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**Five-Year Review Report for  
the Soldier Creek / Building 3001 NPL Site**

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*Submitted to*



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

**Air Force Contract F34650-98-D-0034**

**Delivery Order 5006**



*September 1998*

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**FIVE-YEAR REVIEW REPORT FOR**  
**THE SOLDIER CREEK / BUILDING 3001 NPL SITE**

Submitted to

**DEPARTMENT OF THE AIR FORCE**  
**OKLAHOMA CITY AIR LOGISTICS CENTER**  
**TINKER AIR FORCE BASE, OKLAHOMA**

**Air Force Contract F34650-98-D-0034**  
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September 1998



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## ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
ARAR	Applicable or relevant and appropriate requirement
ATSDR	Agency for Toxic Substances and Disease Registry
Battelle	Battelle Memorial Institute
BHRA	Baseline human health risk assessment
BTEX	Benzene, toluene, ethylbenzene, and xylenes
B&V	Black & Veatch Waste Science and Technology Corporation
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	Chemical of potential concern
Cr	Chromium
CSM	Conceptual site model
CWA	Clean Water Act
DCE	Dichloroethene
DNAPL	Dense non-aqueous phase liquid
EPA	U.S. Environmental Protection Agency
ERA	Ecological risk assessment
FFA	Federal facilities agreement
GWTP	Groundwater treatment plant
HHRA	Human health risk assessment
HHRA I	Human health risk assessment (first annual)
HHRA II	Human health risk assessment (second annual)
HHRA III	Human health risk assessment (third annual)
HI	Hazard index
HKS	Harry Keith & Sons, Incorporated
IRP	Installation Restoration Program
IWTP	Industrial wastewater treatment plant
LSZ	Lower saturated zone
MCL	Maximum contaminant level
mg/Kg	Milligrams per kilogram
mg/L	Milligrams per liter
NPDES	National Pollutant Discharge Elimination System

## ACRONYMS AND ABBREVIATIONS (Continued)

NPL	National Priority List
NTA	North Tank Area
OAC	Oklahoma Administrative Code
OC-ALC	Oklahoma City – Air Logistics Center
OC-ALC/EMR	Oklahoma City – Air Logistics Center/Environmental Management Restoration Division
OCC	Oklahoma Corporation Commission
ODEQ	Oklahoma Department of Environmental Quality
O&M	Operation and maintenance
OSDH	Oklahoma State Department of Health
OU	Operable unit
PAH	Polycyclic aromatic hydrocarbon
Parsons ES	Parsons Engineering Science, Inc.
PCB	Polychlorinated biphenyl
PCE	Tetrachloroethene
ppb	Parts per billion
POL	Petroleum oil lubricants
ppm	Parts per million
PRP	Potentially responsible party
RA	Risk assessment
RAO	Remedial action objective
RBCA	Risk-based corrective action
RCRA	Resource Conservation and Recovery Act
RGO	Remedial goal option
RI	Remedial investigation
RME	Reasonable maximum exposure
ROD	Record of Decision
SCSSW	Soldier Creek sediment and surface water
SCOBGW	Soldier Creek off-base groundwater
SDWA	Safe Drinking Water Act
SF	Slope factor

## ACRONYMS AND ABBREVIATIONS (Continued)

SVOC	Semivolatile organic compound
TBC	To-be-considered
TCE	Trichloroethene
TPH	Total petroleum hydrocarbon
TTNUS	Tetra Tech NUS, Inc.
µg/L	Micrograms per liter
USACE	United States Army Corps of Engineers
UST	Underground storage tank
USZ	Upper saturated zone
VOC	Volatile organic compound
WCFS	Woodward-Clyde Federal Services



## SECTION 1 INTRODUCTION

The U.S. Air Force has conducted a five-year review of the remedial action implemented at the Soldier Creek/Building 3001 National Priorities List (NPL) site at Tinker Air Force Base in Oklahoma. The primary purpose of the review is to determine whether the remedy remains protective of human health and the environment. Five-year review reports identify deficiencies, if any, and recommendations to address them. Five-year review reports document the evaluation of the implementation of the remedy and operation and maintenance (O&M), as well as the continued appropriateness of remedial action objectives (RAOs), including cleanup levels at a site.

This review is required by statute. Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and Section 300.430 (f) (4) (ii) of the National Oil and Hazardous Substance Contingency Plan (NCP), require that periodic (no less often than every five years) reviews be conducted for sites where hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestricted exposure following the completion of all remedial actions.

Executive Order 12580 delegates the authority to conduct five-year reviews to the Departments of Defense and Energy, where either the release is on, or the sole source of the release is from, any facility under the jurisdiction of those departments. In the Federal Facilities Agreement signed on December 9, 1988 between the U.S. Air Force, EPA, and the Oklahoma State Department of Health (succeeded by the Oklahoma Department of Environmental Quality in 1993), the U.S. Air Force was established as the lead agency for remediating the Soldier Creek/Building 3001 NPL site.

This review is being conducted following EPA guidance. Five-year reviews are conducted as a matter of policy at: 1) sites where no hazardous substances will remain above levels that allow unlimited use and unrestricted exposure after completion of remedial actions, but the cleanup levels specified in the Record of Decision (ROD) will require five or more years to attain; and, 2) sites addressed before SARA at which the remedy, upon attainment of cleanup levels, will not allow unlimited use and unrestricted exposure. The Soldier Creek/Building 3001 NPL site is subject to the five-year review because hazardous waste remains onsite (Building 3001 only) and continued monitoring is required.

This is the first five-year review for the Soldier Creek/Building 3001 NPL site. The trigger for this statutory review is the implementation of the remedial action at the

Building 3001 Operable Unit (OU) in 1993. The groundwater treatment plant was physically completed in February 1993, and operational shakedown activities followed. Continuous operations of the groundwater treatment plant commenced in June 1994.

EPA has established a tiered approach to conducting five-year reviews, which allows reviews to be tailored to the status of activities onsite and to site-specific considerations. Four levels of review have been established that detail the type of activities which should take place. Level 1 represents the fundamental review type, and is appropriate for most sites where construction is complete. Levels 2 and 3 represent enhanced levels of review needed to address site-specific considerations. A recalculation of risk is a typical feature of a level 2 review. A new risk assessment is a typical feature of a level 3 review. Level 1a reviews, which were developed for sites with an ongoing response, generally apply to sites where construction is not complete. A site visit, interviews, and an applicable or relevant and appropriate requirements (ARARs) review are not needed at the 1a review level. A level 1 review was conducted at the Soldier Creek/Building 3001 NPL site.

## **SECTION 2 BACKGROUND**

### **2.1 PHYSICAL CHARACTERISTICS**

The Soldier Creek/Building 3001 NPL site is located within the northeast quadrant of Tinker Air Force Base (AFB), OK, and includes adjoining off-base properties and waterways to the north and east. The off-base properties included in the NPL site are within the corporate limits of Oklahoma City and are bounded to the east by East Soldier Creek and to the north by Interstate 40. Included in the NPL site are the main stem of Soldier Creek, and all tributaries of Soldier Creek originating on Tinker AFB. The Soldier Creek/Building 3001 NPL site is divided into four distinct areas for remediation. Each of these areas is designated as an operable unit (OU) as shown in Figure 1. This five-year review primarily addresses the first two OUs which have had Records of Decision (RODs) issued. The remaining two OUs (OU-3 and OU-4) are discussed as they are contiguous to OU-1 and OU-2 and environmentally related.

Operable Unit 1 (OU-1), also defined as the Building 3001 OU or Building 3001 site, includes the building complex (covering 50 acres), Pit Q-51, the North Tank Area (NTA), and the surrounding areas encompassed by the lateral extent of a groundwater contaminant plume emanating from Building 3001. OU-1 is located in the northeast quadrant of the base and covers an area of approximately 220 acres.

Operable Unit 2 (OU-2), also referred to as the Soldier Creek Sediment and Surface Water (SCSSW) OU of the Soldier Creek site includes Soldier Creek, its tributaries, and any area underlying or adjacent to the waterway that may be contaminated by the migration of hazardous substances or pollutants from Tinker AFB. The tributaries of Soldier Creek are unnamed, but are referred to as East and West Soldier Creeks in this report. As required in the SCSSW ROD, a work plan was created for monitoring this OU and the work plan established the boundaries of the OU. As defined in the work plan (WCFS, 1994), the boundaries of the SCSSW OU are as follows: 1) All sediment and surface water of East Soldier Creek that originate on Tinker AFB to the intersection of East Soldier Creek and Interstate 40 north of Tinker AFB, and 2) All sediment and surface water of West Soldier Creek that originate on Tinker AFB to the intersection of West Soldier Creek and Interstate 40 north of Tinker AFB.

These boundaries include the ditches leading from the eight NPDES outfalls to East and West Soldier Creeks, the lower portion of the stream defined as Tributary B in the RI/FS documents (just prior to its confluence with East Soldier Creek), and terrestrial habitats within the 100-year floodplain of the aforementioned stream segments (or within 50 feet from either bank of the stream where it is not located in the 100-year floodplain).

These boundaries supercede the boundaries originally established in the Soldier Creek RI (B&V, 1993b).

Operable Unit 3 (OU-3) is the Soldier Creek Off-Base Groundwater (SCOBGW) OU. Operable Unit 4 (OU-4) is the Industrial Wastewater Treatment Plant (IWTP) groundwater OU. These OUs underlay an area bounded by East Soldier Creek on the east and southeast, 44th Street on the south, West Soldier Creek on the west, and Interstate 40 on the north. The IWTP covers an area of approximately 4 acres. The SCOBGW OU covers an area of approximately 230 acres. The status of activities conducted at the SCOBGW and the IWTP is described in Appendix D as this five-year review primarily addresses OUs 1 and 2.

Environmentally sensitive areas within the Soldier Creek/Building 3001 NPL site include the Garber-Wellington aquifer and Soldier Creek as described above. The closest Superfund site is the Mosley Road Landfill site located approximately 6 miles north of Tinker AFB.

## **2.2 LAND AND RESOURCE USE**

Prior to 1941, the site was located on undeveloped pasture and prairie lands. There were some agricultural activities and ranching but no known industrial uses prior to 1941. Beginning in 1941, 960 acres of land, including the area now occupied by the IWTP, were donated to the Army Air Corps by the City of Oklahoma City for the construction of the Midwest Air Depot. Renamed Tinker Field in 1942 and subsequently Tinker Air Force Base in 1948, the entire base now covers 5,277 acres.

The on-base portion of the Soldier Creek/Building 3001 site is in the northeast quadrant of Tinker AFB which is the most industrialized area of the base. All of OUs 1 and 4 and portions of OUs 2 and 3 are within the northeast quadrant of Tinker AFB.

The off-base properties within the Soldier Creek/Building 3001 NPL site include the Kimsey Addition to the north, along with commercial/retail establishments and mobile homes to the east. The Kimsey Addition is a residential area consisting of approximately 100 homes bounded by Tinker AFB to the south and west, Interstate 40 to the north, and Douglas Boulevard to the east. The commercial/retail facilities between Tinker AFB and East Soldier Creek include convenience stores and self-storage units. Other than the Evergreen Mobile Home Park, the remainder of the site east of Douglas Boulevard and northwest of East Soldier Creek is undeveloped between the mobile home park and Interstate 40.

### **2.2.1 Building 3001**

The Building 3001 complex has been involved in reconditioning, modifying, and modernizing aircraft, including jet engine overhaul and missile repair. The industrial processes used or generated solutions containing organic chemicals including trichloroethylene (TCE), tetrachloroethylene (PCE) and metals such as chromium. Fuels for the boiler system included No. 2 fuel oil stored at the NTA. Diesel, gasoline, and waste oil were also stored at the NTA.

### **2.2.2 Soldier Creek**

Soldier Creek and its tributaries receive surface runoff from approximately 9,000 acres (14 square miles), at its confluence with Crutcho Creek. Areas of Tinker AFB that contribute runoff or discharge to Soldier Creek and its tributaries include the eastern-most runway areas and the Building 3001 complex. Prior to April 1996, the IWTP discharged treated water to East Soldier Creek.

In general, the water table aquifer discharges to East Soldier Creek within the off-base portions of the SCOBGW OU. Any recharge from East Soldier Creek to the aquifer occurs and remains within the boundaries of Tinker AFB.

### **2.2.3 Industrial Wastewater Treatment Plant**

The former sanitary wastewater treatment plant (SWTP) in the northeast quadrant of Tinker AFB was constructed in 1943. The IWTP was built in 1972 for the batch process treatment of painting and stripping solutions. The IWTP was built in conjunction with the former SWTP which operated until 1996. The SWTP was decommissioned in 1996 following further IWTP upgrades which allowed discharge of sanitary and pretreated industrial effluent directly to the Oklahoma City publicly-owned treatment works (POTW). The IWTP now operates under National Pollutant Discharge Elimination System (NPDES) permit number OK0000809 and discharges to the Oklahoma City POTW under permit number 00029-FC.

### **2.2.4 Surrounding Community**

The Soldier Creek/Building 3001 NPL site and Tinker AFB lie within an area representing transition from residential and industrial/commercial land use on the north and west to agricultural land use to the east and south. Soldier Creek and its tributaries, which flow northwest through the area, are bordered mainly by recreational and residential areas with some areas supporting commercial and industrial land use. Some off-base industries, such as a metal plating facility and a dry cleaning facility, and commercial facilities such as gas stations, auto repair facilities, and a closed sanitary landfill are located within the drainage basin. In addition, three schools, Soldier Creek Elementary, Steed Elementary, and Monroney Junior High are located within the drainage basin. There are ten public parks within the general vicinity of Tinker AFB, including the Joe B. Barns, Fred F. Meyers, Kiwanis, and Lions Parks. A public golf course is also located north of the base. Five trailer parks are located north and northeast of Tinker AFB.

The land use plan for the area immediately north of Tinker AFB, between Sooner Road and Douglas Boulevard includes all levels of land use. The areas between Sooner Road and Midwest Boulevard (see Figure 1 for location) are zoned primarily for housing (single and multifamily units) and low to medium commercial use. The area between Midwest Boulevard and Douglas Boulevard is zoned primarily for heavy commercial and moderate to heavy industrial use.

Soldier Creek, which flows from Tinker AFB into adjacent neighborhoods, is reportedly used for wading and playing by area children and is large enough to support

edible fish. No hunting or fishing has been reported to occur in the immediate area outside of Tinker AFB. Hunting is not permitted on base and fishing is not permitted in Soldier Creek within base boundaries. Beneficial uses of Soldier Creek include agriculture, secondary recreation, process and cooling water, and aesthetics. Soldier Creek also supports a warm-water aquatic community.

### **2.2.5 Human Use of Resources**

The most important source of potable groundwater in the Oklahoma City metropolitan area is the Central Oklahoma aquifer, which is commonly referred to as the "Garber-Wellington aquifer." Tinker AFB presently obtains part of its water supplies from wells that are completed in the Garber-Wellington aquifer. Base wells range from 700 to 1,100 feet in total depth, with yields ranging from 205 to 250 gallons per minute (gpm).

On the east side of Tinker AFB, the Garber-Wellington aquifer has been classified as a Class IIA aquifer by the State of Oklahoma, indicating that it provides groundwater from a major, unconfined basin that is capable of being used as a drinking water supply with little or no treatment (OAC 785:45-7-3). The western portion of the Garber-Wellington aquifer basin, which extends from the west side of the base to just west of Oklahoma County is classified as a Class IIC aquifer, a major confined groundwater basin. Tinker AFB and the nearby communities of Midwest City and Del City derive a portion of their water supply from the Garber-Wellington aquifer.

Until 1993, groundwater was used as a domestic water source by several of the residents living within and adjacent to the boundaries of the site. Most of these wells were removed from service in 1994 after municipal water distribution lines were conveyed to and installed at the residences and businesses. There are no off-base wells that are known to be used for drinking water purposes. All of the water supply wells on Tinker AFB are routinely sampled for contaminants.

## **2.3 CONTAMINANTS**

The Air Force Installation Restoration Program (IRP) Phase I identified potential sources of contamination through records searches and reviews of waste management practices. The first report of a release to the environment occurred in 1983 during routine wellhead sampling and testing. TCE and PCE were detected in two of the base water supply wells (WS 18 and WS 19) at Building 3001. A Phase II IRP investigation was conducted in 1984 to confirm and quantify contamination resulting from past waste storage practices at Building 3001. Sampling was also initiated at East and West Soldier Creek in 1984. Sample results indicated the presence of chromium and solvent contamination in the sediment and surface water. In 1985, fuel and free product contamination were found at the NTA. In September 1987, the Soldier Creek/Building 3001 site was evaluated under the hazard ranking system with a score of 42.24 and was placed on the NPL.

### 2.3.1 Building 3001 OU

Remedial investigations (RIs) were conducted at the Building 3001 OU between 1986 and 1987 to determine the nature and extent of contamination associated with Building 3001, the NTA, and Pit Q-51. The areas with highest concentrations of groundwater contamination were located beneath Building 3001, the NTA, and the Southwest Tank Area (shown on Figure 1). TCE and chromium were considered the primary groundwater contaminants, since their maximum concentrations were higher than the other contaminants and they were consistently detected over a large portion of the site. Other significant contaminants included dichloroethylene (DCE), PCE, acetone, toluene, benzene, xylenes, lead, nickel, and barium.

Samples collected from sludge in Pit Q-51 in 1986 indicated TCE, cadmium, chromium, and lead contamination. Leakage from this pit and other similar structures is considered as the source of soil and groundwater contamination beneath Building 3001.

Fuel product in the form of No. 2 fuel oil was discovered beneath a leaking 235,000 gallon underground storage tank (UST) at the NTA. As a result, the soils and groundwater beneath the NTA and the north end of Building 3001 were heavily contaminated with fuel and other organic compounds.

The groundwater used by residents and the work force of Tinker AFB was identified as an exposure pathway. Potential points of exposure included water supply wells and discharge to surface water bodies. Exposure with long-term health effects was deemed a possibility in the 1988 baseline risk assessment. A chronology leading to the NPL listing is provided in Table 2.1

**Table 2.1**  
**Chronology of Activities for Building 3001 OU**

Investigation/Activity	Description	Event Date (Source)
IRP Phase I records search conducted	Records search conducted to identify past waste disposal activities that may have caused environmental contamination.	1981 (ES, 1982)
USTs removed at North Tank Area	Two tanks (800-gallon waste oil tank and 13,000-gallon gasoline tank) removed at NTA.	1983-1985 (Battelle, 1993a)
IRP Phase II Confirmation/Quantification investigation conducted	TCE detected in groundwater in the vicinity of Building 3001.	1983 (Radian, 1985a and 1985b)
Supply wells in Building 3001 taken out of service	Water supply wells (WS-18 and WS-19) located inside Building 3001 taken out of service.	1984 (Engineering Enterprises, 1984)
Supply wells in Building 3001 plugged	Water supply wells (WS-18 and WS-19) located inside Building 3001 plugged.	1986 (Dansby & Associates, 1986)

**Table 2.1 (Continued)  
Chronology of Activities for Building 3001 OU**

Investigation/Activity	Description	Event Date (Source)
Remedial investigation and risk assessment conducted	Pit Q-51 identified as containing hazardous contaminants. Investigation conducted to determine nature and extent of contamination.	1986-1987 (USACE, 1988a and 1988b)
NPL listing	Soldier Creek/Building 3001 added to the NPL	July 22, 1987

### 2.3.2 Soldier Creek Sediment and Surface Water OU

Remedial investigations of the SCSSW OU were conducted between 1990 and 1991. Results of the sediment analyses indicated acetone, chloroform, methylene chloride, PCE, toluene, xylene, cadmium, chromium, and lead were the primary sediment contaminants. The primary surface water contaminants were acetone, chloroform, methylene chloride, PCE, toluene, 1,1,1 trichloroethane, cadmium, chromium, and lead.

The surface water and sediment of Soldier Creek were considered as potential exposure pathways for human receptors, but results of the 1993 risk assessment for these media indicated that there was not an unacceptable risk to human health. Further study was recommended to evaluate environmental risk to ecological receptors. A chronology of the events leading up to the NPL listing is provided in Table 2.2.

**Table 2.2  
Chronology of Activities for SCSSW OU**

Investigation/Activity	Description	Event Date (Source)
IRP Phase II Confirmation/Quantification Stage 2 Investigation	Determine environmental impact of solvent storage and waste disposal at Tinker AFB (initial discovery of contamination)	June 1984 – July 1984 (Radian, 1985)
Sediment and surface water sampling	Evaluate water quality effects of wastewater discharge from Tinker AFB on Soldier and Crutchko Creeks	October/November 1984 (USEPA, 1984)
Sediment sampling	Site investigation to evaluate magnitude of contamination in East and West Soldier Creeks	October 1985 (HKS, 1985)
Sediment dredging	Dredging of unknown volume of sediment from on-base portions of East and West Soldier Creeks	April/May 1986 (HKS, 1986)
NPDES surface water sampling	Determine surface water concentrations downstream of IWTP effluent discharge location	September 1986 – July 1987 (Tinker AFB)



**Table 2.2 (Continued)  
Chronology of Activities for SCSSW OU**

Investigation/Activity	Description	Event Date (Source)
Sediment and surface water sampling	Sampling was performed to collect sediment and surface water samples at the IWTP and sanitary wastewater treatment plant outfalls.	March – September 1987 (Source: B&V, 1993b)
NPL listing	Main stem of Soldier Creek and all tributaries of Soldier Creek originating on Tinker AFB were included in the NPL site	July 22, 1987

## **2.4 INITIAL RESPONSE**

The U.S. Environmental Protection Agency (EPA), U.S. Air Force, and Oklahoma State Department of Health (succeeded by the Oklahoma Department of Environmental Quality in 1993) signed a Federal Facilities Agreement (FFA) designating the Air Force as the only Potentially Responsible Party (PRP). Response actions initiated prior to the ROD are discussed below.

### **2.4.1 Building 3001 OU**

Between 1983 and 1985, two USTs, Tank 3403 (300 gallon waste oil tank) and Tank 3405 (13,000 gallon leaking gasoline tank), were removed from the NTA. Inside of Building 3001, the contents of three pits containing solvent and metals contamination were removed in 1985. The pits were backfilled and capped with concrete. Water supply wells WS 18 and WS 19 were plugged and abandoned in 1986. WS 17 was plugged and abandoned in 1988.

The Building 3001 ROD was signed in August 1990. Soils and groundwater contamination remain onsite and are in remediation. Groundwater concentrations remain above maximum contaminant levels (MCLs).

### **2.4.2 Soldier Creek Sediment and Surface Water OU**

In 1986, excavation activities were conducted along East and West Soldier Creek to identify and eliminate potential sources of contamination to Soldier Creek. Approximately 7,500 cubic yards of sediment were removed. In 1990 and 1991, several industrial cross-connections were removed that may have been contaminating the Soldier Creek storm-water system. Between 1990 and 1993, fourteen solvent pits and USTs in the vicinity of Soldier Creek were removed or abandoned.

The SCSSW ROD was signed in September 1993. Contamination remains onsite, but there have been no unacceptable human health risks associated with the levels of contaminants detected. Numerous contaminants, however, were found to present an unacceptable ecological risk. These risks were based on concentrations of site contaminants which exceeded the lowest available ecotoxicological benchmark for the exposure pathway. The adverse effects were limited to a localized scale in on-base areas. In following monitoring events, the uncertainties identified in the conclusions and recommendations of the ERA should be addressed to more clearly define the ecological risk.

## SECTION 3

### DEVELOPMENT AND IMPLEMENTATION OF THE REMEDY AND OPERATION AND MAINTENANCE

The selected remedy for the Building 3001 OU was comprised of three components: the groundwater associated with Building 3001 activities, Pit Q-51 contaminants, and the NTA impacts. This section discusses the components and operation and maintenance aspects of the Building 3001 and SCSSW OUs.

#### 3.1 BUILDING 3001 OU

##### 3.1.1 Remedy Selection

The Record of Decision (ROD), signed in August, 1990, addressed remedies for groundwater beneath Building 3001. The remedial actions selected in the ROD incorporated the following components:

###### *Building 3001 Groundwater*

- Addition of monitoring wells in order to monitor the groundwater contaminant plume.
- Extraction of contaminated groundwater from the perched water zone, top of regional water zone, and regional water zone by exterior and interior extraction wells.
- Treatment of the contaminated groundwater in a treatment facility constructed specifically for the Building 3001 remedial action.
- Treatment of volatiles contamination by air stripping and carbon adsorption.
- Treatment of metals by chemical reduction and precipitation.
- Reuse of the treated water in TAFB's industrial operations.
- Disposal of the sludge from groundwater treatment operations at an offsite RCRA-permitted facility approved to receive CERCLA waste.

###### *Pit Q-51*

- Removal of approximately 45 gallons of liquid.
- Steam cleaning of the pit, analysis of the liquid and washwater, and disposal of wastes in a facility that is approved to receive CERCLA waste.
- Backfilling of the pit with sand and covering with an 8-inch thick concrete cap to prevent future use.

*North Tank Area*

- Installation of a floating fuel product removal system to recover fuel floating above the groundwater table.
- Disposal of the recovered fuel at a RCRA-approved facility.
- Treatment of the recovered groundwater at the Building 3001 treatment plant.
- Installation of a vapor extraction system to remove fuel vapors from the subsurface soils.
- Thermal combustion of fuel vapors recovered by the removal systems.
- Removal and disposal of a 750 gallon waste tank and proper closure of a 235,000 gallon fuel oil tank.

**3.1.2 Remedy Implementation**

A chronology of the remedy development and implementation activities for the Building 3001 OU is provided in Table 3.1.

**Table 3.1  
Summary of Remedy Development and Implementation Activities at Building 3001 OU**

Investigation/Activity	Description	Date (and Source)
Remedial Investigation.	Determine extent of groundwater contamination from Building 3001.	1988 (USACE, 1988a)
Feasibility study conducted.	Feasibility study for Building 3001 site evaluated alternatives for remediating groundwater plume.	1988 (USACE, 1989b)
FFA signed.	Federal Facilities Agreement signed by Tinker AFB, EPA, and Oklahoma State Department of Health.	December 1988 (EPA, 1988)
Quarterly RI conducted.	Supplemental remedial investigation conducted.	1988-1989 (USACE, 1989a)
ROD signed.	Record of decision for Building 3001 site, including Pit Q-51 and NTA, signed. Identified selected alternatives.	August 1990 (USACE, 1990a)
Groundwater collection pilot test conducted at Building 3001.	Tested proposed groundwater collection and treatment system on a small-scale.	September 1990 (USACE, 1990b)
Product recovery initiated at NTA.	Product recovered from seven monitoring wells installed at the NTA.	May 1991 (Battelle, 1993a)
Additional recovery wells installed at NTA.	Two product recovery wells (RC-1 and RC-2) installed at NTA.	December 1991 (CDM, 1992)

**Table 3.1 (Continued)**  
**Summary of Remedy Development and Implementation Activities at Building 3001 OU**

Investigation/Activity	Description	Date (and Source)
Pit Q-51 remediated.	Pit Q-51 contents were removed and disposed of off-site. Decision document prepared. Site closed.	1991 (OC-ALC, 1991b)
Modeling and system design conducted.	Modeled groundwater flow and designed full-scale groundwater collection and treatment system.	1991 (B&V, 1991)
In-situ respiration and air permeability tests in NTA soils.	Two vapor extraction wells, five tri-level vapor pressure monitoring points, and two blower units were installed for in-situ respiration and air permeability tests.	March 1992 (Battelle, 1993)
One UST removed, one abandoned at NTA.	1,200 gallon sump pump tank removed in April, and 235,000 gallon fuel oil tank abandoned in place in May.	April and May 1992 (Parsons ES and Battelle, 1994)
Additional recovery wells installed at NTA.	Four additional recovery wells (RC-3, RC-4, RC-5, and RC-6) installed to enhance product removal at the NTA.	September 1992 (Roy F. Weston, 1992)
Groundwater treatment plant (GWTP) construction initiated at Building 3001.	GWTP construction initiated and 33 groundwater extraction wells installed.	1992 (B&V, 1992a and 1992b)
GWTP construction completed and intermittent pumping initiated.	GWTP construction completed and intermittent pumping of Building 3001 groundwater plume initiated.	February 1993 (Tinker AFB)
Fracturing demonstration project conducted at NTA.	Fracturing demonstration project was conducted to determine if fracturing could enhance product recovery at the NTA.	Summer 1993 (Parsons ES & Battelle, 1994)
Focused remedial investigation conducted at NTA.	Supplemental field investigation conducted at the NTA to further delineate the extent of product contamination.	October-December 1993 (Parsons ES & Battelle, 1994)
Extraction system operations fully initiated.	Continuous pumping of groundwater extraction wells at Building 3001 site began.	June 1994 (Tinker AFB)
Expanded fracture injection treatment at the NTA.	Installed additional recovery wells at the NTA and fracture treated the uppermost aquifer.	January 1995 (Parsons ES, 1995)
Building 3001 remediation system evaluated.	Results from one full year of operation were evaluated to evaluate progress and to determine what ways the system could be optimized.	1996 (Parsons ES, 1996)

**Table 3.1 (Continued)**  
**Summary of Remedy Development and Implementation Activities at Building 3001 OU**

Investigation/Activity	Description	Date (and Source)
Building 3001 extraction system evaluated.	Results from 2 years of groundwater extraction at Building 3001 site were evaluated. Volume of contamination removed and remaining in groundwater estimated. Estimates of the time to recover remaining contaminants were made.	1997 (Parsons ES, 1998a)
Remediation continued.	Product recovery at NTA and groundwater extraction and treatment at Building 3001 continued.	1994 - ongoing

### 3.1.3 Operation and Maintenance Requirements

Elements of the Building 3001 OU that require O&M include: 1) the extraction well field and groundwater transport system associated with Building 3001 groundwater; 2) the groundwater treatment plant (GWTP) for Building 3001 Groundwater and 3) the product recovery system at the NTA. The removal of the contents from Pit Q-51 and its off-base disposal was a permanent remedy and required no O&M.

#### 3.1.3.1 Extraction Well Field and Groundwater Transport System

The Building 3001 extraction well network consists of 33 extraction wells installed in three aquifer zones, as shown in the following Table 3.2. It should be noted that the TOR-series wells are completed primarily in the upper portion of the lower saturated zone (LSZ), but two of the wells also penetrate the lower portion of the LSZ.

**Table 3.2**  
**Groundwater Extraction Wells by Hydrogeologic Zone**

Tinker AFB Groundwater Conceptual Model (Tinker AFB, 1994)	U.S. Army Corps of Engineers Designation (USACE, 1988a)	Number of horizontal wells	Number of vertical wells
USZ	P-1 through P-19 (Perched Aquifer)	3	16
LSZ (upper)	TOR-1 through TOR-7 (Top of Regional Aquifer)	1	6
LSZ (lower)	R-1 through R-7 (Regional Aquifer)	1	6

Each well is surrounded by a water-proof well vault containing the well head, piping from the well into the pipe manifold which transports the water to the GWTP, electrical equipment, and instrumentation. The pump in each well pumps with sufficient head to carry the extracted water to the influent holding tank of the GWTP.

This system is operated and maintained by the same staff responsible for operating the GWTP. Some requirements for the extraction and transport system overlap with the GWTP requirements. See Section 3.1.3.2 for the delineation of the requirements associated with staffing, reporting, emergency procedures, etc.. Specific O&M requirements for this system are as follows:

1. Perform Daily Inspections and Operations Tasks- see that wells pump according to schedule; observe equipment, instruments, and unit processes for proper operation; maintain daily operating log in current condition; check instruments, controls, and alarms for proper operation; check for visible sign of leaks; collect samples; check sampling results and provide proper feedback to well field operation and control.
2. Perform Periodic Inspections and Routine Maintenance of Equipment - perform periodic inspections of pumps, valves, and piping to identify wear, needs for special maintenance, and insure proper operation; perform lubrication at specified intervals; perform cleaning at specified intervals or as required; repair as necessary.
3. Perform Instrument Inspections and Calibration - periodically, at specified intervals, inspect all instruments including meters, controllers, and electrical equipment for proper working, needs for maintenance; clean; calibrate; repair as necessary.
4. Perform Well Field Maintenance - perform periodic inspections of extraction and monitoring wells; perform maintenance and well redevelopment tasks as needed.

### **3.1.3.2 Groundwater Treatment Plant (GWTP)**

The GWTP is contained in a pre-engineered metal building. This building also contains chemical storage facilities, a maintenance area, and a control room which includes office space. The GWTP is located east of Building 3001 and lies within the secured area of the base. An alarm on the door to the building alerts the on-duty operator to the arrival of anyone into or out of the building.

The GWTP consists of the following components:

- An influent holding tank to which the extracted water is pumped.
- An air stripper coupled with a vapor phase activated carbon system for the removal of volatile organics.
- A chemical reduction system for the reduction of hexavalent chromium.
- A chemical precipitation system for the precipitation and removal of trivalent chromium and other metals. This system consists of chemical addition systems, flocculation, and sedimentation in an inclined plate settler.
- Granular media filtration for the removal of additional suspended solids. This filter is a "moving bed" type (Dynasand brand).

- Sludge handling using a sludge holding tank, recessed plate filter press, and thermal sludge dryer. Dried sludge is disposed in a RCRA landfill certified to receive CERCLA wastes.
- An effluent holding tank from which the treated water is pumped for reuse.

O&M requirements for the GWTP are presented in several categories as follows:

1. Develop and Maintain Adequate Operations and Supervisory Staff - hire, train, and supervise O&M staff.
2. Meet Performance Requirements - keep system running, keep down time to a minimum, meet performance specifications including required effluent quality, air quality, and sludge quality; advise management of any major problems or potential major problems.
3. Meet Reporting Requirements - perform system monitoring, collect required data, perform laboratory audits, if required, develop and maintain system for data management, submit reports as required, make notifications of abnormal operating conditions, maintain daily operations logs, maintenance logs, spare parts inventory, and other logs required; perform all waste manifesting in a timely manner.
4. Perform Daily Inspections and Operations Tasks- manage water flow through system including associated air flows, sludge flows, and chemical feeds; observe equipment, instruments, and unit processes for proper operation; maintain daily operating log in current condition; check instruments, controls, and alarms for proper operation; check for visible sign of leaks; collect samples; check sampling results and provide proper feedback to GWTP operation and control.
5. Perform Periodic Inspections and Routine Maintenance of Small Equipment - perform periodic inspections to identify wear, needs for special maintenance, and insure proper operation; perform lubrication at specified intervals; perform cleaning at specified intervals or as required; repair as necessary.
6. Perform Instrument Inspections and Calibration - periodically, at specified intervals, inspect all instruments for proper working, needs for maintenance; clean; calibrate; repair as necessary.
7. Perform Inspections and Maintenance of Major Equipment - inspect major equipment (major rotating equipment, other equipment with moving parts, and large and/or complicated pieces of equipment) at specified intervals; perform routine maintenance including cleaning, lubrication, performance checks, etc., perform preventive maintenance tasks; repair, recoat, and replace as necessary; schedule next inspection.
8. Keep and Update Maintenance Records - using the prescribed system, keep records up to date, regarding maintenance history, equipment replacement, maintenance advisories, etc.
9. Perform Periodic Leak Inspections - in addition to daily observations for leaks, make more thorough inspections on a periodic basis; report findings.



10. Perform Periodic Infrastructure Inspections - periodically inspect building, loading/unloading areas, on-site maintenance area, and utilities supply points for repair and maintenance needs; be aware of and correct any hazards to operators, visitors, delivery personnel, etc.
11. Employ Proper Emergency Procedures - keep staff properly trained in emergency operating procedures, response procedures, and safety practices; update requirements as necessary.
12. Maintain Spare Parts Inventory - update inventory as parts are used; periodically review and update required inventory based on maintenance history.
13. Review and Update O&M Manual and Operating Procedures - perform periodically as required.

### **3.1.3.3 Product Recovery System at NTA**

The original design of the product recovery system specified a dual phase recovery system consisting of a hydrocarbon recovery pump and a groundwater pump. The groundwater pump was installed to depress the water table and create a cone of depression around the wellbore so the hydrocarbon pump could collect the phase separated hydrocarbon off the surface of the water table. This system was installed in 1991, but the groundwater depression pumps are no longer used. It was intended that the water pumped from below the product would be discharged to the Building 3001 groundwater treatment system; however, this design approach was never realized. The pneumatic hydrocarbon pumps are still run intermittently to skim product from the surface of the water table in 2 of the recovery wells. An O&M manual was developed for the system which was expanded to a total 6 wells and included submersible electric pumps as well as the pneumatic pumps. The original pumping schedule and protocols are no longer used except for routine maintenance of the compressor and repairs (Battelle, 1993a).

Three additional dual pump pneumatic recovery wells were added in 1995 (Parsons ES, 1995). Two recovery wells were installed on the west side of Building 3001 and one monitoring well was converted to a recovery well north of the abandoned 235,000 gallon fuel tank. All pump controls are maintained inside of a locked metal building within the fenced and secured compound.

Perimeter wells around the NTA are equipped with hydrocarbon sensor probes in the event fuel begins to migrate away from the NTA. An O&M Plan was developed to monitor these sensors (Parsons ES, 1996c). The sensors record water level and other groundwater data and have an illuminating alarm at the well head to signal if free-phase hydrocarbons are entering the well.

### **3.1.4 Operation and Maintenance Activities**

O&M activities are conducted by experienced environmental contractors. The contractor personnel are trained in operational and health and safety procedures relevant to the job performance.

#### **3.1.4.1 Extraction Well Field and Groundwater Transport System**

TetraTech NUS, Inc. (TTNUS) is responsible for the O&M of this system under contract to the Air Force. Additional details of the operating arrangement appear in Section 3.1.4.2 below.

O&M activities related to the extraction and transport system include the necessary tasks to carry out the responsibilities enumerated in Section 3.1.3.1. Based on the inspections associated with this project, all of the required activities are being effectively and regularly performed.

#### **3.1.4.2 Groundwater Treatment Plant (GWTP)**

O&M of the GWTP is contracted to TTNUS. TTNUS is responsible for operator staffing, operator training, engineering support, system maintenance, monitoring, and reporting results to the on-site Tinker AFB personnel. Some maintenance is performed by the operations staff; other tasks are subcontracted by TTNUS to outside vendors. TTNUS is also responsible for containerizing dewatered and dried sludge from the sludge handling operation and recovered organics from the air stripping operation for shipment offsite. This waste is transported and disposed under another Tinker AFB contract. TTNUS's responsibilities at the GWTP begin at the influent holding tank (Tank T-1) and continue to the pumping of treated effluent into the reuse system downstream of the effluent holding tank (Tank T-2). (TTNUS is also responsible for operating the extraction well field and transport system and monitor these components from the GWTP control room. See Section 3.1.4.1. above.)

The GWTP is staffed with an operator 24 hr/day, 7 days/wk. Process engineering support is available from a TTNUS staff person located at the base. At the time this inspection was performed, the lead operator was Mr. Jim Holcomb; technical support was provided by Scott Boling. Tinker AFB personnel monitor the operation. Mr. Keith Buehler (OC-ALC/EMR) is responsible for the TTNUS contract. Mr. Buehler conducts daily site visits. The O&M activities are those associated with the operating and maintenance requirements enumerated in Section 3.1.3.2 above. Based on the inspections associated with this project, all of the required activities are being effectively and regularly performed.

#### **3.1.4.3 Product Recovery System**

O&M of the product recovery system is contracted to TTNUS. Product recovery wells are either equipped with skimmer pumps that operate automatically or wells are periodically pumped or purged for free phase hydrocarbon by TTNUS. TTNUS also performs weekly gauging of the tanks and site monitoring wells. The NTA site manager for Tinker AFB is Mr. Dan Hunt (OC-ALC/EMR).

## **3.2 SOLDIER CREEK SEDIMENT AND SURFACE WATER OU**

### **3.2.1 Remedy Selection**

The ROD, signed in August, 1993 provided for a limited action remedy for the SCSSW OU. The remedial action objectives for the OU were to prevent the ingestion of, or dermal contact with, sediment and surface water with contaminant concentrations greater than health-based cleanup goals and to prevent off-base migration of contaminants with concentrations greater than health-based cleanup goals. Existing or potential groundwater contamination was to be addressed separately under the SCOBGW OU due to the complexity of potential groundwater interactions between all of the OUs at Tinker AFB. The IWTP/SCOBGW investigations included evaluation of the interactions between the creeks and groundwater.

The baseline risk assessment determined that the Soldier Creek sediment and surface water did not pose a risk to human health or the environment in excess of the acceptable risk-based levels established by EPA. However, the environmental assessment conducted as a part of the baseline risk assessment was only qualitative and could not be used to fully assess ecological risk. Long-term monitoring would be used to determine if levels in the creek remain below the health-based cleanup goals over time and quantitatively evaluate the environmental risk, if any, that exists at the OU. The remedial actions selected in the ROD incorporated the following components:

- A five-year monitoring program of Soldier Creek sediment and surface water at on-base and off-base locations to determine if contaminant migration has occurred and, if so, determine if migration has resulted in contaminant concentrations greater than health-based cleanup goals.
- An ecological investigation (quantitative and qualitative) of Soldier Creek sediment and surface water to further define potential environmental risk.
- Annual monitoring reports to present and evaluate monitoring results for exceedance of health-based cleanup goals.
- A five-year ROD review to ensure that the remedy continues to provide adequate protection of human health and the environment or whether additional remedial actions are necessary.

### **3.2.2 Remedy Implementation**

A chronology of the remedy development and implementation activities for the SCSSW OU is provided in Table 3.3.

**Table 3.3**  
**Summary of Remedy Development and Implementation Activities at SCSSW OU**

Investigation/Activity	Description	Date (and Source)
Quarterly groundwater sampling	Sample groundwater in area of East and West Soldier Creeks, Building 3001, and IWTP.	December 1987 – March 1989 USACE, Tulsa District (Source: WCFS, 1998)
Final stormwater investigation	Sample surface water to identify contaminant release from Building 3001 storm sewers to East and West Soldier Creeks	October 1989 (NUS, 1989)
Phase I and Phase II RI/FS	Determine extent of sediment and surface water contamination along East, Main, and West Soldier Creeks	Phase I – July 1990 Phase II – June 1991 (B&V, 1993b)
BHRA and qualitative ERA	Quantitative BHRA and qualitative ERA to establish potential current and future risk to on-base and off-base receptors utilizing sediment, surface water, and groundwater data	February 1993 (B&V, 1993c)
ROD issued/signed	Establish remedial action for the site	Issued – August 1993 Signed – September 14, 1993 (B&V, 1993a)
Quantitative ERA	Quantitative ERA to determine potential effects of chemicals in surface water and sediment on biological environment – included biological survey to determine characteristics of species within on-base and off-base portions of the OU (conducted as ROD requirement)	October 1994, and January/June 1995 (WCFS, 1997b)
First-year long-term monitoring and annual report	Quarterly monitoring of sediment and surface water and first-year report to present monitoring results and HHRA I (conducted as ROD requirement)	November 1994, and January/April/June 1995 (WCFS, 1996)
Second-year long-term monitoring and annual report	Quarterly monitoring of sediment and surface water and second-year report to present monitoring results and HHRA II (conducted as ROD requirement)	October 1995, and March/May/August 1996 (WCFS, 1997a)
Third-year long-term monitoring and annual report	Semi-annual monitoring of sediment and surface water and third-year report to present monitoring results and HHRA III (conducted as ROD requirement)	January/July 1997 (WCFS, 1998)

**Table 3.3 (Continued)**  
**Summary of Remedy Development and Implementation Activities at SCSSW OU**

Investigation/Activity	Description	Date (and Source)
Remedial responses	Numerous past and on-going remedial actions in the area to provide protectiveness of the environment in response to the levels of contamination found in the creek (actions not identified as a ROD requirement)	1990 – on-going

**3.2.3 Operation and Maintenance Requirements**

There are no O&M requirements associated with the continued monitoring remedy. Flight line criteria at Tinker AFB have prompted upgrades to the landscape along West Soldier Creek. The channel of West Soldier Creek has also been concreted. This action serves as a facility improvement for Tinker's mission, as well as a remedial measure (although not identified as a ROD requirement) to minimize the potential for sediments to move offbase and pose a human health or ecological threat to downstream receptors.

**3.2.4 Operation and Maintenance Activities**

Documentation of correspondence with EPA regarding the planned construction activities in West Soldier Creek are contained in Appendix C. These activities were underway at the time of this writing.

## SECTION 4 FIVE-YEAR REVIEW FINDINGS

### 4.1 BUILDING 3001 OU

#### 4.1.1 Five-Year Review Process

A level 1 review was conducted for the Building 3001 OU. The review was conducted by the following senior staff of Parsons Engineering Science, Inc. (Parsons ES): Stephen Rossello - hydrogeology; John Koon, Ph.D., P.E. - process engineering; Douglas Downey, P.E. - environmental engineering, and Lea Aurelius - ARARs review. Additional technical oversight was provided by Robert Hinchee, Ph.D., P.E. and Kenneth Stockwell, P.E. The project was managed by John Osweiler, P.G. Groundwater contaminant plume and potentiometric maps were prepared by Tad Fox of Battelle Memorial Institute. The key elements of the five-year review included: document review, interviews, site inspection, evaluation of findings and report preparation.

A site visit and interviews were conducted with representatives of the environmental management directorate, restoration division of the Oklahoma City Air Logistics Center (OC-ALC/EMR) at Tinker AFB and the O&M personnel contracted by Tinker Air Force Base. The O&M contractor for the NTA is TTNUS. Both the environmental management directorate, restoration division (EMR) and TTNUS maintain a constant presence on the site. Parsons ES did not initiate or participate in any community involvement activities nor were any off-base local agencies contacted. However, Tinker AFB holds regular restoration advisory board (RAB) meetings with the community and discusses activities and progress at this OU on a routine basis.

Pit Q-51 was closed in accordance with the ROD. The five-year review activities only included review of the closure records. No on-going maintenance nor monitoring is associated with Pit Q-51.

#### 4.1.2 Interviews

##### *Building 3001 Groundwater*

Stephen Rossello conducted an interview with Scott Bowen of Oklahoma City Air Logistics Center (OC-ALC) to discuss the Building 3001 extraction and monitoring well field operation and performance on July 16, 1998. John Koon conducted interviews with Keith Buehler of Oklahoma City Air Logistics Center (OC-ALC) and Jim Holcomb of the contract operating company, TTNUS, on July 16 and 17, 1998.

### *North Tank Area*

Stephen Rossello and John Osweiler conducted interviews with the OC-ALC/EMR site manager, Dan Hunt, his alternate, and the O&M contractor from TTNUS. Interviews with the site manager's alternate, James Dawson, were conducted during the site visit on July 16, 1998. Interviews with the site manager were conducted on August 5, 1998.

#### *Pit Q-51*

No interviews associated with the closed Pit Q-51 were conducted as part of this five-year review.

### **4.1.3 Site Visits**

#### *Building 3001 Groundwater*

A site visit to the Building 3001 groundwater treatment plant and extraction well field was conducted on July 16, 1998. The site visit was attended by John Osweiler, John Koon, Stephen Rossello, and Kenneth Stockwell, of Parsons ES and James Dawson, Keith Buehler and Scott Bowen of OC-ALC/EMR. Follow-up visits to the GWTP and to the base OC-ALC/EMR offices were made on July 17, 1998 by John Koon for additional interviews, records reviews, and equipment inspections. He was accompanied by Keith Buehler of OC-ALC/EMR and Jim Holcomb of TTNUS.

During the Groundwater Treatment Plant (GWTP) inspection visits and the visit to the base environmental office several key documents were reviewed including: daily and monthly operation logs for the GWTP, quarterly reports, chemical use inventories, and design drawings. John Koon held discussions at the GWTP with plant operating and supervisory personnel to further assess operating condition of equipment, level of maintenance, housekeeping practices, performance history and operator knowledge.

#### *North Tank Area*

A preliminary overview of the NTA was completed on the afternoon of July 16, 1998. This visit was attended by the OC-ALC/EMR site manager's alternate, James Dawson, and Stephen Rossello of Parsons ES and was conducted to establish the layout of the recovery and monitoring systems.

A more detailed site visit was conducted on July 17, 1998. This visit was attended by John Osweiler and Stephen Rossello of Parsons ES along with the TTNUS O&M project superintendent, Mr. Ray Cromer. The recovery wells, monitoring wells, product recovery tanks, flow lines, flow controls were observed and inspected for performance. No leaks, spills, or other potential releases were observed during the inspection and no deterioration of primary or secondary containment was evident; however, the above-ground carrier lines from the well heads to the pump controls are weathered and aging. The site manager stated that the carrier lines are replaced annually. The product pumping and recovery schedule were discussed and a list of wells currently recovering product was evaluated. O&M plans were not available onsite.

### *Pit Q-51*

The location of former Pit Q-51 was visited to observe the condition of the concrete cap by John Osweiler of Parsons ES and Keith Buehler OC-ALC/EMR on August 28, 1998. Equipment and materials were staged on top of the patch, but the surface was sufficiently visible to determine the condition of the concrete. The concrete patch was intact and all the seals around the joints were in good condition and no separation or deterioration was evident.

#### **4.1.4 Remedial Action Objectives**

ARAR's reviewed included Maximum Contaminant Levels (MCLs) established under the Safe Drinking Water Act (SDWA), Clean Air Act (CAA) requirements under which relate to the emission standards for ambient air quality, and RCRA requirements for the management of hazardous waste.

#### *Building 3001 Groundwater*

Since the treatment system installed at the Building 3001 site involves pumping contaminated groundwater at the site and treating it via air stripping, there are ARARs associated with groundwater remediation and air emissions. Remedial action objectives (RAOs) for groundwater listed in the Building 3001 ROD include MCLs for benzene, TCE, PCE, barium, chromium, lead, and nickel.

The ROD does not specify how attainment of these RAOs will be measured. Attainment could be measured by determining average well concentrations or actual concentrations, using estimated plume volumes or volumes of contaminants removed at the GWTP, etc. The ROD does indicate that groundwater extraction is expected to reduce contaminant concentrations by 93% in the lower saturated zone and 97% in the upper saturated zone within the first 30 years of operation.

Changes in MCLs in the past five years affect the RAOs for the Building 3001 groundwater. These changes are presented in the Table 4.1 below:

**Table 4.1  
Changes in RAOs for Building 3001 Groundwater**

Contaminant	Record of Decision				Current Standard			
	Cleanup Level (µg/L)	Source	Year	Status	Applicable ARAR (µg/L)	Source	Year	Status
Barium	1000	SDWA	1990	Applicable	2000	SDWA	1998	Applicable
Chromium	50	SDWA	1990	Applicable	100	SDWA	1998	Applicable



**Table 4.1 (Continued)**  
**Changes in RAOs for Building 3001 Groundwater**

Contaminant	Record of Decision				Current Standard			
	Cleanup Level (µg/L)	Source	Year	Status	Applicable ARAR (µg/L)	Source	Year	Status
Lead	50	SDWA	1990	Applicable	15	SDWA	1998	Relevant and appropriate
Nickel	–	SDWA	1990	NA	140	SDWA	1998	Applicable

*North Tank Area*

The appropriate groundwater ARARs at the NTA are the federal MCLs as promulgated under the SDWA. Other ARARs include Oklahoma Water Quality Standards for the contaminants of concern and the established levels of petroleum, oil, lubricating (POL)-contaminated sites as established under the Oklahoma Corporation Commission (OCC) for benzene, toluene, ethylbenzene, and xylenes (BTEX) and total petroleum hydrocarbons (TPH) in groundwater and soils. Contaminants of concern in groundwater and soil at the site include BTEX, TPH, and naphthalene. In addition, fluoranthene, fluorene, and phenanthrene are additional contaminants of concern in soil (Parsons ES and Battelle, 1994).

Since the ROD was signed in 1990, MCLs for the contaminants of concern have not changed. There have been some changes to the state ARARs. In 1996, the OCC revised its rules regarding cleanup levels at UST sites. Formerly, Oklahoma Administrative Code (OAC) 165:25 Appendix K established soil and groundwater cleanup levels for UST sites. However, Appendix K was revoked in September 1996 and a risk-based corrective action (RBCA) process (OAC 165:25, Subchapter 3, Part 15) based on site-specific conditions was promulgated. However, since the NTA is a CERCLA site, MCLs are the primary ARARs for the site.

*Pit Q-51*

At the time that the Building 3001 ROD was signed in August 1990, Pit Q-51 held approximately 45 gallons of liquid containing 42 milligrams per liter (mg/L) TCE, 3 mg/L cadmium, 4 mg/L chromium, and 22 mg/L lead. The contents of the pit were removed and placed in a 55-gallon drum. After the pit was steam cleaned, the wash water was also placed in 55-gallon drums for disposal. The hazardous material and wash water were transported and disposed of offsite at a facility permitted to receive hazardous wastes (OC-ALC, 1991a). The pit was backfilled with sand and covered with an 8-inch thick concrete cap. The potential risk to human health and the environment was eliminated by

the removal of the pit contents, steam cleaning of the pit, removal of the wash water, and the filling and capping of the pit; thus, the RAOs for Pit Q-51 have been met.

Since the contents of Pit Q-51 were permanently removed from the Building 3001 site and disposed at a facility approved to receive the waste material, all ARARs have been met.

#### 4.1.5 Data Review

##### *Building 3001 Groundwater*

The performance and effectiveness of the groundwater extraction and treatment system was reviewed. Based on the site inspections and data review, the GWTP was found to be in good operating order, well maintained, staffed with competent operating personnel, and supervised by a knowledgeable and informed base staff. According to records reviewed, the system has consistently performed at or above required operating levels and was found to meet effluent requirements without exception. Beginning in 1998, groundwater extracted at the Southwest Tank Area was being pumped to the GWTP.

The subsurface underlying Building 3001 site has been divided into 5 discrete hydrostratigraphic units. These units in descending order are the upper saturated zone (USZ), the upper shale, the LSZ, the lower shale, and the production zone (PZ). Figure 2 illustrates the hydrostratigraphic sequence in the vicinity of Building 3001. These zones were further subdivided into layers for groundwater computer modeling purposes. The zones and corresponding layers are also shown in Figure 2.

Only the USZ (formerly known as the "Perched" aquifer) and the LSZ (formerly divided and referred to individually as the "Top of Regional" and "Regional" aquifers) portions of the aquifer system underlying Tinker AFB were evaluated. The deeper "Producing Zone" is not part of the ROD for the Building 3001 OU and was not evaluated. A map of the northeast quadrant showing the location of Building 3001 and associated extraction wells is provided in Figure 3.

During the data review, it was determined that water levels measured in the monitoring and extraction wells during November 1997 were collected when the extraction wells were shut down for a major system upgrade at the GWTP. The wells were shut down for a period of one week. Because of this, the flow fields of the extraction system could not be reliably established for this period. Therefore, well measurements obtained in June 1998 were used to evaluate the effectiveness of the recovery wells.

Dense non-aqueous phase liquid (DNAPL) TCE has not been identified at the Building 3001 site, but it is likely that it is present. According to the EPA's *Dense Nonaqueous Phase Liquids Workshop Summary* (EPA, 1992): "groundwater concentrations of 1% or less of effective solubility can be found even in the immediate proximity of the DNAPL." The effective solubility of TCE is 1,000 mg/L, and concentrations greater than 10 mg/L would indicate the presence of DNAPL. Concentrations of TCE in the USZ are as high as 250 mg/L (1-70B); therefore, DNAPL

may be present. Given that TCE concentrations in layers 3 and 5 are as high as 20 mg/L, it is possible that the DNAPL has migrated to these layers as well.

#### Evaluation of USZ (Layer 1)

The USZ is a shallow, unconfined, water-table aquifer that is known to be perched in the vicinity of Building 3001. The lower boundary of the USZ is the upper shale. The saturated thickness of the USZ ranges from 0 on the east where the upper shale subcrops along Soldier Creek, to 33.9 feet on the west where the depth of the upper shale reaches 50 feet. The mean thickness of the USZ is 15.1 feet.

Figure 4 shows the distribution of TCE in the USZ (layer 1) in November, 1997. TCE concentrations ranged from less than 1 µg/L to a maximum of 260,000 µg/L (well 1-70B). Concentrations were less than 1 µg/L at eight wells. The cleanup level for TCE is 5 µg/L. Since 1994, concentrations have generally decreased at the edges of the plume and in the northern and southern portions of the plume. Concentrations in the center of the plume, in the vicinity of P-8 and P-9 increased. The increase in concentration is considered to be the result of mobilization of TCE to those extraction wells. Though well 1-75B is within the capture zone, concentrations have generally continued to rise. It should also be noted that hydraulic capture may not be established near P-12. Northwest of Building 3001, the TCE concentration in well 2-162B is 1,100 µg/L and although significant, contamination in this area is probably not related to Building 3001. Southeast of Building 3001, TCE contamination is present at well 1-72B (18 µg/L), but Building 3001 is probably not the source.

Figure 5 shows the distribution of chromium in the USZ (layer 1) in November, 1997. Chromium concentrations ranged from less than 10 µg/L to a maximum of 10,500 µg/L (well P-17). Concentrations were less than 10 µg/L at one well. Note that the cleanup level for chromium is 50 µg/L, while the MCL is 100 µg/L. Since 1994, the concentrations of chromium have generally increased at several locations across the site; however, the plume beneath Building 3001 is decreasing in concentration particularly near recovery wells P-15 and P-17. The most pronounced increase has been observed at wells 1-65B and 1-67B, located over 2,000 feet west and southwest of Building 3001 (Figure 5). Due to the distance between these wells and Building 3001, and the historic distribution of chromium, it is believed that the chromium detected in these wells is not related to Building 3001.

A water table map for the USZ generated from water levels measured in June 1998 is overlain on both Figures 4 and 5. The June 1998 water level map clearly shows the depression of the water table by the Building 3001 extraction system immediately west of the building. A trough beneath the north-central portion of Building 3001 coincides with the locations of the horizontal wells and indicates that the water table in this area has also been lowered by the extraction wells. With the exception of P-18, the capture zones of the extraction wells located on the east side of the building are much less pronounced.

### Evaluation of LSZ Layer 3

The LSZ layer 3 unit is unconfined under much of Building 3001. Between 1,000 and 1,500 feet west of Building 3001, layer 3 water levels intersect the upper shale unit (layer 2) resulting in confined or semi-confined conditions in layer 3 to the west. The unsaturated zone also thins north of Building 3001. An east-west trending groundwater mound located north of Building 3001 is coincident with the discontinuity in the upper shale unit believed to exist at the 1-76 well cluster location and a depression in the USZ water table at the same location. Groundwater flow directions in layer 3 are generally to the west-southwest except in the vicinity of the groundwater mound and the groundwater extraction system. North of the mound, groundwater flow is primarily to the north and northeast.

The highest concentrations of TCE and chromium in the LSZ layer 3 plume are observed in wells TOR-3 and 34B, respectively. These high concentrations may be due to the downward movement of DNAPL and/or a result of the downward vertical gradient between each aquifer unit.

Figure 6 shows the distribution of TCE in the LSZ (layer 3) in November 1997. TCE concentrations ranged from less than 1  $\mu\text{g/L}$  to a maximum of 5,200  $\mu\text{g/L}$  (well TOR-3). Concentrations were less than 1  $\mu\text{g/L}$  at four wells. The cleanup level for TCE is 5  $\mu\text{g/L}$ . Since 1994, concentrations have substantially decreased in the northern portion of Building 3001 and in well TOR-5. Concentrations in the center of the plume, in the vicinity of TOR-3 and TOR-4 have increased, likely as the result of mobilization of TCE to those extraction wells.

Figure 7 shows the distribution of chromium in the LSZ (layer 3) in November, 1997. Chromium concentrations ranged from less than 1  $\mu\text{g/L}$  to a maximum of 15,100  $\mu\text{g/L}$  (well 34B). Concentrations were less than 1  $\mu\text{g/L}$  at two wells. Note that the cleanup level for chromium is 50  $\mu\text{g/L}$ , while the MCL is 100  $\mu\text{g/L}$ . Since 1994, the chromium plume has been reduced in both size and concentration, and is essentially limited to the area around well 34B.

The water level map for June 1998 is overlain on both Figures 6 and 7. The capture zone is well developed across layer 3. All of the TCE, except contaminants in the vicinity of well M-2AR, is enclosed by the capture zone. The chromium plume in layer 3 is completely captured by the recovery system.

### Evaluation of LSZ Layer 5

Layer 5 of the LSZ is confined. Groundwater flow in layer 5 is primarily to the southwest, except northeast and west of Building 3001. There is a local groundwater divide located northeast of Building 3001. The groundwater divide trends northwest-southeast between TOB-2 and the northeast corner of the IWTP. Northeast of the divide, groundwater flow is to the northeast. The southwesterly flow pattern is also interrupted by the capture zone of the extraction wells located just west of Building 3001.

Figure 8 shows the distribution of TCE in the LSZ (layer 5) in November 1997. TCE concentrations ranged from less than 1 µg/L to a maximum of 3,700 µg/L (well M-3A). Concentrations were less than 1 µg/L at 10 wells. The cleanup level for TCE is 5 µg/L. The highest concentration of TCE beneath Building 3001 is at well cluster 34; however, the highest level of TCE is found beneath the north-south runway at monitoring well M-3A. The source of TCE in this area has not been determined. TCE concentrations have substantially decreased in the northern portion of Building 3001 and west of the southern half of Building 3001 since 1994. Concentrations in the center of the plume, in the vicinity of TOR-3 and TOR-4 have increased, likely as the result of mobilization of TCE to those extraction wells.

Figure 9 shows the distribution of chromium in the LSZ (layer 5) in November, 1997. Chromium concentrations ranged from less than 1 µg/L to a maximum of 15,100 µg/L (well 34B). Concentrations were less than 1 µg/L at two wells. Note that the cleanup level for chromium is 50 µg/L, while the MCL is 100 µg/L. Since 1994, concentrations of chromium at well 34B have substantially decreased, while concentrations at wells TOR-3, TOR-4 and TOR-5 have slightly increased, likely as the result of mobilization of chromium to those extraction wells.

The water level map for June 1998 is overlain on both Figures 8 and 9. A long, deep capture zone is well developed across layer 5. The capture zone encompasses both the TCE and chromium plumes associated with Building 3001. However, the TCE and chromium detected under the runways west of Building 3001 is outside of the capture zone.

#### Evaluation of LSZ Layer 7

Groundwater in layer 7 is confined or semi-confined by the overlying shale lenses comprising layer 6. The hydraulic heads in layer 7 are generally less than 5 feet lower than in the overlying layer 5. The only major exception is in the area to the northeast of Building 3001, under the groundwater divide in layer 5, where the water levels in layer 7 are as much as 14 feet lower than in layer 5. Groundwater flow in layer 7 is from the shallower recharge areas in the northeast to the deeper, more confined aquifer zone in the southwest. This general flow direction is interrupted by the capture zone of the extraction wells just west of Building 3001.

Figure 10 shows the distribution of TCE in the LSZ (layer 7) in November, 1997. TCE concentrations ranged from less than 1 µg/L to a maximum of 6,300 µg/L (well 1-8A). Concentrations were less than 1 µg/L at 14 wells. The cleanup level for TCE is 5 µg/L. Since 1994 concentrations within extraction wells have increased, likely as a result of the mobilization of TCE to the extraction wells.

Figure 11 shows the distribution of chromium in the LSZ (layer 7) in November, 1997. Chromium concentrations ranged from less than 1 µg/L to a maximum of 1,240 µg/L (well M-3CR). Concentrations were less than 1 µg/L at five wells. Note that the cleanup level for chromium is 50 µg/L, while the MCL is 100 µg/L. Since 1994 the

chromium plume associated with Building 3001 has been greatly reduced. However, concentrations of chromium at well M-3CR have substantially increased.

The water level map for June 1998 is overlain on both Figures 10 and 11. A long, deep capture zone is well developed across layer 7. Both the TCE and chromium plumes are completely enclosed by the capture zone with the exception of 6 µg/L TCE and 1,240 µg/L chromium in well M-3CR.

### *North Tank Area*

Documents from the administrative record were reviewed in order to assess the progress and actions taken at the NTA. The remedies specified in the ROD were implemented to the extent possible. Deviations from the selected remedies are supported by the results of site specific investigations and tests conducted prior to and subsequent to the ROD and are summarized below.

### Source Removal

Tank 3404 was abandoned in place between April and June 1992. Approximately 3,500 gallons of product were removed from the tank during the abandonment. After the roof of the tank and appurtenances were removed, debris was removed from the floor of the tank, and concrete was poured into the base of the tank. Clean soil was used to backfill the tank to near surface and a concrete cover was placed over the soil at slightly below grade. Additional fill was placed over the concrete and the area planted with Bermuda grass.

### Free Product Removal

Free product removal began on May 26, 1991. Recovery of floating fuel has been accomplished by a number of methods, including bailing, product-only pumping, dual fluid, and total fluids (product and water) pumping. In addition, pneumatic fracturing of the aquifer was performed in 1993 to enhance product recovery. Between May 1991 and December 1994, approximately 6,400 gallons of free product were removed from the aquifer as a result of well pumping and hand bailing. The ROD specified dual-fluid methods of product recovery was discontinued at the end of 1994 due to excessive water production. Total fluids recovery was discontinued for the same reason. Additional recovery wells were installed and further pneumatic fracturing performed on the aquifer in January 1995. Product-only pumping was re-initiated in February 1995. Hand bailing at selected wells was also reestablished on a weekly basis in October 1996. Between January 1995 and December 1997 an additional 8,400 gallons of free product were removed. Total product removed through December 1997 was 14,900 gallons (Personal communication, Dan Hunt, OC-ALC/EMR 1998). This amount does not include product recovered during drilling and aquifer testing activities.

Results of focused RIs (Parsons ES and Battelle, 1994) indicate that the majority of the fuel is not floating on the unconfined aquifer. The product is trapped in a lower confined unit, because the bottom of the tank that leaked was below a confining clay layer.

It was originally estimated that 6,000 to 12,000 gallons of product existed in the subsurface. More than 14,000 gallons of fuel have actually been recovered. From results of special case treatability investigations (Parsons ES 1995), it is evident that a more substantial amount of fuel exists in the confined aquifer.

Dual fluid pumping is not necessary to direct the product towards the recovery wells since this is a confined aquifer. The product will remain relatively immobile as the product-only pumps remove the fuel. Though the free product continues to be a source of contamination to the groundwater, the dissolved fuel compounds in both the unconfined and the confined shallow aquifer are, and will be, contained and/or captured by the Building 3001 extraction well system. In addition, dissolved fuel residuals in the NTA will be subject to continuing natural biodegradation processes, which will limit migration from the NTA.

### Soil Vapor Extraction

Implementation of the soil vapor extraction remedy was tested in three separate efforts beginning in 1990. The Advance Final Design Analysis (Triax 1990), indicated that the soil permeabilities were less than anticipated during the original design, that the radius of influence for soil vapor extraction wells would be no more than 20 feet, and that an extensive network of horizontal well screens would be required along with the blower(s) operating at a high output level.

The recommended method for installing the horizontal borings through the tank walls conflicted with the ROD requirement for tank removal. The tank was removed in 1992 and no additional design for soil vapor extraction was performed.

Following the tank removal, in situ respiration and air permeability tests were performed (Battelle, 1993). Results of the tests indicated that the radius of influence for soil vapor extraction would be low. Due to high soil moisture, the soils may not be suited for soil vapor extraction. Bioventing was considered as an alternative; however, neither vapor extraction nor bioventing were implemented.

In 1993, the New Jersey Institute of Technology performed pneumatic fracture injections in the vadose zone of the NTA. Results indicated that the vadose zone permeability was improved, but the information from the test as to the overall application of fracture injection to remediating the vadose zone soils contamination was inconclusive.

Based on results of the focused RI (Parsons ES and Battelle, 1994), remediation through natural attenuation was recommended. This no-action alternative was recommended because time is not a critical factor due to long-term monitoring for the Building 3001 groundwater plume. The shallow soils are considered sufficiently impermeable so that soil vapor exposure to potential receptors at the surface will not occur. There are also institutional controls in place to prevent unprotected workers from digging in the NTA.

## *Pit Q-51*

Other than ARARs, no data were evaluated for Pit Q-51.

## **4.2 SOLDIER CREEK SEDIMENT AND SURFACE WATER OU**

### **4.2.1 Five-Year Review Process**

A level 1 review was conducted for the SCSSW OU. The review was conducted by the following senior staff of Parsons ES: Stephen Rossello - hydrogeology; Douglas Downey, P.E. - environmental engineering, and Lea Aurelius - ARARs review. Additional technical oversight was provided by Robert Hinchee, Ph.D., P.E. and Kenneth Stockwell, P.E. The project was managed by John Osweiler, P.G. The key elements of the five-year review included: document review, interviews, site inspection, evaluation of findings and report preparation.

### **4.2.2 Interviews**

Kenneth Stockwell, Stephen Rossello, and John Osweiler of Parsons ES conducted an interview with James Dawson (OC-ALC/EMR) on July 16, 1998, to discuss the status of SCSSW OU.

### **4.2.3 Site Visits**

Kenneth Stockwell, Stephen Rossello, John Koon and John Osweiler of Parsons ES walked portions of the SCSSW with James Dawson, Scott Bowen and Keith Buehler (OC-ALC) on July 16 and 17, 1998 and observed landscaping and current conditions.

### **4.2.4 Remedial Action Objectives**

The selected remedial action goals for the SCSSW were based on results of the baseline risk assessment (RA) conducted for the OU (B&V, 1993c), which included a quantitative baseline human health risk assessment (BHRA), and a qualitative ecological risk assessment (ERA). Results of the BHRA showed that potential risk to human health from Soldier Creek sediment and surface water was within acceptable risk-based exposure levels established by the EPA. The qualitative ERA identified several contaminants that may pose a potential environmental concern, however, additional study was recommended to fully characterize potential risk.

The health-based cleanup goals were identified in the ROD as to-be-considered (TBC) criteria to be used as guidelines for evaluating future concentrations of contaminants detected in Soldier Creek sediment and surface water. TBCs are evaluated in the five-year review with respect to any changes since the time of their development. TBCs can vary due to changes in site characteristics (e.g., receptors, exposures, or pathways) and/or characteristics of the contaminant (e.g., new toxicity information and level of contaminant). The TBCs were initially based on the existing site conditions and contaminant characteristics computed by back-calculating equations used in the BHRA (B&V, 1993b; 1993c).



The ROD response action was based on sediment and surface water data collected during Phase I and Phase II of the RI. For these media, the BHRA evaluated potential risks for incidental ingestion and dermal contact for adult workers and child/adult recreators. Based on the conceptual site model (CSM) which identifies and describes exposure pathways which may be potentially complete for the site, ten reasonable maximum exposure (RME) scenarios were selected to represent the current and future land use. The exposure pathways and RME assumptions initially evaluated in the BHRA are considered to be applicable to current conditions.

The qualitative ERA focused on the effects of contaminant exposure on general populations of aquatic and terrestrial species typical of the OU area (B&V, 1993c). It was found that the presence of several metals in surface water and sediment (barium, cadmium, chromium, copper lead, nickel, selenium, silver, and zinc) were of potential environmental concern to aquatic species; however, additional data were needed to fully characterize this risk as well as the potential risk to terrestrial species.

#### **4.2.5 Data Review**

Since the time of the original BHRA and qualitative ERA, additional information on the nature and extent of contamination has been collected, including additional sediment and surface water sampling, as well as information on pesticides and polychlorinated biphenyls (PCBs) not previously evaluated. A review of the first three years of monitoring data on human health and ecological risk are discussed below.

##### **4.2.5.1 Human Health Risk Assessment**

The first annual human health risk assessment (HHRA I) was prepared to provide information on potential "current" and future risks based on data for surface water and sediment samples collected in November 1994, and January, April, and June 1995. The stream segments that were sampled are shown on Figure 12. The data were also used to compare results with those of the RI (B&V, 1993b) and determine if previous conclusions remained valid. Based on results of the second year of quarterly monitoring, the second annual HHRA (HHRA II) was prepared to address the same issues as the HHRA I. "Current" data for HHRA II (collected in October 1995, and March, May, and August 1996) were used to identify potential risk and also verify that previous conclusions remained valid. These issues were similarly addressed in the third annual HHRA (HHRA III) using monitoring results from samples collected in January and July 1997.

Although not impacting the overall results, slight differences in methodology are noted between the original BHRA and the long-term HHRAs:

- PCB/pesticide analyses were added as sampling criteria in the long-term monitoring study (these analytes were not included in the RI samples);
- Four stream segments were evaluated for risk in the long-term HHRAs (nine segments were evaluated in the BHRA); and

- Age-corrected skin surface areas for the potential receptors were used in the long-term HHRAs for evaluating exposure to surface water and sediments (these parameters were not corrected in the BHRA).

Despite these slight differences in approach, there were no unacceptable cancer risks or non-carcinogenic hazards calculated during any of the long-term HHRAs. Thus, under the "current" or future stream use conditions for potential on-base or off-base population exposures to sediment and surface water in the SCSSW OU, there continues to be no unacceptable human health risk.

#### **4.2.5.2 Comparison of Data to Health-Based Cleanup Goals**

Based on the remedial action requirements for the SCSSW OU, human health-based cleanup goals were developed to evaluate the long-term monitoring results. These health-based goals were calculated for each chemical using the most health-protective exposure scenario (i.e., the scenario associated with the highest calculated risk or hazard). The residential exposure scenario was used for chemicals found offbase and the construction worker scenario was used for on-base chemicals.

Four sets of human health-based cleanup goals were developed based on acceptable risk levels established by the EPA. This included three levels for carcinogens based on the EPA-acceptable cancer risk range of 1E-06 (one additional case of cancer per one million), 1E-05 (one additional case per one hundred thousand), and 1E-04 (one additional case per ten thousand). One health-based risk level was also calculated for each non-carcinogenic chemical based on the target Hazard Index (HI) of 1.0. For chemicals with both carcinogenic and noncarcinogenic properties, the lower (more health-protective) level was selected. Since surface water is dynamic (constantly changing), the calculated health-based cleanup goals are referred to as "health-based indicators of water quality." Both sediment and surface water values, however, provide the basis for comparing chemical concentrations to health-based levels and for evaluating whether additional remedial action may be necessary at the site.

During the BHRA and subsequent long-term monitoring HHRAs, health-based indicators for water quality were not exceeded for any detected contaminants. No analytes in sediment samples exceeded the 1E-04 RAO, which is the highest TBC concentration for a chemical detected at the site based on the USEPA-accepted risk range (1E-06 to 1E-04). The third year long-term monitoring annual report (Tables 5-8 and 5-9) (WCFS, 1998) shows the comparison of site data to the acceptable 1E-04 to 1E-06 range of health-based cleanup goals.

TBCs are evaluated in the five-year review with respect to any new information on chemical toxicity which may increase or decrease the TBC. Since the time of the third year monitoring report, toxicity data for two of the detected contaminants (alpha-chlordane and beryllium) have been updated (EPA, 1998). The new cancer and noncancer toxicity data for alpha-chlordane show that the chemical is less toxic than indicated in the HHRAs. Beryllium was not identified as presenting a potential human health risk using the previous toxicity data, and although new data indicate that the chemical is slightly more toxic as a noncarcinogen, the change in the toxicity value is not

significant for the site. [The change in the toxicity value would result in a decrease of the noncarcinogenic action level for sediments from 21,800 to 8,720 milligrams per kilogram (mg/kg). Compared to the range of detected concentrations for beryllium in sediments (1.7 to 0.27 mg/kg), this change is not significant]. Since beryllium was not detected in surface water during the third year monitoring results, there is no effect on the level of risk for this medium. Additionally, the oral slope factor (SF) for beryllium has been withdrawn (the toxicity data show that beryllium is not carcinogenic by ingestion). Thus, the chemical would not be calculated as a carcinogen via ingestion of sediments (i.e., the calculated overall carcinogenic risk would decrease).

#### **4.2.5.3 Ecological Risk Assessment**

The ecological investigation mandated by the ROD for the SCSSW OU was conducted as part of the environmental monitoring program to quantify potential effects of contaminant concentrations on the biological environment of the creek (WCFS, 1997b). The main ERA field activities were performed during October 1994 and June 1995. One noted observation of the ecological survey was that no federally listed threatened or endangered species or their habitats were found to occur within the SCSSW OU.

For sampling data evaluated in the ERA, a constituent was selected as a chemical of potential concern (COPC) if it was detected in one ecological or quarterly-monitoring sample (i.e., detected in at least one sampling event and at one location) at a concentration that exceeded the lowest available ecotoxicological benchmark for the specific medium. Using this screening process, forty-six COPCs (including chemical "groups" in some cases) were identified in either sediment, surface water, or both media. These forty-six chemicals, or groups of chemicals, included:

- Nineteen inorganics: aluminum, antimony, arsenic, barium, cadmium, chromium, cobalt, copper, cyanide, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, vanadium, and zinc;
- Eleven VOCs/SVOCs: acetone, benzidine, bis(2-ethylhexyl)phthalate, carbon disulfide, chlorobenzene, 1,4-dichlorobenzene, methylene chloride, toluene, 2,3,6-trichloronaphthalene, triphenyl phosphine sulfide, and total xylenes;
- Four phenols and substituted phenols/nonylphenols: 2,4-dimethylphenol, pentachlorophenol, phenols and various substituted phenols (counted as one chemical group), and nonylphenols (counted as one chemical group);
- Total PCBs (counted as one chemical group): Aroclor 1254 and other mixtures;
- Eight organochlorine pesticides: aldrin, alpha- and delta-BHC (counted as one pesticide), alpha-chlordane, dieldrin, endosulfan sulfate, heptachlor, heptachlor epoxide, and methoxychlor;
- Low molecular weight PAHs (counted as one chemical group): acenaphthene, anthracene, fluorene, and phenanthrene;
- Medium molecular weight PAHs (counted as one chemical group): fluoranthene and pyrene; and

- High molecular weight PAHs (counted as one chemical group): benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

At the concentrations estimated for direct exposures to strictly-aquatic organisms (algae, benthic and water-column invertebrates, and fish) and/or the doses estimated for indirect exposure (via the ingestion pathway) to terrestrial/semi-aquatic birds and mammals, sixteen of the forty-six chemicals were found to pose a potential threat to ecological species. In general, the potential risks to strictly-aquatic organisms were somewhat greater than the potential hazards to terrestrial animals. The potential risks associated with both direct (aqueous) and dietary exposures were largely, but not entirely, confined to on-base portions of East and West Soldier Creeks.

Results of the ERA showed that the most significant COPCs for sediments were cadmium, chromium, copper, nickel, silver, zinc, total PCBs, PAHs, certain organochlorine pesticides, and certain phenolic compounds. Among these, cadmium, chromium, copper, nickel, PCBs, and PAHs were the most ubiquitous. The ERA indicated that potential effects of these contaminants may extend downstream (northward) beyond the ERA study boundary at Interstate 40. However, the potential for downstream hazards was not considered to be of major ecological significance, particularly at higher levels of biological organization (i.e., populations, communities, ecosystems).

The most significant chemicals in surface water were barium, cadmium, chromium, copper, lead, molybdenum, and zinc. All of these chemicals, except molybdenum, were ubiquitous, and were also considered, to some extent, as possible contaminants of concern for areas downstream of Interstate 40. Copper and chromium were of particular concern due to their phytotoxicity and indirect effect on higher trophic levels. These two metals, as well as cadmium and zinc (and possibly barium), were also considered to possibly directly affect invertebrate and fish communities.

Chromium, PCBs, and high molecular weight PAHs appeared to be the most significant chemicals for the ingestion pathways of terrestrial/semi-aquatic receptors. However, the lack of relevant dietary toxicological data prevented detailed quantitative estimation of dietary risk to amphibians and semi-aquatic reptiles (e.g., certain turtles and water snakes) which may be the most sensitive wildlife receptors for the OU.

Toxicity tests (acute and chronic effects under controlled laboratory conditions) were also measured on ecological species exposed to sediment and surface water. With the exception of conditions in off-base portions of West Soldier Creek, which did not appear to be as hazardous to aquatic receptors as indicated by the risk estimates described above (based on the hazard quotient / hazard index approach), the toxicity tests generally corroborated the risk estimates. Biological surveys, particularly of benthic invertebrate and fish communities, also generally supported conclusions of the risk estimates.

Initial chemical-specific concentrations referred to as preliminary remedial goal options (RGOs) were developed as protective levels for ecological receptors in sediment and surface water of Soldier Creek. These levels are similar to the human health-based

cleanup goals and can be used for evaluating chemical concentrations detected in the on-going five-year monitoring efforts and for evaluating whether additional remedial action may be necessary at the site.

It should be noted that the ERA is based on very conservative exposure values and that the risk characterization is inflated by additive conservative assumptions. The degree to which exposures and toxicities are overestimated leads to a great deal of uncertainty in the assessment. Additionally, the adverse effects identified in the assessment were limited to a localized scale in on-base areas. Further data are necessary to more accurately characterize the extent of contamination and the associated potential hazards to ecological receptors in downstream areas. Interpretation of the ecological significance of the ERA results is provided in Section 5.

## SECTION 5 CONCLUSIONS

### 5.1 BUILDING 3001 OU

#### *Building 3001 Groundwater*

The O&M records of the GWTP were reviewed and found to meet effluent requirements without exception.

The extraction system is effectively controlling the TCE and chromium groundwater plumes; however, there are areas of the site with isolated occurrences of TCE and chromium that do not appear to be related to Building 3001. In the USZ these exceptions occur in the northwestern and southwestern portions of the site. West of the north-south runway TCE and chromium contamination occur in the USZ and LSZ. The chromium contamination in this area of the USZ is not believed to be related to Building 3001. It has not yet been determined if Building 3001 is the source of contamination in the LSZ west of the north-south runway.

The ROD predicted that the GWTP extraction system would remove approximately 72 percent of the TCE and 77 percent of the chromium in the first five years of operation and that 85 percent of both contaminants would be removed within 20 years. It is important to note that these estimates did not take into consideration the addition of contaminants into the flow system as a result of recharge through source zones, the effects of retardation (sorption, desorption, chemical reactions), the likely presence of DNAPL or travel time to the extraction wells. Incorporation of these factors would have resulted in longer estimated cleanup times.

The conceptual model developed for Tinker AFB along with updated water level and water quality data has provided a more reliable estimate of contaminant extent and migration. Several attempts have been made to calculate the cleanup time for the Building 3001 groundwater plume, but a conclusive estimate has not been reached. This is primarily because of the uncertainties posed by the probable occurrence of chlorinated DNAPL compounds in the groundwater. Reduction of the chromium plume may be proceeding at the originally anticipated rate, particularly in the regional zone (layer 7).

In general the highest concentrations of TCE and chromium have declined beneath Building 3001. Concentrations in some of the monitoring wells have risen and fallen erratically since full scale monitoring of this OU was initiated in 1994. However, the 1997 contaminant concentration data and 1998 water level data indicate that the extraction wells are capturing the contaminants associated with Building 3001. Increases in concentrations to the north and southeast of the line of recovery wells indicates that some

contaminant spreading from Building 3001 may be occurring and should be corrected. Nevertheless, the Building 3001 plume and other areas of contamination remain onsite within the boundaries of the Building 3001 OU.

#### *North Tank Area*

Free product at the site is relatively immobile. Although, the free product continues to be a source of contamination to groundwater, the dissolved plume is contained by the Building 3001 extraction well system. Multiple pilot testing using SVE and pneumatic fracturing has determined that formation permeability is very low and soil contamination is not very conducive to contaminant removal using these technologies. Natural attenuation is an appropriate remedial action based on cost and on the presumption that time is not a factor due to the anticipated long-term remediation and monitoring for the Bldg 3001 groundwater plume.

As long as the fuel product remains relatively immobile, the O&M activities currently performed at the site are protective of human health and the environment. Sufficient monitoring and institutional controls are in place to determine if product is migrating from the NTA.

#### *Pit Q-51*

Pit Q-51 has been effectively remediated with removal of the pit contents and sealing with an 8-inch thick concrete cap. The site inspection confirmed that the cap is intact.

## **5.2 SOLDIER CREEK SEDIMENT AND SURFACE WATER OU**

### **5.2.1 Interpretation of Human Health Significance**

As required by the ROD, the five-year monitoring program for the SCSSW OU has been implemented. Over the three-year duration of the monitoring program, health-based indicators for water quality (health-based cleanup goals) were not exceeded for any chemical detected in water. Additionally, no analytes in sediment samples exceeded the 1E-04 RAO, which is the highest TBC level (human health-based action level) for a detected chemical based on the EPA-acceptable risk range (1E-06 to 1E-04).

In addition to these results, the quantitative HHRAs did not show an unacceptable health risk. Results of the HHRAs for the first three years of the monitoring program, as well as results of the BHRA, indicate that under "current" or future stream use conditions there is no unacceptable human health risk (cancer or noncancer risk) for potential on-base or off-base receptors due to sediment and surface water exposures for the SCSSW OU.

### **5.2.2 Interpretation of Ecological Significance**

The ERA indicated that forty-six chemicals, or chemical groups, were of ecological concern (pesticides, PCBs, PAHs, and other volatile and semivolatile compounds). Ecological exposures were found to pose some risk of acute and chronic, sublethal effects to certain individual receptors or individuals of receptor classes.

The study indicated that the ecological exposures and effects were largely confined to the on-base portions of the SCSSW OU. The concentrations of the PAHs were found to vary between sampling segments and sampling events suggesting that multiple on-base origins for the PAHs may exist. For example, highest PAH concentrations for the second year of monitoring occurred in the stream segment representing Outfall G, but during the third year of monitoring, many of the highest PAH concentrations occurred in the segment representing Outfall F. Data also indicated that discharge from Outfall G is a possible source of the PCB contamination. Although all electrical transformers with PCB-containing oil were replaced at the base in 1989, minor leaks or spills of old transformer oil may have previously entered the storm drain system. There are no known industrial processes that use PCBs in the area.

The ERA states that the adverse affects are clearly limited to a localized scale. This is also why results showed that the most ecologically-relevant actual or potential effects are those on strictly-aquatic communities (i.e., algae, benthic and water-column invertebrates, fish) and small terrestrial/semiaquatic animals. The ERA states that it is unlikely that larger terrestrial vertebrates (wildlife) are at much risk from site-related chemicals.

The conclusions of this limited ERA also indicate that the risk characterization is inflated by additive conservative assumptions and that there is much uncertainty related to the degree to which exposures and toxicities are overestimated. The conclusions indicate that better understanding of the ingestion-pathway exposures is needed (as opposed to estimating dietary constituent concentrations of chemicals) and additional sampling may be required. As an example, the ERA suggests sampling and analyses of plant tissues (particularly fruits), amphibians, and/or small mammals to provide a better understanding of the dietary exposures to higher-level consumers as well as more insights into the actual availability for direct uptake of the chemicals.



## **SECTION 6 DEFICIENCIES**

### **6.1 BUILDING 3001 OU**

#### *Building 3001 Groundwater*

There were no significant deficiencies identified for the Building 3001 OU. A comparison of TCE distribution with the USZ capture zone, as interpreted from the June 1998 water levels suggests that the USZ capture zone needs to more effectively control the TCE found in well 1-75B in the northwest corner of the site. In the southern portion of the site, the USZ zone of capture needs to be confirmed southwest of P-12.

#### *North Tank Area*

There were no deficiencies identified for the NTA.

#### *Pit Q-51*

There were no deficiencies identified for Pit Q-51.

### **6.2 SOLDIER CREEK SEDIMENT AND SURFACE WATER OU**

There were no deficiencies identified for the SCSSW OU. The additional sampling details identified as uncertainties in the ERA should be added to the next rounds of monitoring to more clearly define the ecological risk. These efforts will provide the basis for determining whether additional remedial action is necessary in the area. Based on these results, actions may be required to reduce the risk of contaminants to ecological receptors in the SCSSW OU.

## SECTION 7 RECOMMENDATIONS

### 7.1 BUILDING 3001 OU

#### *Building 3001 Groundwater*

The USZ hydraulic gradient in the vicinity of extraction well P-1 should be increased to ensure efficient recovery of contaminants near well 1-75B. Therefore, it is recommended that the pumping rate be increased in well P-1. This may be accomplished through simple adjustment of the water level controls. Extraction well P-12 is a low yield well and pumping cannot be increased at this location. It is recommended that an additional USZ well be placed southwest of P-12 to confirm or deny the presence of TCE beyond the P-12 capture zone.

The five-year review identified areas of contamination west of the north-south runway that are likely unrelated to Building 3001. The sources of contamination at wells 1-65B and 1-67B should be identified. Also, the source area for the contamination detected in well 1-72B, located southeast of recovery well P-12, should be identified. Additional investigations should be conducted west of the north-south runway in layers 1 through 7 to determine the horizontal and vertical extent of contamination. Following delineation, recommendations for remediation should be completed and an alternative selected and implemented. An RI in the vicinity of well 2-162B was completed in 1996 and identified the source of contamination to be the 290 Fuel Farm. Remediation in this area is planned for 1999.

Based on changes in MCLs for some of the chemicals of concern, and the likelihood that DNAPL exists at this site, it is recommended that the RAOs for this site be re-assessed. The MCL for chromium has increased, while other contaminant MCLs have decreased (lead) or are newly established (nickel). The likelihood of DNAPL sources impacts the extraction system's capability of meeting TCE MCLs for the entire site within the originally estimated 30 year time frame. Therefore, it is recommended that review of the RAOs should focus more on TCE containment rather than total aquifer restoration. The RAO review should also consider the feasible benefit and risk associated with natural attenuation of TCE.

#### *North Tank Area*

The conclusion in the Focused RI (Parsons ES and Battelle, 1994) is that natural attenuation is appropriate based on cost and on the presumption that time is not a factor

due to the anticipated long-term remediation and monitoring of the Building 3001 groundwater plume. A vacuum enhanced pumping (VEP) technology demonstration is planned for the NTA in 1999. Existing wells will be screened across the vadose, unconfined, and confined portions of the USZ. Fluids will be removed from the subsurface using a vacuum pump and treated on-site with air stripping and thermal oxidation if necessary. This demonstration will be conducted by OC-AL/EMR. Since O&M plans have not been upgraded since the first dual phase recovery system was installed in 1992, it is recommended that a complete O&M plan (with monitoring requirements) be completed with this new system.

#### *Pit Q-51*

Annual inspection of the concrete cap is recommended to ensure that the cap integrity is maintained.

## **7.2 SOLDIER CREEK SEDIMENT AND SURFACE WATER OU**

Based on results of the HHRAs and comparison of data to health-based action levels, there is no unacceptable risk to human health for the SCSSW OU. The EPA has been notified of the ERA results and efforts are underway to further characterize potential ecological risk in the area. Numerous activities have occurred in the area of the SCSSW OU to remove or reduce potential contaminant sources. There are also continued efforts at Tinker AFB to provide further protectiveness of the environment in response to the levels of contamination found in the creek.

Certain remedial measures have also recently been implemented by OC-ALC/EMR at West Soldier Creek. Flight line criteria at Tinker AFB have prompted upgrades to the landscape along the creek. The channel of the creek has also been concreted. This action serves as a facility improvement as well as a remedial measure (although not identified as a ROD requirement) to minimize the potential for sediments to move offbase and pose a human health or ecological threat to downstream receptors.

Protectiveness of the environment will be improved by these remedial responses. However, to ensure that exposure to and migration of contaminants does not occur at concentrations greater than remediation goals (the human health-based cleanup goals and the ecological RGOs), annual monitoring efforts and risk evaluations should continue for the SCSSW OU.

The additional sampling details identified as uncertainties in the ERA should be added to the next round of monitoring to more clearly define the ecological risk. These efforts will provide the basis for determining whether additional remedial action is necessary in the area. Options for remediation (e.g., phytoremediation) should be considered if these results indicate that an unacceptable risk exists.

It should be noted that since the time of the third year monitoring report, human-health toxicity data for two of the detected contaminants (alpha-chlordane and beryllium) have been updated. The new toxicity data should be used in subsequent HHRAs.

Additionally, methods for evaluating dermal exposure should consider the USEPA (1997) draft guidance which recommends adjusting oral toxicity values for estimating potential risk for dermal contact.

## **SECTION 8 PROTECTIVENESS STATEMENT**

### **8.1 BUILDING 3001 OU**

While it appears that improvements should be made to the Building 3001 extraction well field, the current remedial action is protective of human health and the environment.

### **8.2 SOLDIER CREEK SEDIMENT AND SURFACE WATER OU**

The results from the ERA indicated the potential for ecological risk in the area. Subsequent remedial measures have been implemented by OC-ALC/EMR to remove or reduce potential contaminant sources and minimize the potential for sediments to move offbase and pose a human health or ecological threat to downstream receptors. Continued annual monitoring and evaluation will determine the need for further remedial actions, if necessary.

## **SECTION 9 NEXT REVIEW**

The U.S. Air Force will conduct the next five-year review in 2003, ten years after implementation of the groundwater remedy at the Building 3001 OU.

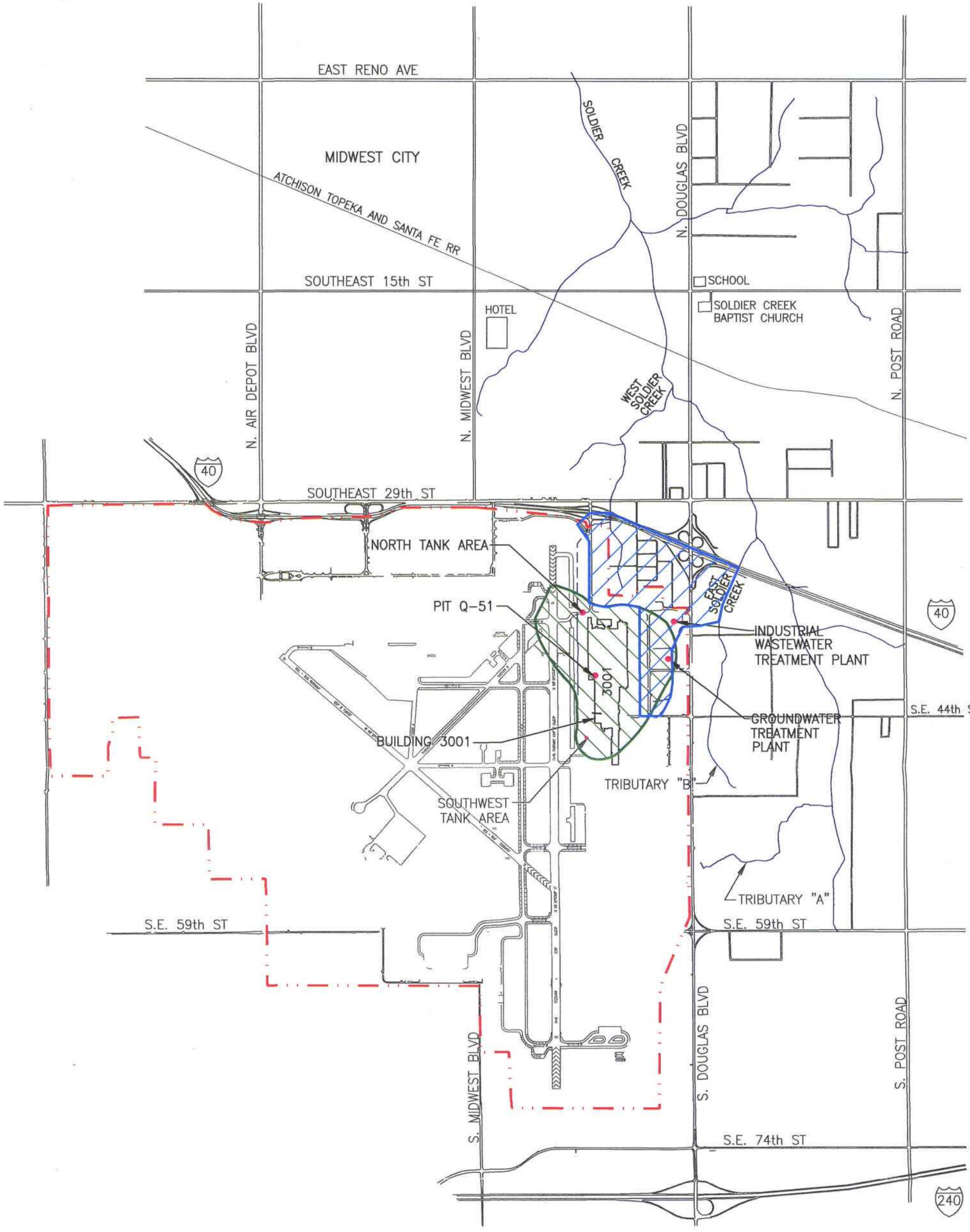
## **SECTION 10 OTHER COMMENTS**

### **10.1 BUILDING 3001 OU**

No as-built drawings have been completed for the Building 3001 GWTP but there is a contract to complete them within the next 6 months. However, sufficient schematics and a sufficient number of accurate or near-accurate design drawings are available. This does not appear to have an adverse effect on the operation or performance of the treatment plant.

### **10.2 SOLDIER CREEK SEDIMENT AND SURFACE WATER OU**

There are no other comments for the SCSSW OU.



LEGEND

- SOLDIER CREEK AND TRIBUTARIES
- - - UNDERGROUND PORTION OF CREEK
- · - · - · BOUNDARY OF TINKER AIR FORCE BASE



BUILDING 3001 OPERABLE UNIT



INDUSTRIAL WASTEWATER TREATMENT PLANT/SOLDIER CREEK OFF-BASE GROUNDWATER OPERABLE UNITS

OPERABLE UNITS

- BUILDING 3001 - OU-1
- SOLDIER CREEK SEDIMENT AND SURFACE WATER - OU-2
- SOLDER CREEK OFF-BASE GROUNDWATER - OU-3
- INDUSTRIAL WASTEWATER TREATMENT PLANT (IWTP) - OU-4

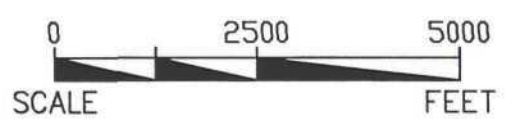
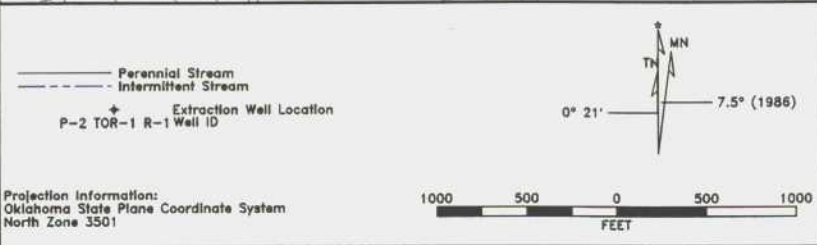
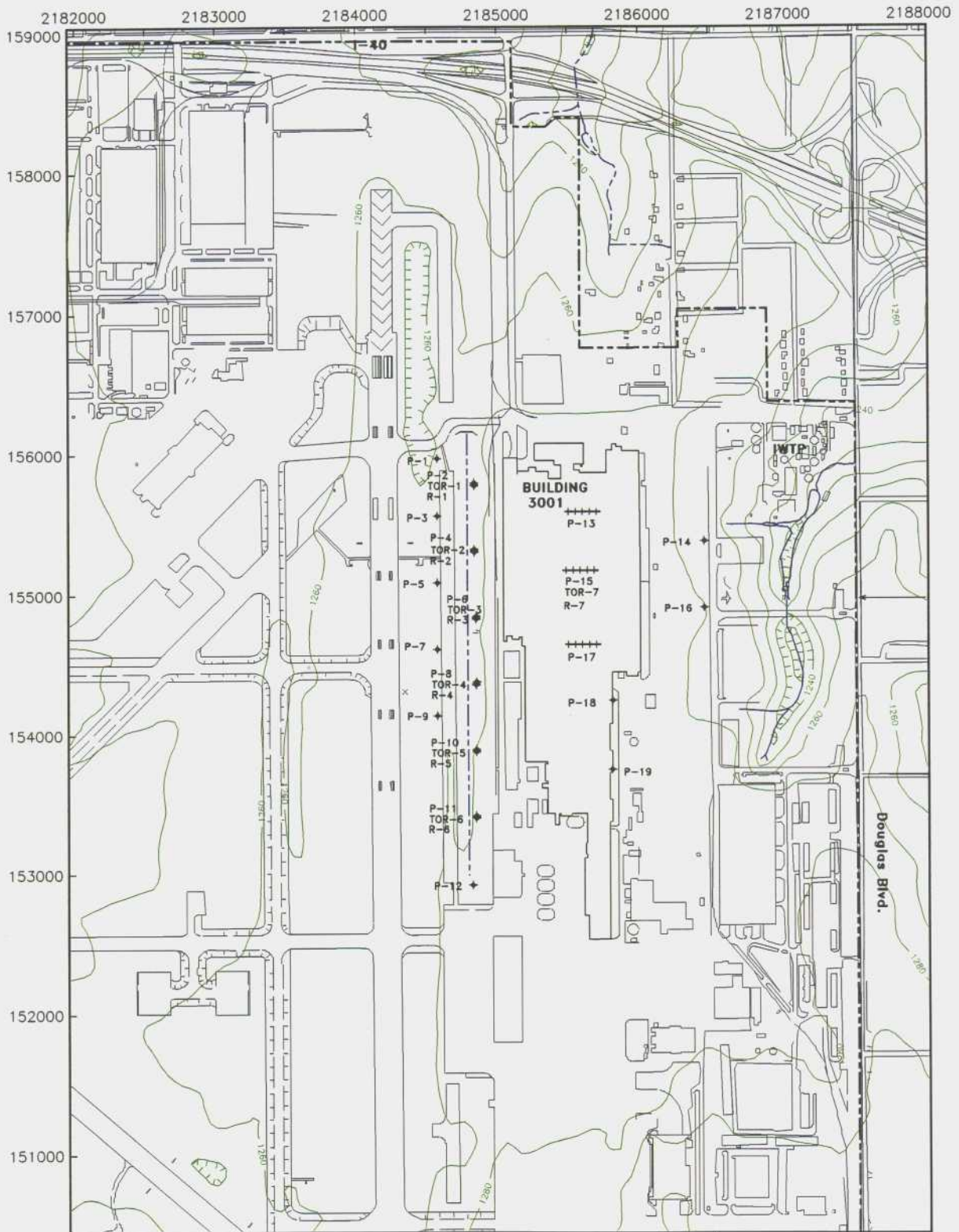


FIGURE 1  
LOCATION MAP  
TINKER A.F.B., OKLAHOMA

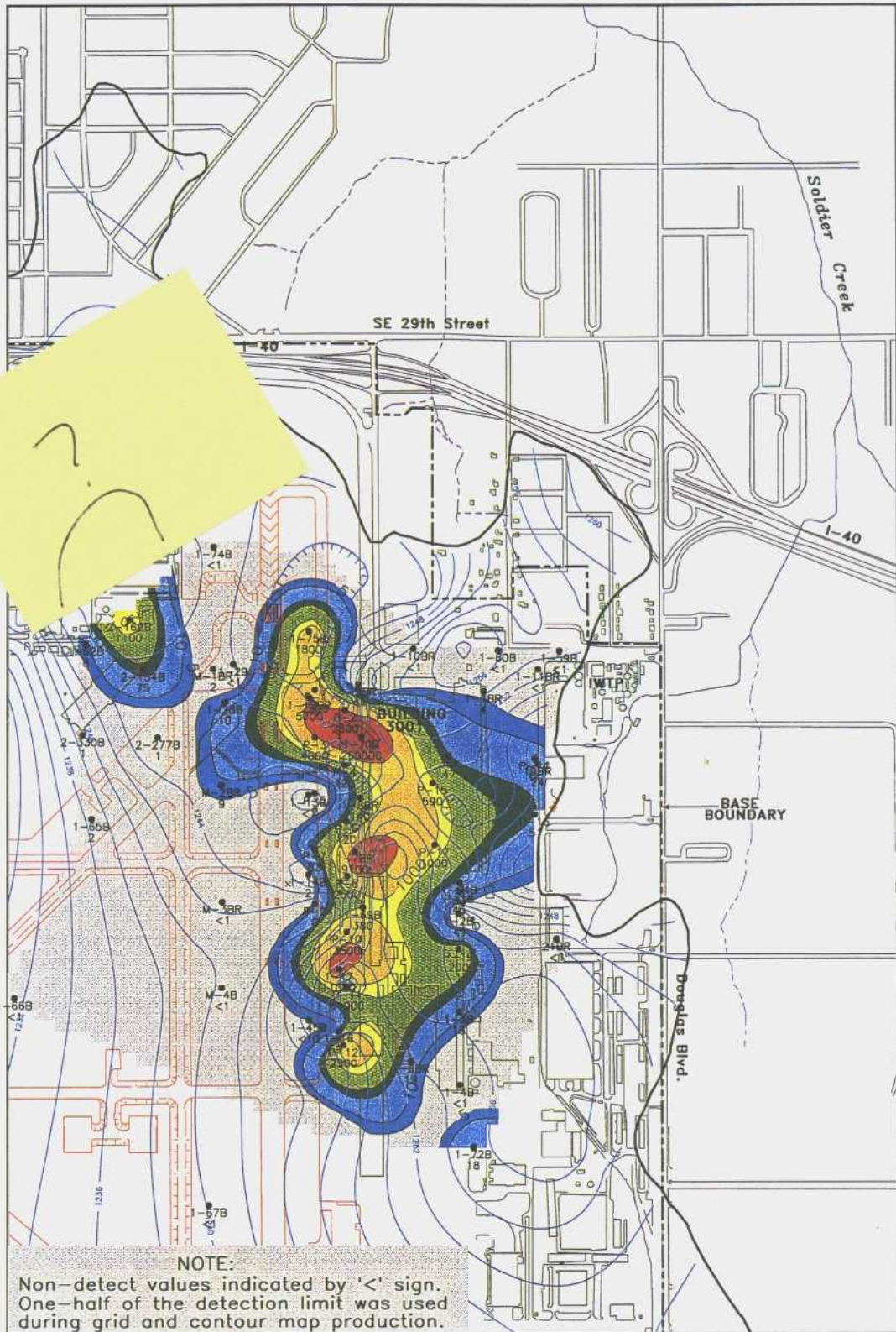




Projection Information:  
 Oklahoma State Plane Coordinate System  
 North Zone 3501

**FIGURE 3**  
**Building 3001**  
**Groundwater Extraction**  
**Wells**  
**Northeast Quadrant**  
**Tinker AFB, Oklahoma**

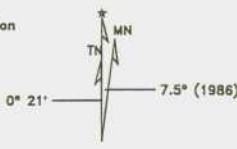
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 Date: 4/13/96



**NOTE:**  
 Non-detect values indicated by '<' sign.  
 One-half of the detection limit was used  
 during grid and contour map production.

- Approx. Extent USZ Saturation
- Water Table Elevation Line
- Isopleth Line
- Perennial Stream
- Intermittent Stream

● NOVEMBER '97 DATA  
 1-3B Well ID  
 15 TCE Concentration



Projection Information:  
 Oklahoma State Plane Coordinate System  
 North Zone 3501

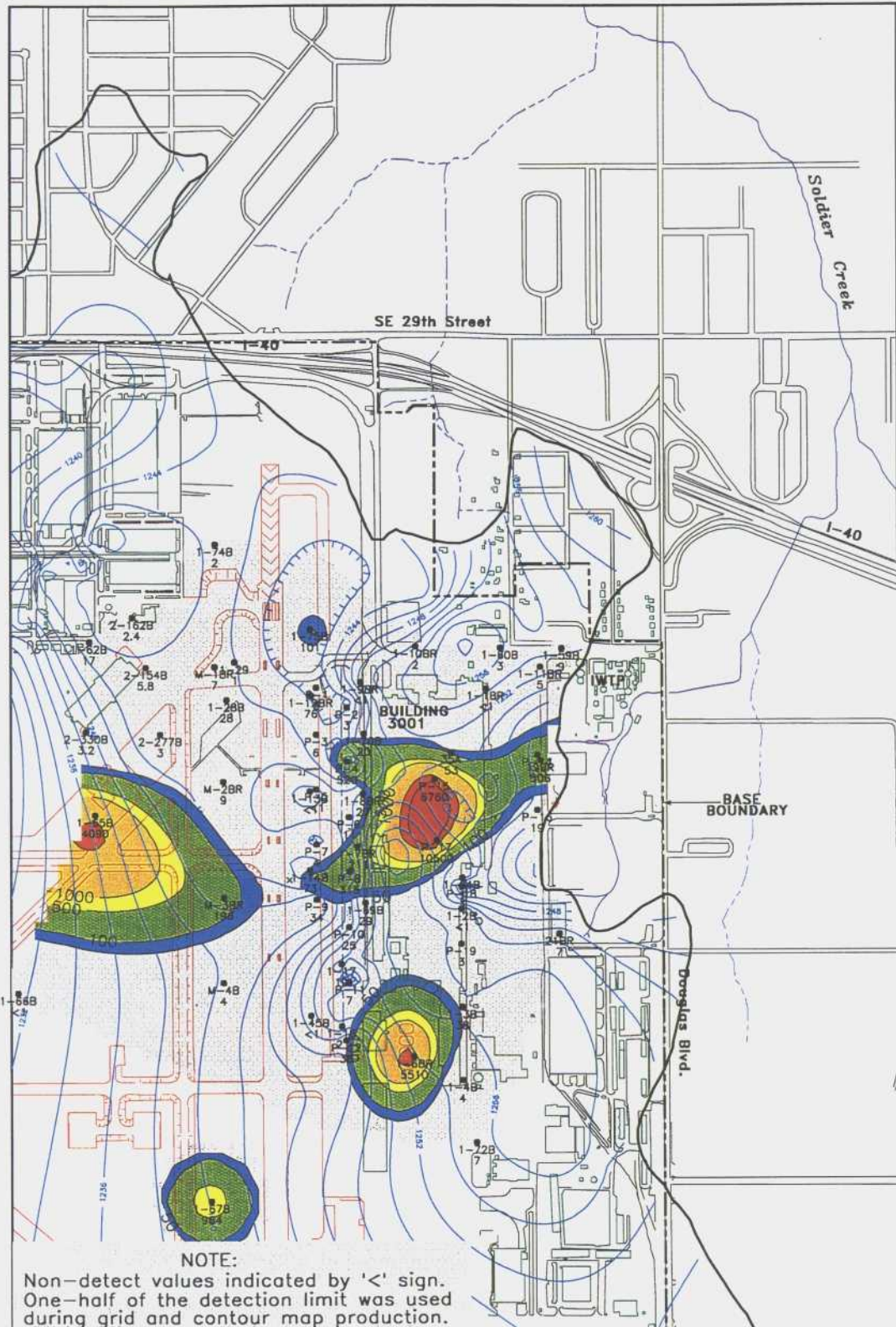


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5-10 PPB
10-50 PPB
50-100 PPB
100-500 PPB
500-1,000 PPB
1,000-5,000 PPB
5,000-25,000 PPB
25,000-50,000 PPB
> 50,000 PPB

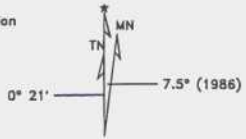
**FIGURE 4**  
 TCE Concentration  
 with Water Levels  
 Layer 1 (USZ)  
 Northeast Quadrant  
 TINKER AFB, OKLAHOMA  
 NOVEMBER 1997

Script File: tce nov97.sh  
 Date: 7/27/98





- Approx. Extent USZ Saturation
- Water Table Elevation Line
- Isopleth Line
- Perennial Stream
- Intermittent Stream



NOVEMBER'97 DATA  
 1-75B Well ID  
 101 CR Concentration

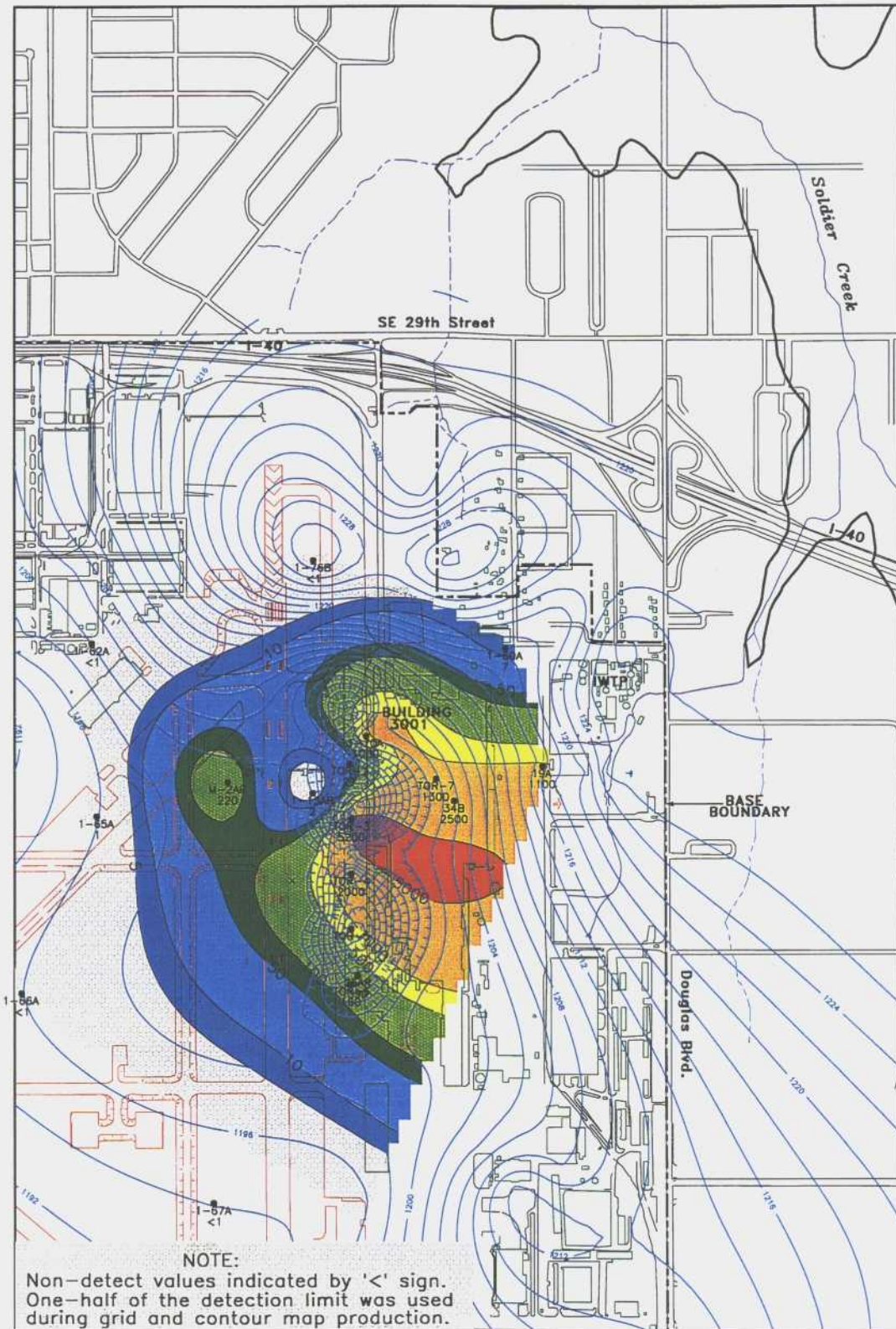
Projection Information:  
 Oklahoma State Plane Coordinate System  
 North Zone 3501

- <50 PPB
- 50-100 PPB
- 100-500 PPB
- 500-1000 PPB
- 1000-5000 PPB
- 5000-10,000 PPB
- >10,000 PPB

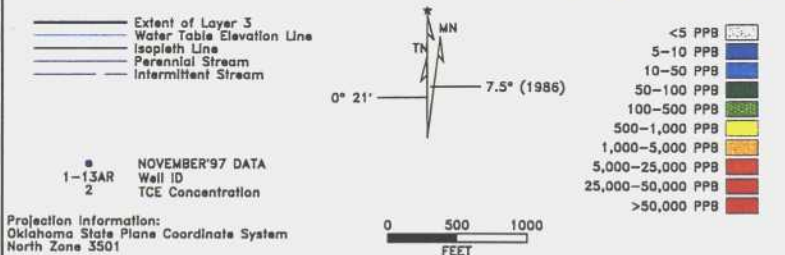
**FIGURE 5**  
 CR Concentration  
 with Water Levels  
 Layer 1 (USZ)  
 Northeast Quadrant  
 TINKER AFB, OKLAHOMA  
 NOVEMBER 1997

Script File: crnov97.sh  
 Date: 7/27/98





**NOTE:**  
 Non-detect values indicated by '<' sign.  
 One-half of the detection limit was used  
 during grid and contour map production.

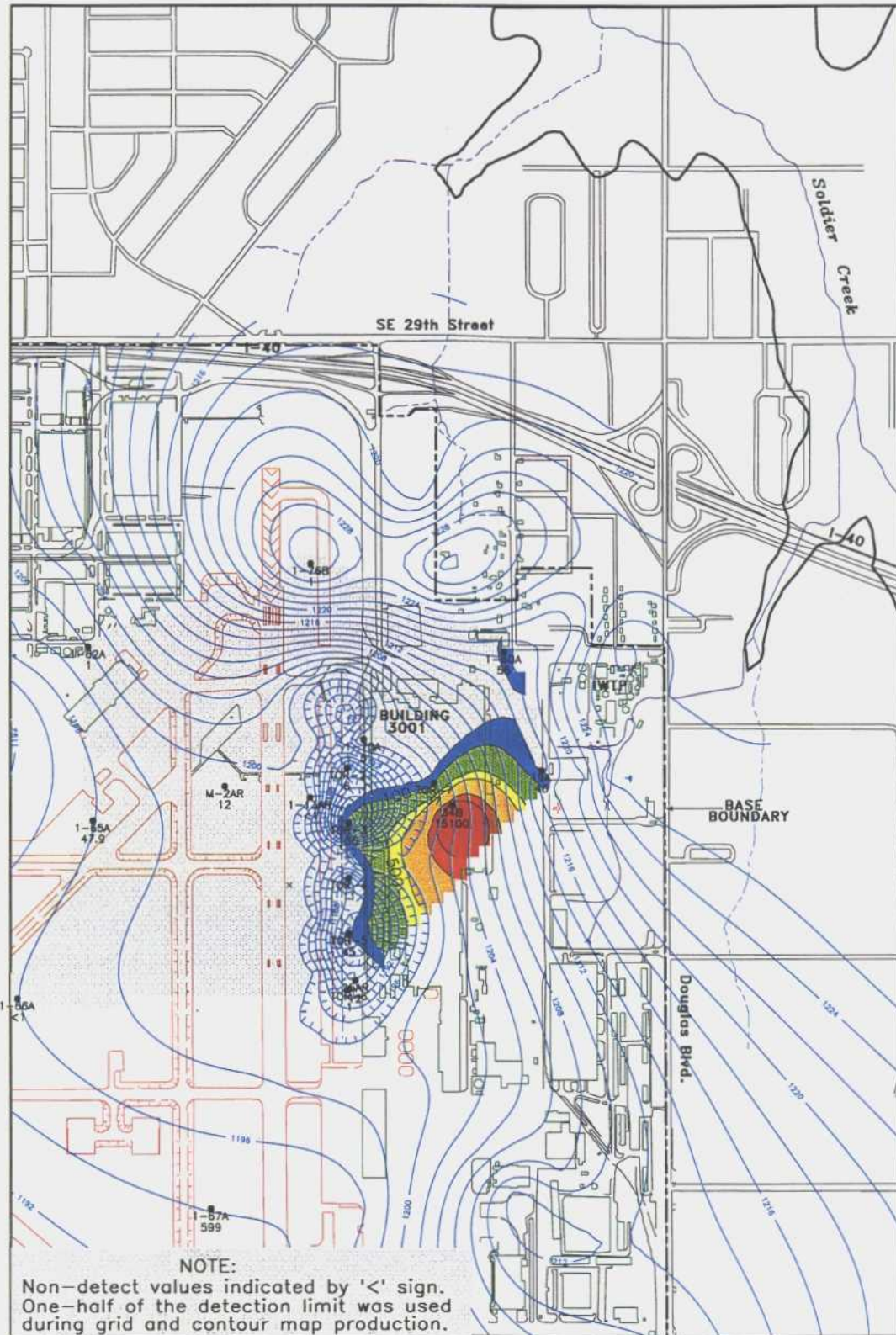


**FIGURE 6**  
**TCE Concentration**  
**with Water Levels**  
**Layer 3 (LSZ)**  
**Northeast Quadrant**  
**TINKER AFB, OKLAHOMA**  
**NOVEMBER 1997**

Script File: tcenov97.sh  
 Date: 7/27/98

Projection Information:  
 Oklahoma State Plane Coordinate System  
 North Zone 3501

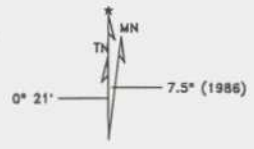




- Extent of Layer 3
- Water Table Elevation Line
- Isopleth Line
- Perennial Stream
- Intermittent Stream

● NOVEMBER'97 DATA  
 25AR Well ID  
 12 CR Concentration

Projection Information:  
 Oklahoma State Plane Coordinate System  
 North Zone 3501

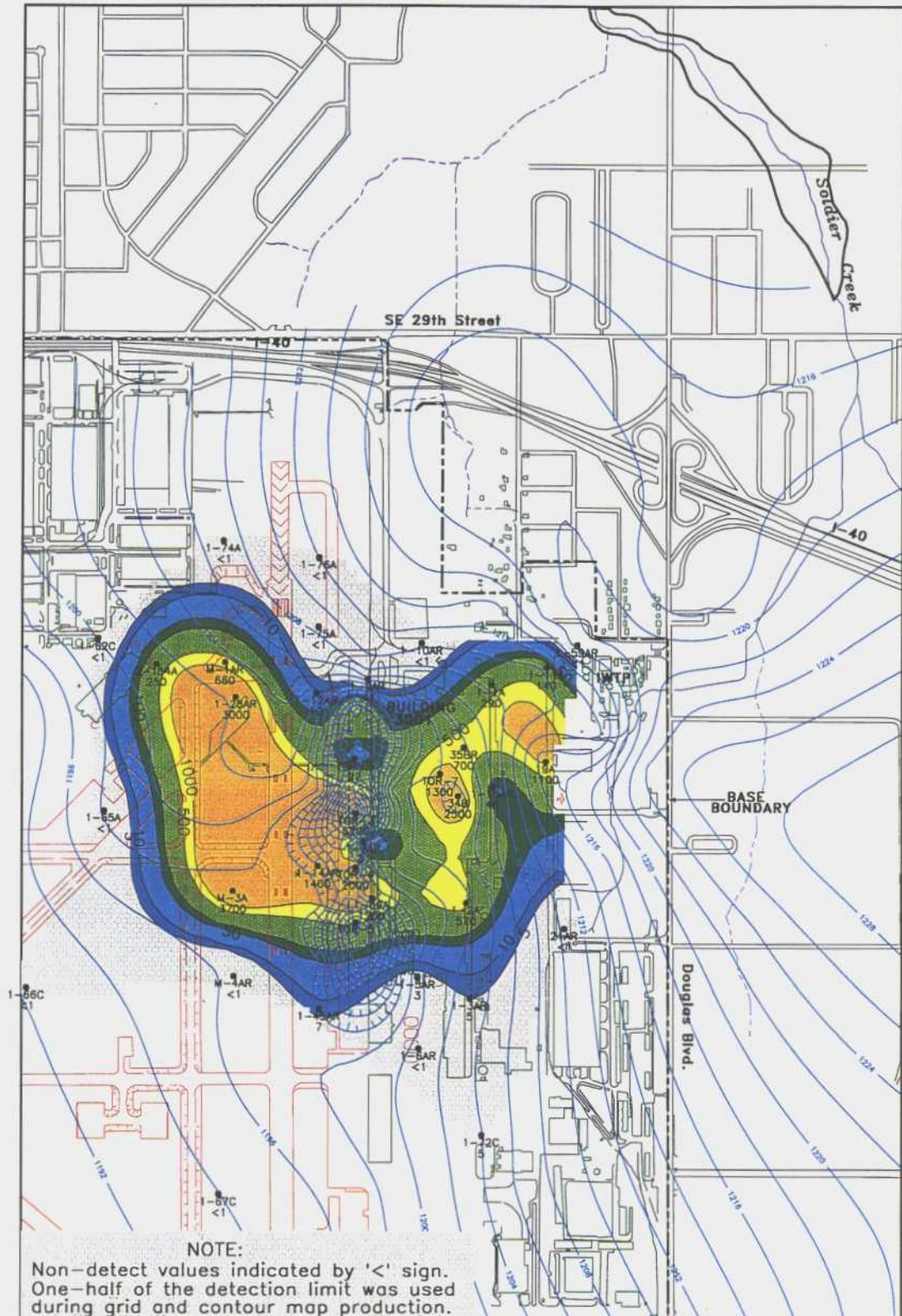


- <50 PPB
- 50-100 PPB
- 100-500 PPB
- 500-1000 PPB
- 1000-5000 PPB
- 5000-10,000 PPB
- >10,000 PPB

**FIGURE 7**  
 CR Concentration  
 with Water Levels  
 Layer 3 (LSZ)  
 Northeast Quadrant  
 TINKER AFB, OKLAHOMA  
 NOVEMBER 1997

Script File: crsep97.sh  
 Date: 7/27/98



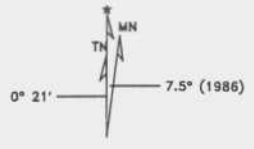


**NOTE:**  
 Non-detect values indicated by '<' sign.  
 One-half of the detection limit was used  
 during grid and contour map production.

- Extent of Layer 5
- Water Table Elevation Line
- Isopleth Line
- Perennial Stream
- Intermittent Stream

● NOVEMBER'97 DATA  
 1-2A Well ID  
 570 TCE Concentration

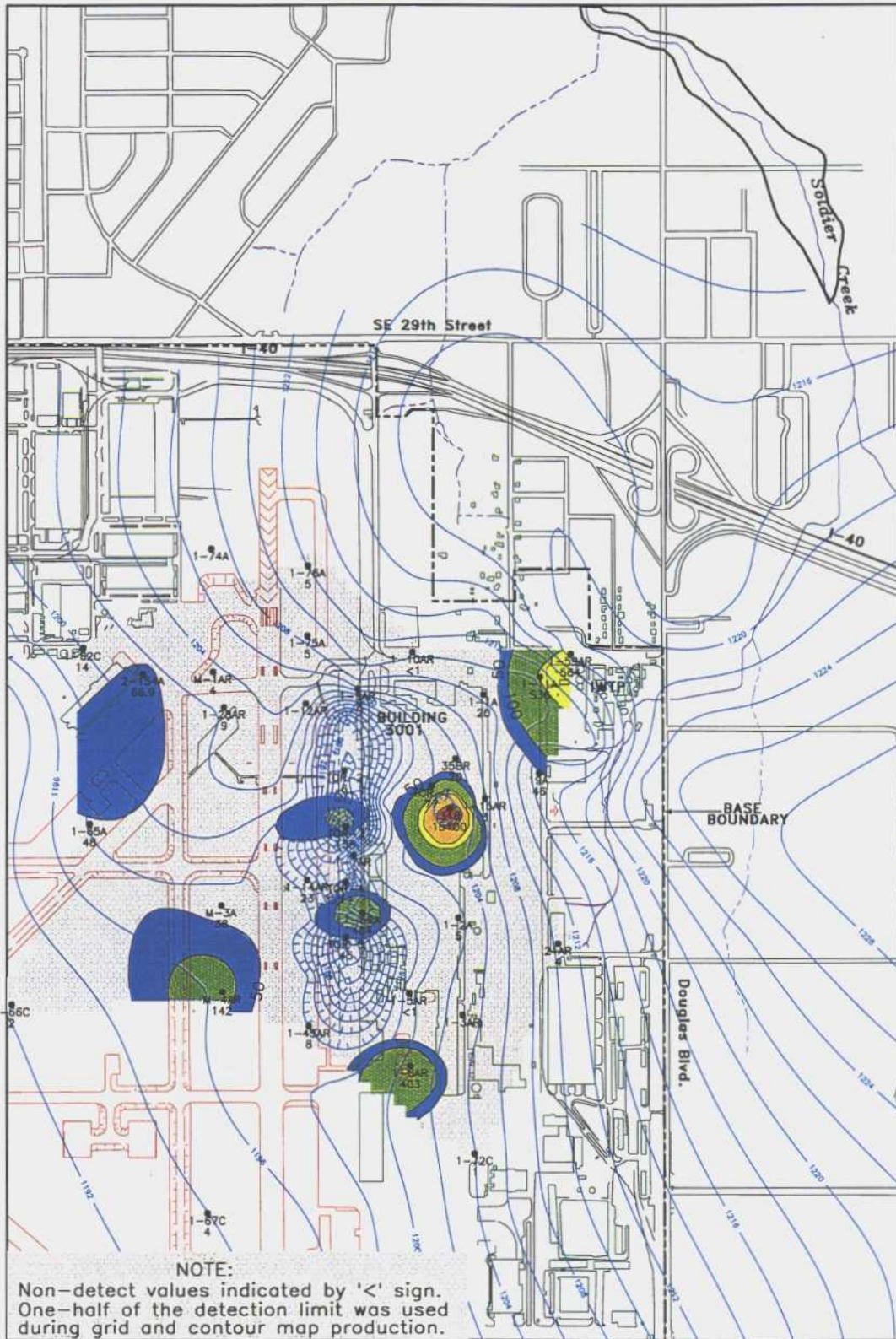
Projection Information:  
 Oklahoma State Plane Coordinate System  
 North Zone 3501



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5-10 PPB	[Light Blue]
10-50 PPB	[Medium Light Blue]
50-100 PPB	[Medium Blue]
100-500 PPB	[Dark Blue]
500-1,000 PPB	[Green-Blue]
1,000-5,000 PPB	[Yellow-Green]
5,000-25,000 PPB	[Yellow-Orange]
25,000-50,000 PPB	[Orange-Red]
>50,000 PPB	[Red]

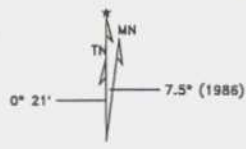
**FIGURE 8**  
**TCE Concentration with Water Levels Layer 5 (LSZ) Northeast Quadrant TINKER AFB, OKLAHOMA NOVEMBER 1997**  
 Script File: tcenov97.sh  
 Date: 7/27/98





— Extent of Layer 5  
 — Water Table Elevation Line  
 — Isopleth Line  
 — Perennial Stream  
 - - - Intermittent Stream

● NOVEMBER'97 DATA  
 1-75A Well ID  
 5 CR Concentration



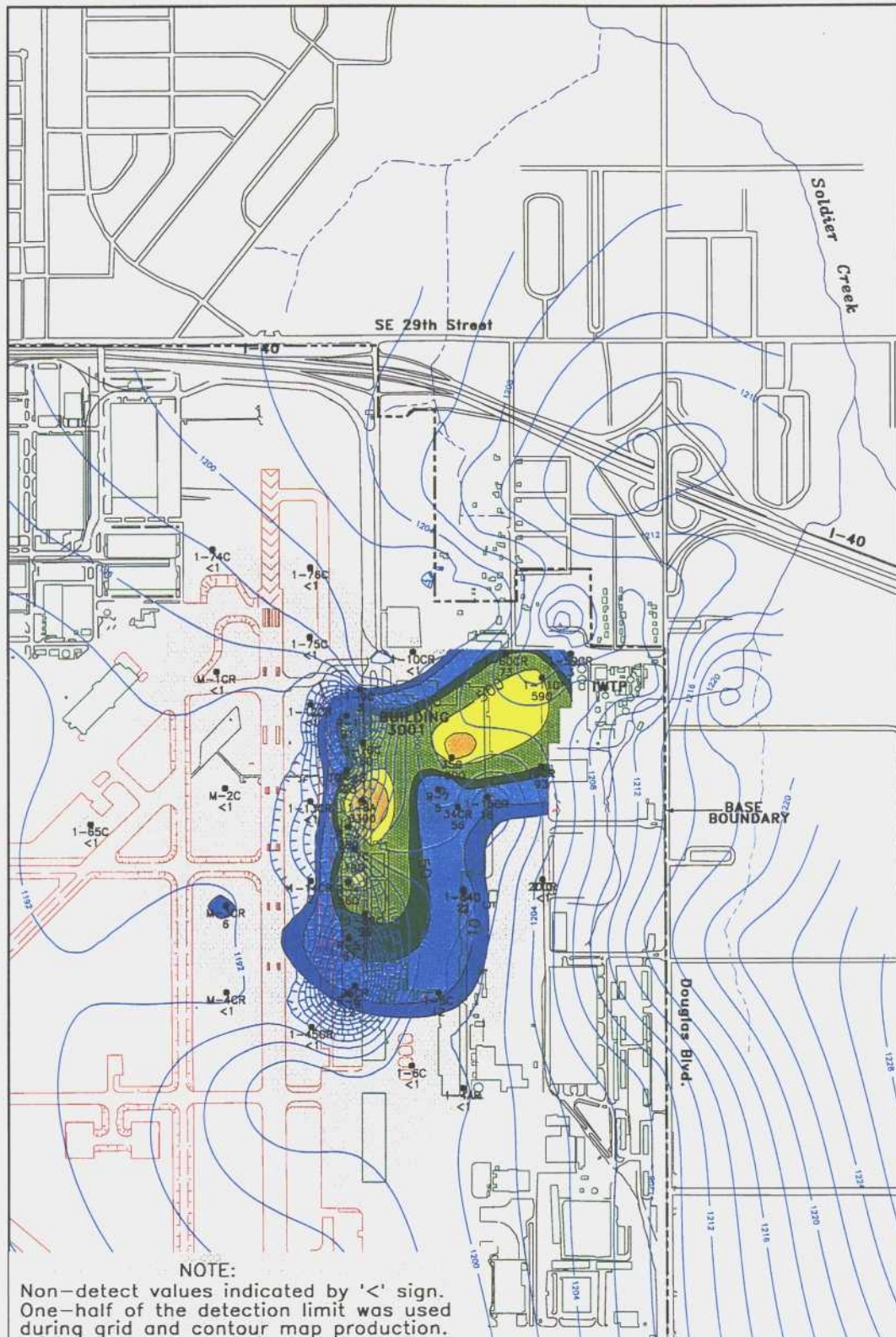
<50 PPB  
 50-100 PPB  
 100-500 PPB  
 500-1000 PPB  
 1000-5000 PPB  
 5000-10,000 PPB  
 >10,000 PPB

**FIGURE 9**  
 CR Concentration  
 with Water Levels  
 Layer 5 (LSZ)  
 Northeast Quadrant  
 TINKER AFB, OKLAHOMA  
 NOVEMBER 1997

Projection Information:  
 Oklahoma State Plane Coordinate System  
 North Zone 3501

Script File: crnov97.sh  
 Date: 7/27/98

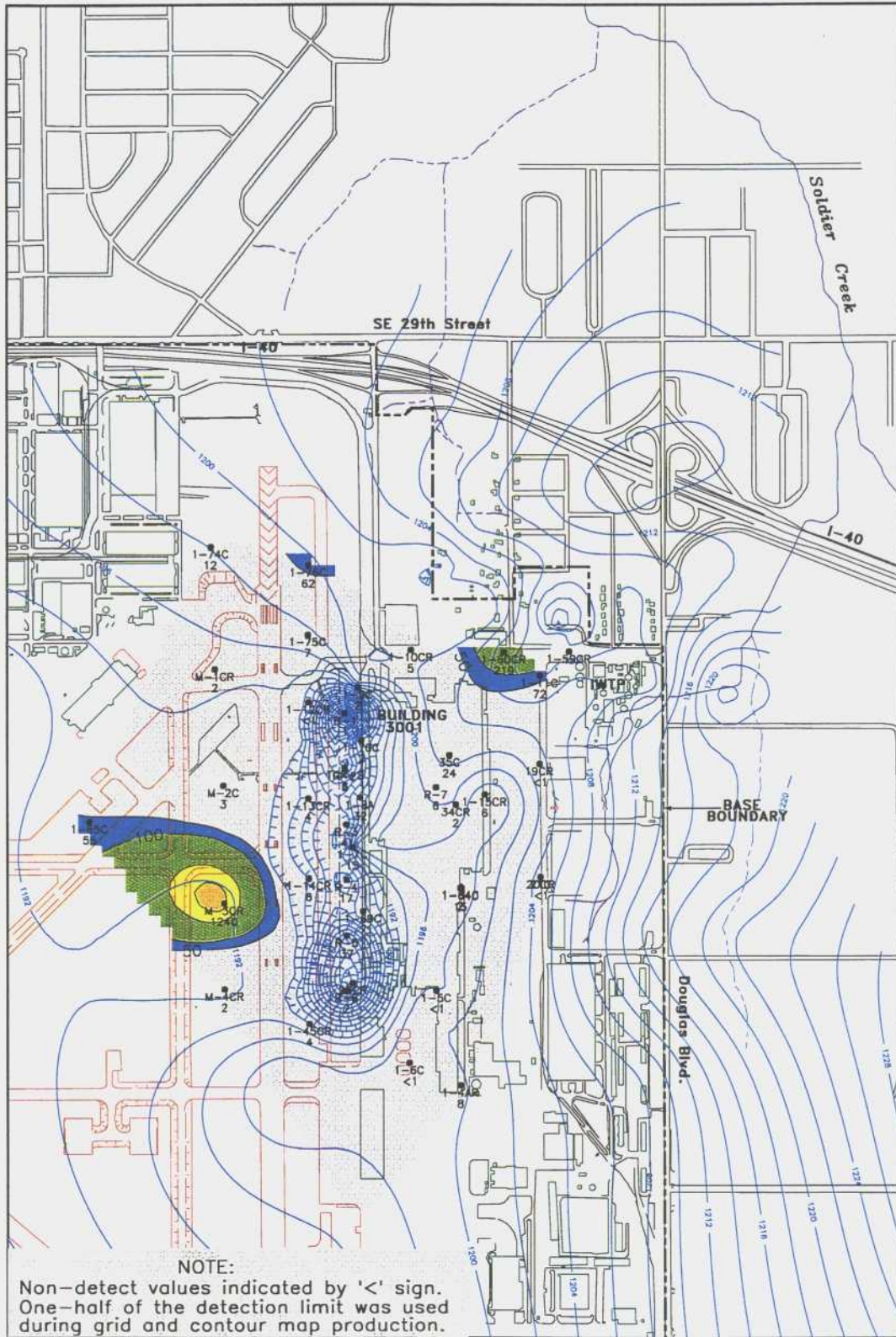




**NOTE:**  
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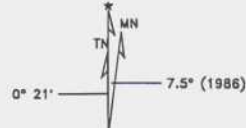
<ul style="list-style-type: none"> <li> Water Table Elevation Line</li> <li> Isopleth Line</li> <li> Perennial Stream</li> <li> Intermittent Stream</li> </ul>		<ul style="list-style-type: none"> <li> &lt; 5 PPB</li> <li> 5-10 PPB</li> <li> 10-50 PPB</li> <li> 50-100 PPB</li> <li> 100-500 PPB</li> <li> 500-1,000 PPB</li> <li> 1,000-5,000 PPB</li> <li> 5,000-25,000 PPB</li> <li> 25,000-50,000 PPB</li> <li> &gt;50,000 PPB</li> </ul>	<p><b>FIGURE 10</b>  <b>TCE Concentration</b>  <b>with Water Levels</b>  <b>Layer 7 (LSZ)</b>  <b>Northeast Quadrant</b>  <b>TINKER AFB, OKLAHOMA</b>  <b>NOVEMBER 1997</b></p>
<ul style="list-style-type: none"> <li> NOVEMBER'97 DATA</li> <li>1-13CR Well ID</li> <li>ND TCE Concentration</li> </ul>	<p>Projection Information:          Oklahoma State Plane Coordinate System          North Zone 3501</p>		<p>Script File: tcnov97.sh          Date: 7/27/98</p>





NOTE:  
 Non-detect values indicated by '<' sign.  
 One-half of the detection limit was used  
 during grid and contour map production.

- Water Table Elevation Line
- Isopleth Line
- Perennial Stream
- Intermittent Stream



- <50 PPB
- 50-100 PPB
- 100-500 PPB
- 500-1000 PPB
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- >10,000 PPB

NOVEMBER '97 DATA  
 1-74C Wall ID  
 12 CR Concentration

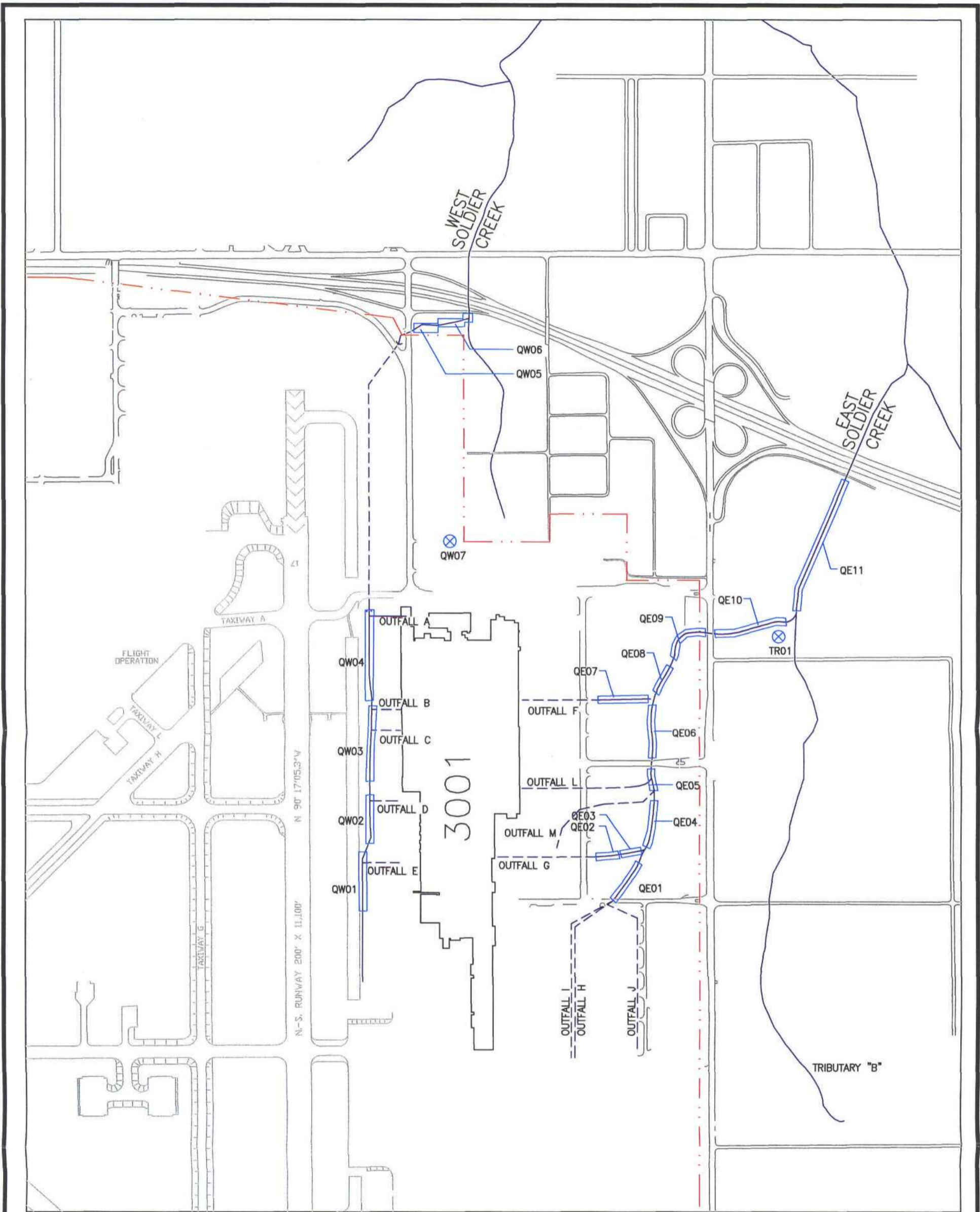
Projection Information:  
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 North Zone 3501



**FIGURE 11**  
 CR Concentration  
 with Water Levels  
 Layer 7 (LSZ)  
 Northeast Quadrant  
 TINKER AFB, OKLAHOMA  
 NOVEMBER 1997

Script File: crnov97.sh  
 Date: 7/27/98





**LEGEND**

- SOLDIER CREEK AND TRIBUTARIES
- UNDERGROUND PORTION OF CREEK
- BOUNDARY OF TINKER AIR FORCE BASE
- STREAM SAMPLING SEGMENT AND IDENTIFICATION
- STORMWATER RUNOFF SAMPLING LOCATION AND IDENTIFICATION

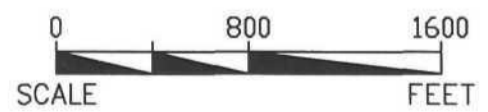


FIGURE 12

SOLDIER CREEK QUARTERLY  
MONITORING SAMPLING LOCATIONS

TINKER A.F.B., OKLAHOMA

## APPENDIX A

### LIST OF DOCUMENTS REVIEWED

- ATSDR, 1995. *Public Health Assessment Addendum*, Tinker Air Force Base (Soldier Creek/Building 3001), Midwest City, Oklahoma County, Oklahoma (addendum to Health Assessment, May 20, 1988). U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. February 27, 1995.
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- Harry Keith & Sons, Inc., 1985. Site Investigation Report. Harry Keith & Sons, Incorporated. October 5, 1985.
- Harry Keith & Sons, Inc., 1986. *Sample Results*. 1986.
- Naber *et al.*, 1997. "Statistical Methods for Assessing the Effectiveness of Intrinsic Remediation." In *Proceedings of the Fourth International In Situ and On-Site Bioremediation Symposium: Volume 5*. B.C. Alleman and A. Leeson (eds.). pp. 349-354. Battelle Press, Columbus, Ohio.
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**APPENDIX B**  
**PHOTOS**





1. North end of Building 3001. Soldier Creek in foreground.



2. Industrial wastewater treatment plant overlying Operable Unit 4.



3. Stream gauging and sampling point at Outfall G to East Soldier Creek.



4. Stream sampling segment QEO6 on East Soldier Creek.



5. Excavation at West Soldier Creek, prior to concrete pouring.



6. Preparation for concrete channel along West Soldier Creek.





7. Excavation of West Soldier Creek channel for concrete resurfacing. Note monitoring wells for Building 3001 recovery system in background.



8. Excavation activities prior to concrete pouring for flightline drainage. Building 3001 to the east, flightline and runway to the west. Monitoring wells and extraction well field to east. Looking north.

**APPENDIX C**  
**SIGNIFICANT DOCUMENTATION AND**  
**CORRESPONDENCE**

DECISION DOCUMENT  
FOR  
PIT Q-51

Installation: Tinker Air Force Base, OK 73145

Site Identification:

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. Building 3001 is located in the northeast portion of the Base. Pit Q-51 is located inside of Building 3001 at column-line Q-51. The pit is 20 feet long, 8 feet wide, and 10 feet in depth. The pit contains a sump area that is 3 feet wide, 3 feet long, and 2 feet in depth. This pit contained approximately 45 gallons of liquid-containing TCE, cadmium (Cd), chromium (Cr), and lead (Pb).

Background:

During the period from the 1940's to the 1970's, industrial solvents and wastewaters inside Building 3001 were contained in subsurface pits and trenches of steel-lined or concrete-lined construction. Leakage from some of the pits percolated into the soils and groundwater beneath Building 3001. Samples from the pit taken in 1986 showed 42 parts per million (ppm) TCE, 3 ppm Cd, 4 ppm Cr, and 22 ppm Pd. Pit Q-51 is an operable unit in the National Priority List (NPL) Building 3001 cleanup. The pit showed no sign of leakage into the subsurface. The site clean-up was coordinated with the Oklahoma State Department of Health and the U.S. Environmental Protection Agency, Region VI. A public hearing was held in April 1990 to inform the public of the planned clean-up of Building 3001 including Pit Q-51.

Study Findings:

As described in the above paragraph.

Alternatives Evaluated:

Alternative 1 - No Action. This alternative would require no action to be taken at the site. This would not comply with all Federal and State requirements since it does not remediate the site.

Alternative 2 - Removal of pit contents/on-base treatment. The pit liquids would be placed in 55-gallon drums and sampled for volatiles and metals. The pit would be steam-cleaned and the wash water would also be placed in 55-gallon drums. One sample each would be taken from the hazardous materials and wash water from the final rinse. The drums would be held in temporary storage until analyses are received then transported to the Base Industrial Waste Treatment Plant (IWTP) for treatment. The pit would be backfilled with sand and covered with an 8-inch concrete cap. This alternative would not meet all of the state and federal requirements. Treating the hazardous material at the IWTP could affect the regulatory status of the IWTP sludges.



CLOSEOUT DOCUMENT  
FOR  
PIT Q-51

Facility: Pit Q-51

Name & Location: Tinker Air Force Base, OK 73145

Statement of Basis: Pit Q-51 was located inside of Building 3001 at Column-Line Q-51. The pit contained approximately 45 gallons of liquid containing 42 parts per million (ppm) TCE, 3 ppm cadmium (Cd), 4 ppm chromium (Cr), and 22 ppm lead (Pb). The pit showed no sign of leakage into the subsurface.

Description of the Selected Remedies: The site cleanup was coordinated with the Oklahoma State Department of Health and the U.S. Environmental Protection Agency, Region VI. The contents of the pit was removed and placed in 55-gallon drums. The pit was steam cleaned with wash water recaptured and placed in 55-gallon drums. The hazardous material and wash water were transported and disposed of off-site. The disposal facility is permitted to receive this type of waste material and also permitted to receive Superfund wastes. The pit was backfilled with sand and covered with an 8-inch concrete cap. The potential risk to human health and the environment was eliminated by the removal of the pit contents, steam cleaning of the pit, removal of the washwater, and the filling and capping of the pit. This site is recommended for closeout and removal from the Installation Restoration Program.

Declaration of Consistency with CERCLA as Amended by SARA and the NCP: The removal of the pit contents, off-base disposal, and capping of the pit was coordinated with state and federal agencies and was consistent with all regulations.



GLOSEOUT DOCUMENT  
FOR  
FIT Q-51  
Signature Page



ALLEN K. LAWRENCE  
Environmental Management Director  
Tinker Air Force Base, Oklahoma

\_\_\_\_\_ Date



**DEPARTMENT OF THE AIR FORCE**  
**HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)**  
**TINKER AIR FORCE BASE, OKLAHOMA**

28 January, 1998

**MEMORANDUM FOR RUBY WILLIAMS**  
**EPA (GSF-AP)**  
**1445 ROSS AVENUE**  
**DALLAS TX 75202-2733**

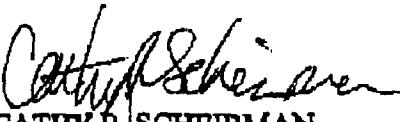
**FROM: OC-ALC/BMR**  
**7701 Arnold Street Suite 214**  
**Tinker AFB OK 73145-9100**

**SUBJECT: Soldier Creek Sediment and Surface Water Operable Unit**

1. Thank you for your visit on 20 January. We were happy to be able to give you a tour of the northeast quadrant area. In so doing, you were able to see West Soldier Creek that has become a problem for the mission of Tinker AFB. As you saw, this ditch is full of reeds and cattails. Although not classified as a wetland, it has become a haven for birds. Since the ditch is only a few hundred feet from the runway, the possibility of a bird striking an airplane is significantly increased. This is not an acceptable situation to the Air Force. Air Force (and FAA) regulations state that there are not to be any water bodies within the flight line area.

2. Due to these safety factors effecting Tinker's mission requirements, we propose to excavate all of the PCB contaminated material from the ditch, which is only a small portion of the area to be excavated. Then we will dispose of the material at an appropriate facility, and place a concrete channel in the ditch to facilitate drainage. This action will meet the environmental requirements for the site and the safety requirements for an airfield.

3. We request that you provide your concurrence or non-concurrence on this safety issue. If you have any questions regarding this matter, please contact James Dawson or me at (405) 734-3058.

  
**CATHY R. SCHEIRMAN**  
Alternate Project Coordinator

cc: DEQ (Hal Cantwell)



DEPARTMENT OF THE AIR FORCE  
HEADQUARTERS OKLAHOMA CITY AIR LOGISTICS CENTER (AFMC)  
TINKER AIR FORCE BASE, OKLAHOMA

30 June, 1998

MEMORANDUM FOR RUBY WILLIAMS  
EPA (6SF-AP)  
1445 ROSS AVENUE  
DALLAS TX 75202-2733

FROM: OC-ALC/EMR  
7701 Arnold Street Suite 214  
Tinker AFB OK 73145-9100

SUBJECT: Soldier Creek Sediment and Surface Water Operable Unit

1. As you are aware, our office intends to excavate portions of West Soldier Creek and replace the ditch with a concrete channel. This is being done to improve drainage in the area and remove the birds from an area so close to the runway. The birds have become a hazard to Tinker's mission.
2. Your only request before implementation of the project was further clarification of what exactly would be done with the contaminated sediments. All sediments will be sampled to determine hazardous characteristics and for PCB TSCA limits. All sediments not exceeding hazardous characteristics will be utilized as backfill for the concrete channel. All sediments that exceed hazardous characteristics will be sent to a facility that is approved to receive CERCLA hazardous waste. All materials that exceed both hazardous characteristics and TSCA limits for PCBs will be sent to a facility that is approved for both CERCLA hazardous waste and TSCA waste.
3. Due to the nature of our contracting avenue, we cannot specify to the contractor the facility to which they can ship the waste. However, we can give the above specifications as a requirement of the contract. When the disposal facility(s) become known, we will notify you.
4. If you have any further questions regarding this matter, please call James Dawson or myself at (405) 734-3058.

A handwritten signature in cursive script that reads "Cathy R. Scheirman".

CATHY R. SCHEIRMAN, Chief  
Environmental Restoration Division  
Directorate of Environmental Mgt.

**APPENDIX D**  
**STATUS OF SOLDIER CREEK OFF-BASE GROUNDWATER (OU-3) AND**  
**INDUSTRIAL WASTEWATER TREATMENT PLANT (OU-4)**

## APPENDIX D

### STATUS OF SOLDIER CREEK OFF-BASE GROUNDWATER (OU-3) AND INDUSTRIAL WASTEWATER TREATMENT PLANT (OU-4)

This appendix describes the status of activities conducted at the Industrial Wastewater Treatment Plant (IWTP) and Soldier Creek Off-Base Groundwater (SCOBGW) OUs. Investigations of the groundwater at the IWTP were first conducted between 1988 and 1990. Sampling results indicated the groundwater beneath the IWTP was contaminated with TCE, DCE, PCE, vinyl chloride, 1,1,1-trichloroethane, 1,1-dichloroethane, chlorobenzene, 1,2-dichlorobenzene, methylene chloride, 1,3-dichloropropane, lead and chromium.

In 1990, groundwater from eight off-base residential wells was sampled and analyzed for VOCs, semivolatile organic compounds (SVOCs), and metals. VOCs and metals exceeding health comparison values were detected in groundwater from one well northeast of the base.

In 1990 and 1991, the Oklahoma State Department of Health (OSDH) sampled privately-owned wells northeast of Tinker AFB. Areas of primary concern included the Kimsey Addition neighborhood, the Evergreen Mobile Home Park, and other areas north and east of the base. Several contaminants including 1,2-dichloroethane, PCE, TCE, benzene, and barium were detected in a number of these wells.

In 1992, remedial activities were conducted at the IWTP to remove sources and potential sources of contamination above and below ground surface. Eleven in-ground concrete storage tanks containing cyanide, chromium, acid, alkali, and phenols were removed. Approximately 490 cubic yards of hazardous waste were removed. In addition, approximately 90 cubic yards of hazardous sludge were removed from the industrial waste sludge drying beds. The sludge drying beds were steam cleaned and remain onsite.

RIs of the IWTP/SCOBGW were conducted between 1994 and 1995 and water samples collected from the SCOBGW OU indicated the presence of the same compounds. The final RI report was submitted to the EPA and the Oklahoma Department of Environmental Quality in July 1998. With the completion of the RI, a risk assessment and feasibility study will be completed to recommend an appropriate remedial action for the groundwater beneath these OUs.