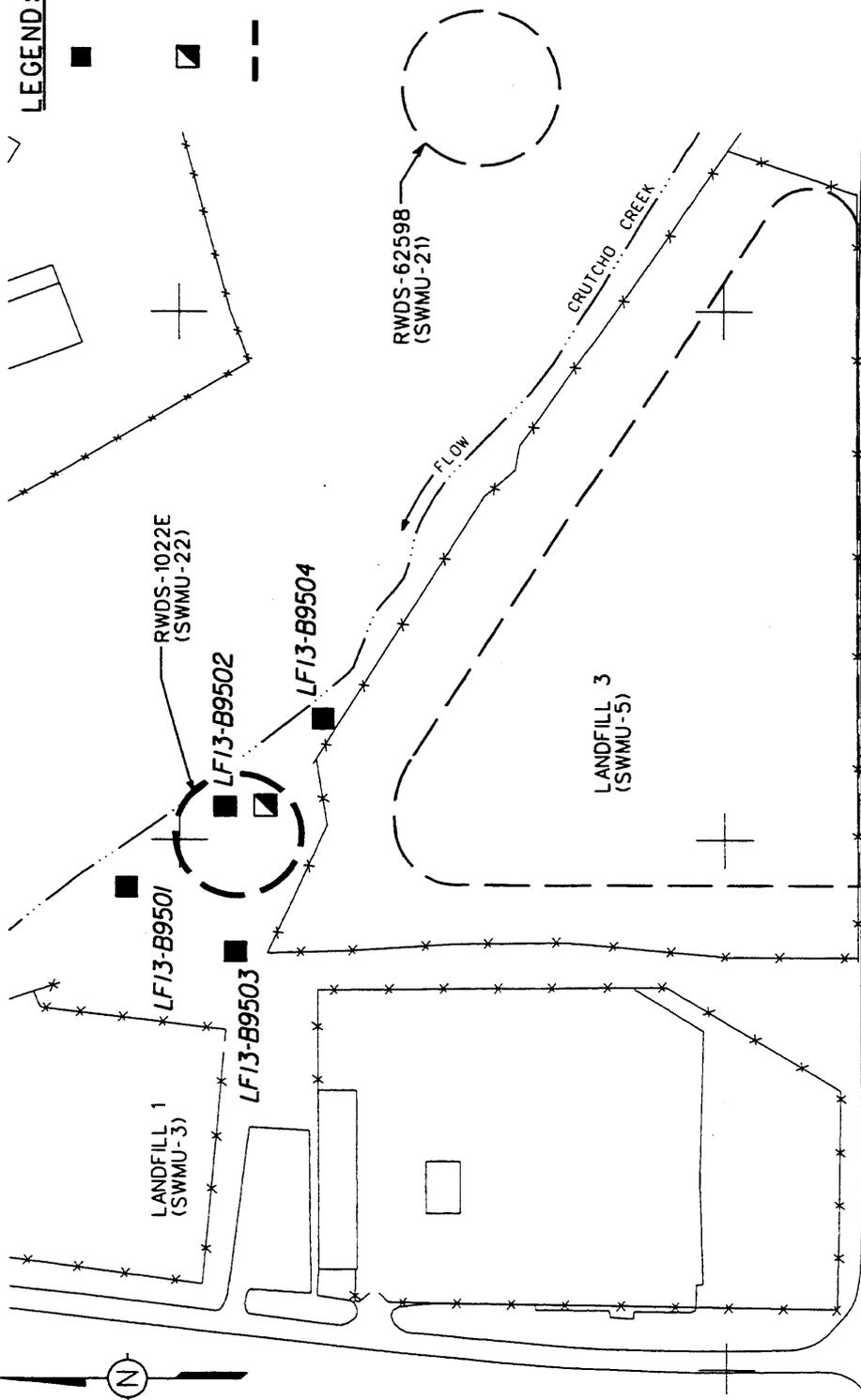
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<sup>8</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume IX, Tinker Air Force Base, Oklahoma*, September 1994.

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 DRAFT. CHCK. BY: C. TUMLIN  
 ENGR. CHCK. BY: F. MAYILA  
 INITIATOR: F. MAYILA  
 PROJ. MGR.: R. DUBISKAS  
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**LEGEND:**

- PHASE II RFI SOIL BORING LOCATION (I.T. CORPORATION, 1995)
- ▣ C.D.M. SOIL BORING LOCATION (C.D.M., 1992)
- - - SITE BOUNDARY



SCALE  
 0 200 400 FEET

**FIGURE ES-1**  
**SOIL BORING LOCATIONS**  
**AT RWDS 1022E**

TINKER AIR FORCE BASE  
 OKLAHOMA CITY, OKLAHOMA

## ***Executive Summary***

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This report presents the results of investigations and the soil removal action conducted at solid waste management unit (SWMU) 19, Radioactive Waste Disposal Site (RWDS) 1030W, Tinker Air Force Base (AFB), in order to meet regulatory requirements. The report summarizes the findings of previous investigations and the results of the removal action implemented at the subject site. The report was prepared as part of the Phase II, Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) program. The results of these investigations form the basis for determining whether sufficient investigations have been conducted, and whether the interim corrective measure adequately removed potential contamination at the subject site. The report focuses on the evaluation of soils analytical data collected at RWDS 1030W. It does not cover the results of groundwater investigations at the subject site. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater investigation program as a part of the Phase II RFI. Therefore, groundwater sampling results from this site are not addressed in this document. Groundwater data are located in the Phase II RFI, Basewide Groundwater Report (IT Corporation [IT], 1997)<sup>1</sup>.

***Background.*** Tinker AFB is located in central Oklahoma, in the southeast portion of Oklahoma City, in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. RWDS 1030W is located on Landfill No. 2 (SWMU-4). The site is now covered with a landfill cap.

In accordance with the RCRA and the Hazardous and Solid Waste Amendments (HSWA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, a facility to undertake corrective action for any release of hazardous waste or constituents from any SWMU at a treatment, storage, and disposal facility. On January 12, 1989, Tinker AFB submitted its Part B permit application for renewal of its operating RCRA Hazardous Waste Storage facility permit.

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

The final RCRA HSWA permit issued on July 1, 1991, requires Tinker AFB to investigate all SWMUs and areas of concern (AOC), and to perform corrective action at those identified as posing a threat to human health or the environment. The permit specifies that an RFI be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document has been prepared to determine whether sufficient investigations have been conducted to meet the permit requirements for RWDS 1030W.

**Source Description.** Radium-coated dials were used in the instrumentation panels of planes during the 1940s and 1950s. The radium paint was stripped from the dials with acetone or methyl ethyl ketone. Until 1951, significant radiological waste generated at Tinker AFB was sent to the Canadian Radium and Uranium Corporation in Mt. Kiska, New York. As a cost-saving measure, certain types of radiological waste were disposed of on Base from 1951 until the 1960s. Insignificant radiological waste was disposed of along with other base refuse in the landfills located in the southwest portion of the Base. RWDS 1030W was reported to be a burial site for burned radium dial waste, including rags and solvent solution. The waste was dumped in a pit, burned, and then covered with soil.

**Site Investigation.** Initial investigations at RWDS 1030W were conducted under the Installation Restoration Program by Engineering Science (ES) in 1981. ES performed a records search for several sites at Tinker AFB that have generated or been used for the disposal of waste materials. Site inspections were conducted at these facilities, interviews were conducted with Base personnel, and files were searched to collect information about these sites. Among the sites inspected were radioactive waste disposal sites, including RWDS 1030W. The ES report stressed the fact that very little information was available concerning radioactive waste disposal at the site. At the time of the site inspection RWDS 1030W was described to be submerged under water. However, information concerning the construction of the disposal pit, depth of burial, or quantity of waste disposed was not available. The ES records search and site assessment concluded that RWDS 1030W had a moderate potential for contaminant migration primarily because a pond was built over the burial site. The ES study recommended that the pond covering RWDS 1030W be drained in order to conduct an investigation of the site.

In 1989, another record search was performed by the U.S. Army Corps of Engineers (USACE). The USACE records search indicated that in the early 1970's, the Pistol Pond was constructed on top of Landfill 2, covering the RWDS 1030W site, but was drained in 1986. Based on the report, RWDS 1030W was a burial pit for burned radium dial waste, including rags and solvent solution. The waste was dumped in the pit and burned; waste residues were then covered with a layer of

soil. The documents searched by USACE did not indicate the existence of the site by 1955 as implied by verbal reports (USACE, 1989<sup>2</sup>).

In December 1990, Chem-Nuclear Environmental Services (Chem-Nuclear) performed the initial Phase II IRP characterization of RWDS 1030W (Chem-Nuclear, 1990)<sup>3</sup>. This work consisted of performing nonintrusive surficial geophysical and radiological surveys across the site in an effort to detect possible subsurface sources of contamination.

Chem-Nuclear used ground-penetrating radar (GPR) and induction electromagnetic (EM) conductivity surveys to search for buried materials. Some of the anomalies encountered during these surveys were previously mapped underground utilities. However, some anomalies were not associated with known utilities and were presumed to be buried wastes (radium paint solids and radium-painted dials).

In addition to GPR and EM surveys, Chem-Nuclear performed a ground surface gamma survey using an Eberline ESP-2 with a SPA-3 probe to determine the intensity and lateral extent of the subsurface radium contamination. During the surface gamma survey, background radiation levels in the site vicinity ranged from 6.1 to 6.5 microRoentgens per hour ( $\mu\text{R/hr}$ ). Radiation levels on the site ranged from background to 1,340  $\mu\text{R/hr}$ . General areas, as well as isolated points of significantly elevated radiation levels, were identified during the survey. The geophysical survey, along with the results from the surface gamma survey, indicated that the RWDS 1030W site had isolated pockets of subsurface soil contamination and/or buried radioactive material. The gamma survey also indicated that the elevated radiation levels roughly followed a former trench, which extended across the site in a northeasterly direction.

**Removal Action by CDM.** CDM Federal Programs Corporation (CDM) was retained by Tinker AFB to conduct a removal action at RWDS 1030W site. CDM performed a removal action by excavation at the site from June 1, 1992 through August 21, 1992. Prior to excavation, the following activities were performed:

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<sup>2</sup> U.S. Army Corps of Engineers (USACE), 1989, *Radiological Waste Disposal Sites, Tinker AFB, Oklahoma City, Oklahoma, Report of Records Search*, Tulsa District.

<sup>3</sup> Chem-Nuclear Environmental Services, 1990, *Investigation of the Tinker AFB Radioactive Waste Disposal Sites, Phase II*, Final Report, Vol. I, December 1990.

- Sampling of native vegetation and surface water to provide baseline data
- Partial drainage of water at the former site of Pistol Pond and stream diversion to assist excavation
- Excavation of two test pits to determine background radiation levels of soils in the vicinity of RWDS 1030W.

The removal action was accomplished through the excavation of potentially contaminated soils. As the site was excavated, soils were segregated into stockpiles based on the results of the surveys on the 6-inch lifts prior to removal. The stockpiles were sampled and analyzed for radioactive and chemical contamination in accordance with the sampling and analysis plan (CDM, 1992)<sup>4</sup>. Analytical results determined disposition of the stockpiles, which were either used as backfill or disposed as waste. This system minimized the amount of radioactive waste generated. All the materials exceeding release criteria were containerized in U.S. Department of Transportation Type A containers (B-25 boxes) and stored for turnover to Tinker AFB. Post-excavation confirmatory surveys were conducted to ensure no areas of elevated radiation remained (CDM, 1993)<sup>5</sup>. Clean areas were properly backfilled.

Approximately 920 cubic yards (yd<sup>3</sup>) of excavated materials were containerized in 253 B-25 boxes and disposed by Tinker AFB. Approximately 400,000 gallons of liquids were stored in 16 on-site holding tanks during the removal action and were disposed by Tinker AFB. Covered stockpiles of contaminated material, totaling approximately 270 yd<sup>3</sup>, remained on-site within the controlled zone at the time. The covered stockpiles consisted of approximately 240 yd<sup>3</sup> of radioactively contaminated soils and 30 yd<sup>3</sup> of chemically contaminated soils. Due to a shortage of project funds, CDM was unable to complete the removal action at RWDS 1030W because the extent of contamination was much greater than historical information and previous data indicated. On August 21, 1992, the site was secured to protect the general public and the surrounding environment, and CDM demobilized from the site.

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<sup>4</sup>CDM Federal Programs Corporation (CDM), 1992, *Work Plan for Radioactive Waste Disposal Sites (RWDS) 1030W (WBS 1301)*, CDM Federal, Golden, Colorado.

<sup>5</sup>CDM Federal Programs Corporation (CDM), 1993, *Interim Status Report (Preliminary Closure Report) for Radioactive Waste Disposal Site (RWDA) 1030W, Tinker AFB, Oklahoma*, August 1993.

**Phase I RFI Findings.** The Phase I RFI was conducted (IT, 1994)<sup>6</sup> with the objective of providing Tinker AFB with one comprehensive report that summarizes the various investigations that have occurred at the RWDS 1030W site since 1981. The purpose of the comprehensive report was to characterize the site, and to identify actual or potential receptors and the action levels for protecting human health and the environment. Essentially, the Phase I RFI involved a review of data collected from various investigations and compiling it into one report. The recommendations made in the Phase I RFI report (IT, 1994) included collection of site-specific background data and additional site data in order to fully define the extent of contamination at the site. The additional site data were to be collected as part of the Phase II RFI program.

**Phase II RFI Findings.** A total of 12 soil samples from 5 borings (Figure ES-1) were collected as part of the Phase II RFI program. These data were collected to fill in the data gaps identified in the Phase I RFI report. Therefore data collected from the Phase II RFI along with data from previous investigations were evaluated to complete site characterization of the RWDS 1030W site. Soil samples collected during the Phase II RFI were analyzed for: volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals, pesticides/polychlorinated biphenyls (PCB), and radionuclides (gamma specification). However, samples collected during the previous investigations were analyzed for radionuclides only. Other chemical constituents were not considered a major concern at this site. Analytical data were compared to site-specific background levels, upper 95 percentile upper tolerance limits (UTL), and risk-based soil screening levels. Compounds with concentrations exceeding the screening criteria indicate the potential presence of contamination at the site.

Six radiological parameters were detected in the soil samples collected. Detected parameters include: alpha and beta (total), potassium-40, Ra-226, Ra-228, and thorium-234 (Th-234). Surface soil samples from borings RW25-B9501, RW25-B9502, and RW25-B9504 contained Ra-226, at concentrations which exceeded the 95 percentile UTL background concentrations. Alpha total and beta total were detected above the background concentrations in the surface soil samples from borings RW25-B9502 and RW25-B9504. Four pesticides and two PCBs were detected at various concentrations in four surface soil samples. Several metallic constituents were also detected in the soil samples. However, no pesticides, PCBs, or metallic constituents were detected above the screening levels in any of the surface soil samples. No VOCs or SVOCs were detected at concentrations above their laboratory quantitation limit (LQL).

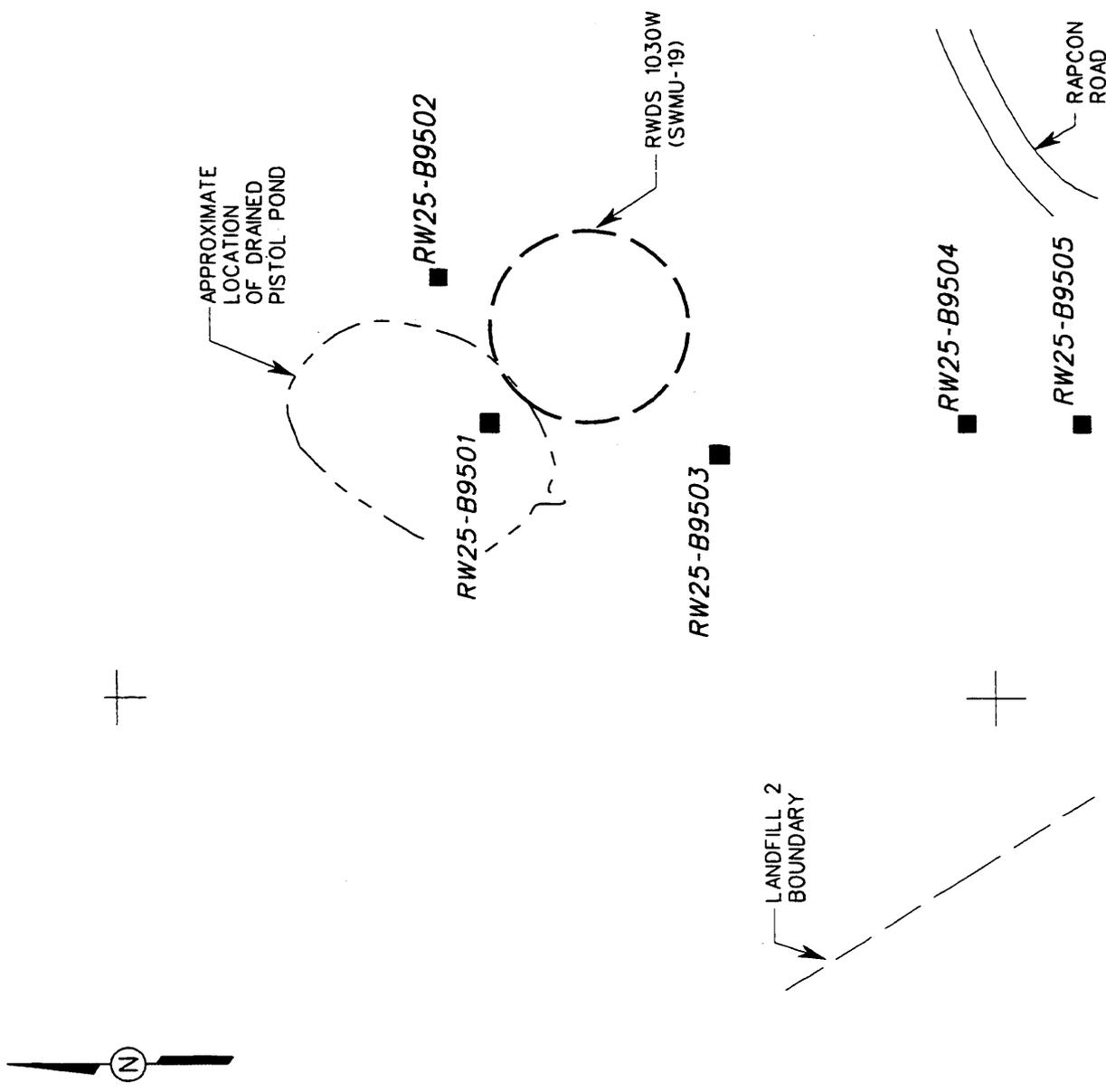
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<sup>6</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume IX, Tinker Air Force Base, Oklahoma*, September 1994.

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**LEGEND:**

- SOIL BORING LOCATION
- SITE BOUNDARY



**FIGURE ES-1**  
**PHASE II RFI SAMPLING**  
**LOCATIONS**  
**RWDS 1030W (SWMU-19)**

TINKER AIR FORCE BASE  
 OKLAHOMA CITY, OKLAHOMA

Subsurface soil samples from borings RW25-B9502, RW25-B9503, and BH-10 contained Ra-226, at concentrations above the 95 percentile UTL background levels. Total alpha was detected above the screening level in samples from borings RW25-B9502 and BH-04. Total beta at a concentration above background was found in only one soil sample. In addition, six metals were detected at concentrations above the screening levels in the soil sample from boring RW25-B9502 at the 5- to 6-foot depth interval. The detected metals included: barium, cadmium, chromium, iron, lead, and nickel. Toluene was the only VOC detected in the subsurface samples collected from soil borings RW25-B9502 and RW25-B9503. However, none of the concentrations were above the screening levels in any of the subsurface soil samples. No SVOCs or pesticides/PCBs were detected at concentrations above their LQL.

Under the Phase II RFI program, IT completed the removal action at RWDS 1030W site. Remediation was accomplished by excavating the soils in hot spot areas. Hand-held field screening instruments (ESP-1 with an SPA-3 probe) were used in determining that potentially contaminated soils had been removed. Approximately 2,100 yd<sup>3</sup> of contaminated soils were excavated and shipped by railroad to Envirocare, Inc. in Utah, for disposal. A drive-over survey performed after the soil removal action confirmed that there are no surface or near-surface areas with radioactive materials at concentrations exceeding background levels.

A RCRA cap has been installed at Landfill 2. The landfill cover was designed to minimize any vertical infiltration of surface water through the landfill, so that potential contaminants into groundwater could be prevented.

**Conclusions.** Evaluation of the site analytical data indicates no signs of soil contamination at the site. Also, the soil removal action performed by IT removed all the soils contaminated with radionuclides. The resulting excavation was backfilled with clean soil. In addition, a RCRA cap has been installed over the site. Therefore, in view of these findings and installation of the landfill cover over the site, further soil investigation at this site is not warranted. Furthermore, the evaluation of the analytical data from the Phase II RFI soil borings indicates no signs of contamination.

## ***Executive Summary***

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This report presents the results of investigations conducted at solid waste management unit (SWMU) 21, Radioactive Waste Disposal Site (RWDS) 62598, Tinker Air Force Base (AFB), Oklahoma to meet regulatory requirements. In accordance with the Resource Conservation and Recovery Act (RCRA), the U.S. Environmental Protection Agency (EPA) requires, as a permit condition, that a facility undertake corrective action for any release of hazardous waste or constituents from any SWMU or area of concern (AOC) at a treatment, storage, and disposal facility. On January 12, 1989, Tinker AFB submitted an application for renewal of its RCRA Part B permit to operate its RCRA hazardous waste storage facility. The final RCRA permit issued on July 1, 1991 requires that Tinker AFB investigate all SWMUs and AOCs and perform corrective action at those sites identified as posing a threat to human health or the environment. The permit specifies that a RCRA facility investigation (RFI) be conducted for 43 identified SWMUs and 2 AOCs on the Base. This document was prepared to determine whether sufficient investigations have been conducted at RWDS 62598 to provide full characterization of the site and whether the site meets permit requirements.

This document integrates the findings of previous investigations conducted at the RWDS 62598 site and those conducted as part of the Phase II RFI program. The results of these investigations form the basis for determining whether additional investigation is warranted at RWDS 62598, and if so, what corrective action should be implemented. This report focuses on the evaluation of analytical data for surface and subsurface soils at RWDS 62598. It does not cover the results of groundwater investigations at the subject site. Evaluation of groundwater contamination at Tinker AFB is being addressed under the Basewide groundwater (BWGW) investigation program as a part of the Phase II RFI. All groundwater data are presented in the BWGW report (IT Corporation [IT], 1997)<sup>1</sup>.

**Background.** Tinker AFB is located in central Oklahoma in the southeast portion of the Oklahoma City metropolitan area in Oklahoma County. The Base is bounded by Sooner Road to the west, Douglas Boulevard to the east, Interstate 40 to the north, and Southeast 74th Street to the south. The Base encompasses approximately 5,000 acres. RWDS 62598 is located north of Crutcho Creek, east of Landfill No. 3, and west of Reserve Road.

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<sup>1</sup>IT Corporation (IT), 1997, *Final Report, Basewide Non-NPL Groundwater, Phase II RCRA Facility Investigation Report for Appendix I and II SWMUs, Tinker Air Force Base, Oklahoma*, June 1997.

**Source Description.** Radium-coated dials were used in the instrument panels of planes during the 1940s and 1950s. The radium paint was stripped from the dials with acetone or methyl ethyl ketone. The resulting waste (radium paint and solvent) was sent to Canadian Radium and Uranium Corporation in Mt. Kisco, New York. After the practice was discontinued in 1951 because it was no longer cost-effective, the waste was processed on Base to reduce the volume of the waste material. The solvents were volatilized from the mixture using a still made from a sheet of lead that had been shaped into a tube approximately 12 to 18 inches in diameter and approximately 18 inches high. When the still became radioactively *hot*, a top was soldered on and the still was buried at RWDS 62598 (U.S. Army Corps of Engineers, 1989)<sup>2</sup>.

**Site Investigation.** A Phase II report by Chem-Nuclear Environmental Services (Chem-Nuclear, 1990)<sup>3</sup> cites a U.S. Air Force document stating that the still had been removed from RWDS 62598. A record search conducted in 1989 did not confirm such a removal. No information has been found that described the fate of any subsequent radium stills. The investigation of RWDS 62598 included nonintrusive survey techniques such as radiation surveys, ground-penetrating radar (GPR), total magnetic field gradiometer, and induced electromagnetic (EM) conductivity surveys in an attempt to characterize the extent of contamination present at this site.

The radiation survey showed that the site's gamma radiation exposure level was equal to or below the general background level. No elevated gamma radiation exposure levels were detected on the ground surface at RWDS 62598. The GPR survey of this site was impeded by soil piles scattered across the site. One anomaly was detected approximately 2 feet southeast of a concrete monument that has a radiation warning sign. The anomaly exhibited the characteristics of a burial pit, 1 to 6 feet deep. The total magnetic field gradiometer survey revealed one significant magnetic anomaly. The location of this anomaly correlated with the anomaly detected during the GPR survey and exhibited the characteristics of a buried ferromagnetic object at the 3 to 6 feet depth. The induced EM conductivity survey detected no significant anomalies.

RWDS 62598 was excavated with the objective of either finding and removing the lead still or providing additional evidence to support the report that the still had previously been removed and shipped off site. Nothing was found at the site, and following a confirmatory survey by

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<sup>2</sup>U.S. Army Corps of Engineers, 1989, *Radiological Waste Disposal Sites, Tinker AFB, Oklahoma City, Oklahoma, Report of Records Search*, Tulsa District.

<sup>3</sup>Chem-Nuclear Environmental Services, 1990, *Investigation of the Tinker AFB Radioactive Waste Disposal Sites, Phase II*, Final Report, Vol.

personnel from Armstrong Laboratory, Brooks AFB, the excavation was backfilled. As an additional safety precaution, Tinker AFB conducted a records search. As in the 1989 Chem-Nuclear records search, the Tinker AFB records search could not conclusively verify off-site shipment. However, the records search does document that a shipping arrangement between Tinker AFB and Canadian Radium and Uranium Corporation was in place at the time, and the still was probably shipped off site for disposal or resource recovery.

The Phase I RFI was conducted (IT, 1994)<sup>4</sup> with the objective of providing Tinker AFB with one comprehensive report that summarizes the various investigations that have occurred at RWDS 62598 since 1981. Upon completion of the report, IT recommended that site-specific background data and additional site data be collected to further define the extent of contamination at the site.

**Findings.** To implement the Phase I RFI recommendations, IT conducted soil sampling at the site as part of the Phase II RFI. A total of five soil borings (RW27-B9501 through RW27-B9505) and two geotechnical borings (RW27-B9506 and RW27-B9507) were drilled at this site (Figure ES-1). The soil borings were located so that data drawn from them would complement the existing database and clarify the exact limits of soil contamination. As previously mentioned, this report presents only the soil analytical results for all of the soil samples collected at the RWDS 62598. Groundwater analytical data from both the Phase II RFI and previous investigations are presented in the BWGW report (IT, 1997).

To evaluate the site, soil analytical data were compared to generic soil-screening levels (SSL) developed by EPA (1996)<sup>5</sup> and with site-specific background data, to define areas of potential contamination. The SSLs are presented separately for major pathways of concern in both surface and subsurface soils. The background values were determined to be at the 95-percent upper tolerance limit (UTL) established in the final reports for the Basewide background study (IT, 1999)<sup>6</sup>. The soil data were divided into surface and subsurface data and were compared to

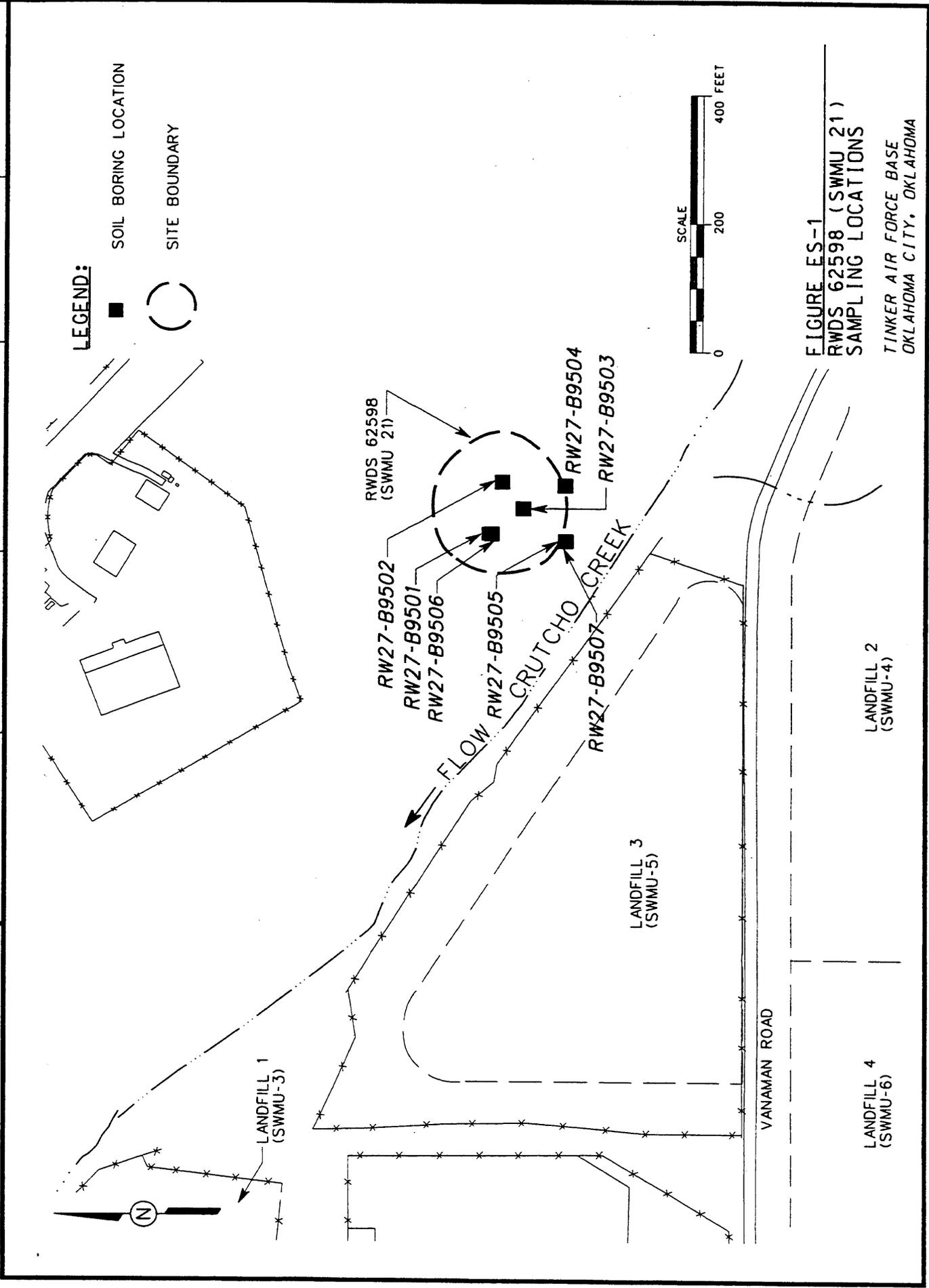
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<sup>4</sup>IT Corporation (IT), 1994, *Final Report, Phase I RCRA Facility Investigation for Appendix I Sites, Volume IX, Tinker Air Force Base, Oklahoma*, September 1994.

<sup>5</sup>U.S. Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: Technical Background Document*, May 1996, EPA/540/R-95/128.

<sup>6</sup>IT Corporation (IT), 1999, *Final Report, Base-Wide Background Screening Levels, Inorganics*, May 1999.

TBRADSHA	15:48:28	STARTING DATE: 07/13/98	DATE LAST REV: 3 JUL 98	DRAFT, CHCK. BY: C. TUMLIN	INITIATOR: F. MAYLIA	DWG. NO.: 762360ES.142
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appropriate screening levels. Constituents with concentration levels exceeding the screening levels indicate potential presence of contamination.

**Surface Soil.** During the Phase II RFI, only radiological constituents and metals were detected in surface soil samples from RWDS 62598. Five radionuclide detections exceeded the 95th-percentile UTL background concentration levels for surface soils. Three detections for total beta ranging from 21.8 picocuries per gram (pCi/g) to 52.1 pCi/g exceeded the 95th-percentile UTL background activity concentration levels. One detection of 42.4 pCi/g for total alpha and one detection of 1.80 pCi/g for radium-228 exceeded their respective 95th-percentile UTL background activity concentration levels. Ten metals were detected in the surface soils at various concentration levels. Cadmium and lead were detected at concentration levels exceeding their respective UTLs, although their SSLs were not exceeded. Arsenic was detected at a concentration level exceeding its SSL but not its UTL. No other metals exhibited concentration levels exceeding the generic SSLs and/or the 95th-percentile UTL background concentration screening levels.

**Subsurface Soil.** During the Phase II RFI, radionuclides, volatile organic compounds (VOC), and metals were detected in the subsurface soil samples at RWDS 62598. Only one radionuclide constituent, total beta at an activity concentration level of 53.9 pCi/g, exceeded its 95th-percentile UTL background activity concentration level. This constituent was detected in a sample collected from boring RW27-B9501 at a depth of 5 to 6 feet below ground surface (bgs). Eleven metals were detected at various concentration levels greater than their lower quantitation limits (LQL) in the subsurface soil samples. Mercury was the only metal reported at a concentration level exceeding both its 95th-percentile UTL and its SSL. It was detected at 1.4 milligrams per kilogram in the subsurface soil sample from boring RW27-B9503 at a depth interval of 3 to 3.5 feet bgs. Arsenic, barium, chromium, nickel, and selenium were detected at concentration levels exceeding their respective SSLs but not their UTLs. Acetone and toluene were the only VOCs detected exceeding their LQLs in the subsurface soil samples. An acetone concentration level of 2,200 micrograms per kilogram was reported in a dilution sample collected from boring RW27-B9501 at a depth of 5 to 6 feet bgs. This concentration level for acetone exceeded its generic SSL. No other VOCs, semivolatile organic compounds, pesticides, or polychlorinated biphenyls were detected in the RWDS 62598 subsurface soil samples at concentration levels exceeding their LQLs.

**Conclusion.** The comparison of the analytical results with the EPA generic SSLs and the 95th-percentile UTLs for the site-specific background concentration levels for radionuclides, metals,

and VOCs indicates that all constituents analyzed, except total alpha, total beta, radium-228, mercury, and acetone, are below these screening levels. The isolated occurrences of radium-228, total alpha, mercury, and acetone in one sample each, and beta (total) in four samples, indicate that these constituents are fairly limited in both areal and vertical extents at the site. Of the three radionuclide contaminants previously noted, radium-228 is the only one that is regulated. A radium-228 activity concentration level of 1.80 pCi/g was detected in surface soil from soil boring RW27-B9505, which exceeds the 95th-percentile UTL background activity concentration level. However, this activity concentration level is less than the 5 pCi/g guideline for total radium in the first 15 centimeters below the soil surface as established by the Nuclear Regulatory Commission. It is concluded that sufficient data are currently available to characterize the extent of contamination at the site. Based upon the data evaluation, no further characterization is warranted at RWDS 62598.