Doc #: 110684~~001~~ 431 Category: 1.1

Title: Bldg 3001 & Soldier Creek Drainage Are, Tinker Air Force Base...NPL Scoring Package

Facility name: Bldg 3001 and Soldier Creek Drainage Area, Tinker AFB

Location: Oklahoma City, Oklahoma

EPA Region: 6

Person(s) in charge of the facility: Richard A. Burpee
Major General, USAF Command
Oklahoma City Air Logistics Ctr.
Tinker AFB, OK 73145

Name of Reviewer: A. J. Puffer Date: 11/6/84

General description of the facility:
(For example landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility, contamination route of major concern, types of information needed for rating, agency action, etc.)

Maintenance and repair building for a aircraft, which uses solvents for paint removal and cleaning and also generates plating wastes. The building is located in the recharge zone and is the source of contamination of base wells #18 and #19, and possibly other base wells. This building is also a source of contamination for the Soldier Creek and its tributaries.

Scores: S_M = ~~42.24~~ 42.24 S_{gw} = ~~42.24~~ 73.08 S_{sw} = 0 S_a = 0)
S_{FE} = 0
S_{DC} = 0

FIGURE 1
HRS COVER SHEET

QA — K. Flemming Johnson 1/31/85

A-1

Ground Water Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Observed Release	0 (45)	1	45	45	3.1
If observed release is given a score of 45, proceed to line 4 If observed release is given a score of 0, proceed to line 2					
2 Route Characteristics					3.2
Depth to Aquifer of Concern	0 1 2 3	2		6	
Net Precipitation	0 1 2 3	1		3	
Permeability of the Unsaturated Zone	0 1 2 3	1		3	
Physical State	0 1 2 3	1		3	
	Total Route Characteristics Score			15	
3 Containment	0 1 2 3	1		3	3.3
4 Waste Characteristics					3.4
Toxicity/Persistence	0 3 6 9 12 15 (18)	1	18	18	
Hazardous Waste Quantity	0 (1) 2 3 4 5 6 7 8	1	1	8	
	Total Waste Characteristics Score		19	26	
5 Targets					3.5
Ground Water Use	0 1 2 (3)	3	9	9	
Distance to Nearest Well/Population Served	0 4 6 8 10 12 16 18 20 24 30 32 35 (40)	1	40	40	
	Total Targets Score		49	49	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5			41,895	57,330	
7 Divide line 6 by 57,330 and multiply by 100		S_{gw} = 73.08			

FIGURE 2
GROUND WATER ROUTE WORK SHEET

RCJ
1/30/85

Surface Water Route Work Sheet					
Rating Factor	**Assigned Value (Circle One)**	**Multi-plier**	**Score**	**Max. Score**	**Ref. (Section)**
1 Observed Release	0 45	1	0	45	4.1
If observed release is given a value of 45, proceed to line 4 If observed release is given a value of 0, proceed to line 2					
2 Route Characteristics					4.2
Facility Slope and Intervening Terrain	0 1 2 3	1		3	
1-yr. 24-hr. Rainfall	0 1 2 3	1		3	
Distance to Nearest Surface Water	0 1 2 3	2		6	
Physical State	0 1 2 3	1		3	
	Total Route Characteristics Score			15	
3 Containment	0 1 2 3	1		3	4.3
4 Waste Characteristics					4.4
Toxicity/Persistence	0 3 6 9 12 15 18	1		18	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
	Total Waste Characteristics Score			26	
5 Targets					4.5
Surface Water Use	0 1 2 3	3		9	
Distance to a Sensitive Environment	0 1 2 3	2		6	
Population Served/Distance to Water Intake Downstream	0 4 6 8 10 12 16 18 20 24 30 32 35 40	1		40	
	NO TARGETS IDENTIFIED				
	Total Targets Score		0	55	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5				64,350	
7 Divide line 6 by 64,350 and multiply by 100		S_{sw} = 0			

FIGURE 7
SURFACE WATER ROUTE WORK SHEET

RGJ
1/31/85

Air Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Observed Release NONE	0 45	1		45	5.1
Date and Location:					
Sampling Protocol:					
If line 1 is 0, the S_a = 0. Enter on line 5. If line 1 is 45, then proceed to line 2.					
2 Waste Characteristics					5.2
Reactivity and Incompatibility	0 1 2 3	1		3	
Toxicity	0 1 2 3	3		9	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
	Total Waste Characteristics Score			20	
3 Targets					5.3
Population Within 4-Mile Radius	0 9 12 15 18 21 24 27 30	1		30	
Distance to Sensitive Environment	0 1 2 3	2		6	
Land Use	0 1 2 3	1		3	
	Total Targets Score			39	
4 Multiply 1 x 2 x 3				35,100	
5 Divide line 4 by 35,100 and multiply by 100		S_a = 0			

FIGURE 9
AIR ROUTE WORK SHEET

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1/21/85

	S	S^2
Groundwater Route Score (S_{gw})	73.08	5,340.24
Surface Water Route Score (S_{sw})	0	0
Air Route Score (S_a)	0	0
$S_{gw}^2 + S_{sw}^2 + S_a^2$		5,340.24
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$		73.08
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2} / 1.73 = S_M =$		42.24

FIGURE 10
WORKSHEET FOR COMPUTING S_M

KCA
1/31/85

Fire and Explosion Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max Score	Ref. (Section)
1 Containment	1 3	1		3	7.1
2 Waste Characteristics					7.2
Direct Evidence	3	1		3	
Ignitability	0 1 2 3	1		3	
Reactivity	0 1 2 3	1		3	
Incompatibility	0 1 2 3	1		3	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
Total Waste Characteristics Score				20	
3 Targets					7.3
Distance to Nearest Population	0 1 2 3 4 5	1		5	
Distance to Nearest Building	0 1 2 3	1		3	
Distance to Sensitive Environment	0 1 2 3	1		3	
Land Use	0 1 2 3	1		3	
Population Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Buildings Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Total Targets Score				24	
4 Multiply 1 x 2 x 3				1,440	
5 Divide line 4 by 1,440 and multiply by 100	S_{FE} = 0				

FIGURE 11
FIRE AND EXPLOSION WORK SHEET

RCB 1/31/85

Direct Contact Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Observed Incident	0 45	1	0	45	8.1
If line 1 is 45, proceed to line 4 If line 1 is 0, proceed to line 2					
2 Accessibility	0 1 2 3	1	0	3	8.2
3 Containment	0 15	1		15	8.3
4 Waste Characteristics Toxicity	0 1 2 3	5		15	8.4
5 Targets					8.5
Population Within a 1-Mile Radius	0 1 2 3 4 5	4		20	
Distance to a Critical Habitat	0 1 2 3	4		12	
Total Targets Score				32	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5				21,600	
7 Divide line 6 by 21,600 and multiply by 100	S_{DC} = 0				

FIGURE 12
DIRECT CONTACT WORK SHEET

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DOCUMENTATION RECORDS
FOR
HAZARD RANKING SYSTEM

INSTRUCTIONS: The purpose of these records is to provide a convenient way to prepare an auditable record of the data and documentation used to apply the Hazard Ranking System to a given facility. As briefly as possible summarize the information you used to assign the score for each factor (e.g., "Waste quantity = 4,230 drums plus 800 cubic yards of sludges"). The source of information should be provided for each entry and should be a bibliographic-type reference that will make the document used for a given data point easier to find. Include the location of the document and consider appending a copy of the relevant page(s) for ease in review.

FACILITY NAME: Building 3001 and Soldier Creek Drainage Area, Tinker AFB

LOCATION: Oklahoma City, Oklahoma

QA —
R. Clearing Johnson
1/31/85

GROUND WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected (5 maximum):

Trichloroethylene	1750ppb	
Tetrachloroethylene	30.1ppb	(Ref. 4, Table 4-13 and Appendix H
1,2 Dichloroethane	25.8ppb	for well 18)
Chlorobenzene	7.9ppb	

Rationale for attributing the contaminants to the facility:
These materials are used on site and have been released to the environment (Ref. 4, above, and Ref. 5) Well 18 within building is contaminated below 140' (Ref. 20). Pattern of contamination of monitoring wells shows contamination centered on building 3001. Lack of trichloroethylene and tetrachloroethylene in wells 8 and 9 to north indicates contamination is not attributable to municipal industrial parks (Ref. 4, 8 and 12).

* * *

2 ROUTE CHARACTERISTICS

Depth to Aquifer of Concern

Name/description of aquifer(s) of concern:
Garber-Wellington Sandstone (Ref. 3, pages 3-7 to 3-18)
Tinker AFB is located in the recharge zone of this aquifer. The water bearing portion of this aquifer are lenses of sandstone which are irregularly interbedded with sandy to silty shales (Ref. 11).

Depth(s) from the ground surface to the highest seasonal level of the saturated zone (water table(s)) of the aquifer of concern:

Depth from the ground surface to the lowest point of waste ~~xxxxxxxx~~ contamination:
~~xxxxxxx~~

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Net Precipitation

Mean annual or seasonal precipitation (list months for seasonal):

Mean annual lake or seasonal evaporation (list months for seasonal):

Net precipitation (subtract the above figures):

Permeability of Unsaturated Zone

Soil type in unsaturated zone:

Permeability associated with soil type:

Physical State

Physical state of substances at time of disposal (or at present time for generated gases):

* * *

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1/31/85

3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Method with highest score:

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated:	Toxicity	Persistence
Tetrachlorethylene	2	2 (Ref. 4, Table 4-13)
Trichloroethylene	2	2 "
1,1Dichloroethene	3	2 "
Chloroform	3	3 (Monitor Wells (Ref. 13)
Chromium	3	3 (Ref. 7, page 7 and Table I)

Compound with highest score:

Chloroform and Chromium - 18

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

Unknown: Value of 1 assigned because the observed release indicates a quantity greater than zero.

Basis of estimating and/or computing waste quantity:

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1/31/85

* * *

5 TARGETS

Ground Water Use

Use(s) of aquifer(s) of concern within a 3-mile radius of the facility:

Drinking water - Garber-Wellington (Ref. 6) serves Midwest City. There is no alternate supply with minimal hookup requirements from alternate unthreatened source (Ref. 21).

Distance to Nearest Well

Location of nearest well drawing from aquifer of concern or occupied building not served by a public water supply:

Onsite water supply wells for Tinker AFB

Distance to above well or building:

Well 18; 0 Feet - well is inside the building and is contaminated (Ref. 4, Fig. 1-1 for location; Ref. 4, Table 4-13 for contamination)

Population Served by Ground Water Wells Within a 3-Mile Radius

Identified water-supply well(s) drawing from aquifer(s) of concern within a 3-mile radius and populations served by each:

Tinker AFB, pop served = 3,320 (Ref. 6); 27 wells on base. At least 16 of 43 Midwest City water supply wells are within 3 miles of the site and screened in the aquifer of concern (Ref. 21). Radial system is used, so the entire population of 55,400 customers are potentially affected (Ref. 6).

Computation of land area irrigated by supply well(s) drawing from aquifer(s) of concern within a 3-mile radius, and conversion to population (1.5 people per acre):

Unidentified

Total population served by ground water within a 3-mile radius:

Minimum 3,320 + 55,400 (Ref. 6)

Ref
1/31/85

SURFACE WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected in surface water at the facility or downhill from it (5 maximum):

Chromium
Tetrachloroethylene (Ref. 7, pages 7-9 and Table 1)

Rationale for attributing the contaminants to the facility:

Contaminants found in water of storm sewer coming from building 3001 and draining into tributary of Soldier Creek. Since these tributaries show as intermittent streams on USGS Quad maps (Midwest City and Choctaw, Okla. Ref. 22) no observed release is recorded for HRS purposes.

* * *

2 ROUTE CHARACTERISTICS

Facility Slope and Intervening Terrain

Average slope of facility in percent:
Route has not been evaluated because no targets within the 3 mile HRS limit have been identified. Thus the route score is 0.

Name/description of nearest downslope surface water:

Average slope of terrain between facility and above-cited surface water body in percent:

Is the facility located either totally or partially in surface water?

1/31/85

Is the facility completely surrounded by areas of higher elevation?

1-Year 24-Hour Rainfall in Inches

Distance to Nearest Downslope Surface Water

Physical State of Waste

* * *

3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Method with highest score:

ECG
1/31/85

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated

Compound with highest score:

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

Basis of estimating and/or computing waste quantity:

* * *

5 TARGETS

Surface Water Use

Use(s) of surface water within 3 miles downstream of the hazardous substance:

KCJ
1/31/85

Is there tidal influence?

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

Distance to critical habitat of an endangered species or national wildlife refuge, if 1 mile or less:

Population Served by Surface Water

Location(s) of water-supply intake(s) within 3 miles (free-flowing bodies) or 1 mile (static water bodies) downstream of the hazardous substance and population served by each intake:

1/31/85

Computation of land area irrigated by above-cited intake(s) and conversion to population (1.5 people per acre):

Total population served:

Name/description of nearest of above water bodies:

Distance to above-cited intakes, measured in stream miles.

KCJ
1/31/85

AIR ROUTE

1 OBSERVED RELEASE NO RELEASE DETECTED, ROUTE SCORE = 0.

Contaminants detected:

Date and location of detection of contaminants

Methods used to detect the contaminants:

Rationale for attributing the contaminants to the site:

* * *

2 WASTE CHARACTERISTICS

Reactivity and Incompatibility

Most reactive compound:

Most incompatible pair of compounds:

RVJ 1/31/85

Toxicity

Most toxic compound:

Hazardous Waste Quantity

Total quantity of hazardous waste:

Basis of estimating and/or computing waste quantity:

* * *

3 TARGETS

Population Within 4-Mile Radius

Circle radius used, give population, and indicate how determined:

0 to 4 mi 0 to 1 mi 0 to 1/2 mi 0 to 1/4 mi

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

RCG 1/31/83

Distance to critical habitat of an endangered species, if 1 mile or less:

Land Use

Distance to commercial/industrial area, if 1 mile or less:

Distance to national or state park, forest, or wildlife reserve, if 2 miles or less:

Distance to residential area, if 2 miles or less:

Distance to agricultural land in production within past 5 years, if 1 mile or less:

Distance to prime agricultural land in production within past 5 years, if 2 miles or less:

Is a historic or landmark site (National Register or Historic Places and National Natural Landmarks) within the view of the site?

Rcf 1/31/89

1 CONTAINMENT

Hazardous substances present:

Threat not observed by field measurement or Fire Marshall certification Ref. HRS manual pp 49 sect. 7.0

Type of containment, if applicable:

* * *

2 WASTE CHARACTERISTICS

Direct Evidence

Type of instrument and measurements:

Ignitability

Compound used:

Reactivity

Most reactive compound:

Incompatibility

Most incompatible pair of compounds:

* * *

Rej 1/31/85

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility:

Basis of estimating and/or computing waste quantity:

* * *

3 TARGETS

Distance to Nearest Population

Distance to Nearest Building

Distance to Sensitive Environment

Distance to wetlands:

Distance to critical habitat

Land Use

Distance to commercial/industrial area, if 1 mile or less.

RCH 1/31/85

Distance to national or state park, forest, or wildlife reserve, if 2 miles or less:

Distance to residential area, if 2 miles or less:

Distance to agricultural land in production within past 5 years, if 1 mile or less:

Distance to prime agricultural land in production within past 5 years, if 2 miles or less:

Is a historic or landmark site (National Register of Historic Places and National Natural Landmarks) within the view of the site?

Population Within 2-Mile Radius

Buildings Within 2-Mile Radius

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DIRECT CONTACT

1 OBSERVED INCIDENT

Date, location, and pertinent details of incident:

NONE

* * *

2 ACCESSIBILITY

Describe type of barrier(s):

Site is a controlled entry and exit area owned by DOD.

* * *

3 CONTAINMENT

Type of containment, if applicable:

* * *

4 WASTE CHARACTERISTICS

Toxicity

Compounds evaluated:

Compound with highest score:

* * *

Rec'd 1/31/85

5 TARGETS

Population within one-mile radius

Distance to critical habitat (of endangered species)

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1/31/85

REFERENCES

If the entire reference is not available for public review in the EPA regional files on this site, indicate where the reference may be found:

Reference Number	Description of the Reference
1	**Uncontrolled Hazardous Waste Site Ranking System; A Users Manual.**
	National Oil and Hazardous Substances Contingency Plan, Appendix A (40 CFR 300)(47 FR 31219), July 16, 1982.
2	Site Inspection Report, USEPA form 2070-3. Kelly Nash. 4/23/84.
3	Installation Restoration Program, Phase I - Records Search. Tinker AFB, Okalhoma. April 1982.
4	Installation Restoration Program, Phase II Stage 1. Field Evaluation. Tinker AFB, Oklahoma. Draft Final Report. Nov. 1984.
5	"Building 3001: Buried Pit and ~~Trails~~ TANK Survey." Radian Corp. 31 Aug. 1984.
6	"Public Water Supply Report" for Midwest City and for Tinker AFB. 1982.
	"Inspection Report - Tinker Air Force Base." Oklahoma Water Resources, Water Quality Division. Dated June 19, 1984.
8	Record of Communication: Drew Puffer, USEPA, to Lt. Bill Johnson, Tinker AFB. Location of wells 8 & 9, along with map showing location. 11/28/84.
9	CERCLA 103C Notification, Tinker AFB. 28 May 81.
10	Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahoma: Sheet 2 - Bedrocks Aquifers and Recharge Areas. Compiled by K.S. Johnson, Oklahoma Geological Survey, 1963.
11	Testimony: Dr. C.J. Mankin, Director, Oklahoma Geological Survey, at Tinker Air Force Base Hearing, Subcommittee on Environment, Energy and Natural Resources, Dec. 12, 1984.
	Map: Oklahoma City Industrial Districts and Expressway Systems. Oklahoma City Chamber of Commerce, Economic Development Division.
13	Analytical Results, Wells 6A through 6G, 1984. Transmitted by WM Little, Radian Corp. to Cpt. R.W. Bauer, Tinker AFB. 8/8/84 and 9/13/84.

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14 Record of Communication: Drew Puffer, USEPA to Wm Little, Radian Corp. 1/8/85.

15 Analytical Results, Well 16. Transmitted by E.A. Jeffrey, USEPA to Cpt. D.R. Escoriaza, Tinker AFB on 30 Aug. 1982.

16 Letter: David W. McElway, Major, USAF to E.A. Jeffrey, USEPA. 30 Sep. 1982.

17 Analytical Results from Ground Water Supply Study. Transmitted by Ed. Jeffrey, USEPA, to Mike Harrell. 3/2/82.

18 Groundwater Supply Survey, by J.J. Westrick et al., Journal AWWA, pages 52-59. May 1964.

19 Oklahoma Water Quality Standards - 1982. Publication 111. Oklahoma Water Resources Board.

20 Record of Communication: Drew Puffer, USEPA to Capt. Cornell, Tinker AFB. 11/5/84.

21 Record of Communication: Kelly Nash, USEPA to T. Perdue, USEPA. 1/30/85, with attachment of Midwest City well locations.

22 USGS topo quad maps: Choctaw and Midwest City, both photorevised to 1975.

RCN 1/29/85

Reference #2
Site Inspection Report, USEPA form 2070-3. Kelly Nash. 4/23/84.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT

REGION	SITE NUMBER (to be assigned by HQ)
6	OK-03646

GENERAL INSTRUCTIONS: Complete Sections I and III through XV of this form as completely as possible. Then use the information on this form to develop a Tentative Disposition (Section II). File this form in its entirety in the regional Hazardous Waste Log F[illegible] sure to include all appropriate Supplemental Reports in the file. Submit a copy of the forms to: U.S. Environmental Protection Agency, Site Tracking System, Hazardous Waste Enforcement Task Force (EN-335), 401 M St., SW, Washington, DC 20460.

I. SITE IDENTIFICATION

A. SITE NAME: Tinker Air Force Base

B. STREET (or other identifier): 2854 CES/DEEX

C. CITY: Oklahoma City

D. STATE: OK.

E. ZIP CODE:

F. COUNTY NAME:

G. SITE OPERATOR INFORMATION

1. NAME: U.S. Air Force

2. TELEPHONE NUMBER:

3. STREET:

4. CITY:

5. STATE:

6. ZIP CODE:

H. REALTY OWNER INFORMATION (if different from operator of site)

1. NAME: U.S. Air Force

2. TELEPHONE NUMBER:

3. CITY:

4. STATE:

5. ZIP CODE:

I. SITE DESCRIPTION: Airbase, aircraft maintenance, jet engine rebuilding

J. TYPE OF OWNERSHIP

[X] 1. FEDERAL [ ] 2. STATE [ ] 3. COUNTY [ ] 4. MUNICIPAL [ ] 5. PRIVATE

II. TENTATIVE DISPOSITION (complete this section last)

A. ESTIMATE DATE OF TENTATIVE DISPOSITION (mo., day, & yr.):

B. APPARENT SERIOUSNESS OF PROBLEM

[ ] 1. HIGH [ ] 2. MEDIUM [ ] 3. LOW [ ] 4. NONE

PARER INFORMATION

NAME: Kelly Nash

2. TELEPHONE NUMBER: (214)767-9706

3. DATE (mo., day, & yr.): 4/23/84

III. INSPECTION INFORMATION

A. PRINCIPAL INSPECTOR INFORMATION

1. NAME:

2. TITLE:

3. ORGANIZATION:

4. TELEPHONE NO. (area code & no.):

B. INSPECTION PARTICIPANTS

1. NAME	2. ORGANIZATION	3. TELEPHONE NO.

C. SITE REPRESENTATIVES INTERVIEWED (corporate officials, workers, residents)

1. NAME	2. TITLE & TELEPHONE NO.	3. ADDRESS

Continue On Reverse

Continued From Page 2

IV. SAMPLING INFORMATION (continued)

C. PHOTOS

1. TYPE OF PHOTOS
   - [ ] a. GROUND
   - [ ] b. AERIAL
2. PHOTOS IN CUSTODY OF:

D. MAPPED?

ES. SPECIFY LOCATION OF MAPS

E. COORDINATES

1. LATITUDE (deg.-min.-sec.)
2. LONGITUDE (deg.-min.-sec.)

V. SITE INFORMATION

A. SITE STATUS

- [X] 1. ACTIVE (Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.)
- [ ] 2. INACTIVE (Those sites which no longer receive wastes.)
- [ ] 3. OTHER (specify): _____ (Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.)

B. IS GENERATOR ON SITE?

- [ ] 1. NO
- [ ] 2. YES (specify generator's four-digit SIC Code): _____

C. AREA OF SITE (in acres)

D. ARE THERE BUILDINGS ON THE SITE?

- [ ] 1. NO
- [X] 2. YES (specify):

VI. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major site activity(ies) and details relating to each activity by marking 'X' in the appropriate boxes.

X	A. TRANSPORTER	X	B. STORER	X	C. TREATER	X	D. DISPOSER
	1. RAIL		1. PILE		1. FILTRATION	X	1. LANDFILL
	2. SHIP	X	2. SURFACE IMPOUNDMENT		2. INCINERATION		2. LANDFARM
	3. BARGE		3. DRUMS		3. VOLUME REDUCTION		3. OPEN DUMP
	TRUCK	X	4. TANK, ABOVE GROUND		4. RECYCLING/RECOVERY	X	4. SURFACE IMPOUNDMENT
	PIPELINE	X	5. TANK, BELOW GROUND		5. CHEM./PHYS./TREATMENT		5. MIDNIGHT DUMPING
	6. OTHER (specify):		6. OTHER (specify):		6. BIOLOGICAL TREATMENT		6. INCINERATION
					7. WASTE OIL REPROCESSING		7. UNDERGROUND INJECTION
					8. SOLVENT RECOVERY		8. OTHER (specify)
					9. OTHER (specify):		

E. SUPPLEMENTAL REPORTS If the site falls within any of the categories listed below, Supplemental Reports must be completed. Indicate which Supplemental Reports you have filled out and attached to this form.

- [ ] 1. STORAGE
- [ ] 2. INCINERATION
- [ ] 3. LANDFILL
- [ ] 4. SURFACE IMPOUNDMENT
- [ ] 5. DEEP WELL
- [ ] 6. CHEM/BIO/PHYS TREATMENT
- [ ] 7. LANDFARM
- [ ] 8. OPEN DUMP
- [ ] 9. TRANSPORTER
- [ ] 10. RECYCLOR/RECLAIMER

VII. WASTE RELATED INFORMATION

A. WASTE TYPE

- [X] 1. LIQUID
- [X] 2. SOLID
- [X] 3. SLUDGE
- [ ] 4. GAS

B. WASTE CHARACTERISTICS

- [ ] 1. CORROSIVE
- [X] 2. IGNITABLE
- [X] 3. RADIOACTIVE
- [ ] 4. HIGHLY VOLATILE
- [X] 5. TOXIC
- [ ] 6. REACTIVE
- [X] 7. INERT
- [X] 8. FLAMMABLE
- [ ] 9. OTHER (specify):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify forms such as manifests, inventories, etc. below.

Phase I Assessment completed, Phase II report expected 5/84.

Continue On Reverse

Continued From Page 2

IV. SAMPLING INFORMATION (continued)

C. PHOTOS

1. TYPE OF PHOTOS

☐ a. GROUND ☐ b. AERIAL

2. PHOTOS IN CUSTODY OF:

D. MAPPED?

ES. SPECIFY LOCATION OF MAPS

E. COORDINATES

1. LATITUDE (deg.-min.-sec.)

2. LONGITUDE (deg.-min.-sec.)

V. SITE INFORMATION

A. SITE STATUS

☒ 1. ACTIVE (Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.)

☐ 2. INACTIVE (Those sites which no longer receive wastes.)

☐ 3. OTHER (specify): (Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.)

B. IS GENERATOR ON SITE?

☐ 1. NO ☐ 2. YES (specify generator's four-digit SIC Code):

C. AREA OF SITE (in acres)

D. ARE THERE BUILDINGS ON THE SITE?

☐ 1. NO ☒ 2. YES (specify):

VI. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major site activity(ies) and details relating to each activity by marking 'X' in the appropriate boxes.

X	A. TRANSPORTER	X	B. STORER	X	C. TREATER	X	D. DISPOSER
	1. RAIL		1. PILE		1. FILTRATION	X	1. LANDFILL
	2. SHIP	X	2. SURFACE IMPOUNDMENT		2. INCINERATION		2. LANDFARM
	3. BARGE		3. DRUMS		3. VOLUME REDUCTION		3. OPEN DUMP
	UCK	X	4. TANK, ABOVE GROUND		4. RECYCLING/RECOVERY	X	4. SURFACE IMPOUNDMENT
	ELINE	X	5. TANK, BELOW GROUND		5. CHEM./PHYS./TREATMENT		5. MIDNIGHT DUMPING
	6. OTHER (specify):		6. OTHER (specify):		6. BIOLOGICAL TREATMENT		6. INCINERATION
					7. WASTE OIL REPROCESSING		7. UNDERGROUND INJECTION
					8. SOLVENT RECOVERY		8. OTHER (specify):
					9. OTHER (specify):		

E. SUPPLEMENTAL REPORTS If the site falls within any of the categories listed below, Supplemental Reports must be completed. Indicate which Supplemental Reports you have filled out and attached to this form.

☐ 1. STORAGE ☐ 2. INCINERATION ☐ 3. LANDFILL ☐ 4. SURFACE IMPOUNDMENT ☐ 5. DEEP WELL

☐ 6. CHEM/BIO/PHYS TREATMENT ☐ 7. LANDFARM ☐ 8. OPEN DUMP ☐ 9. TRANSPORTER ☐ 10. RECYCLOR/RECLAIMER

VII. WASTE RELATED INFORMATION

A. WASTE TYPE

☒ 1. LIQUID ☒ 2. SOLID ☒ 3. SLUDGE ☐ 4. GAS

B. WASTE CHARACTERISTICS

☐ 1. CORROSIVE ☒ 2. IGNITABLE ☒ 3. RADIOACTIVE ☐ 4. HIGHLY VOLATILE

☒ 5. TOXIC ☐ 6. REACTIVE ☒ 7. INERT ☒ 8. FLAMMABLE

☐ 9. OTHER (specify):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

Phase I Assessment completed, Phase II report expected 5/84.

Continue On Reverse

Continued From Front

VII. WASTE RELATED INFORMATION (continued)

2. Estimate the amount (specify unit of measure) of waste by category, mark 'X' to indicate which wastes are present.

a. SLUDGE	b. OIL	c. SOLVENTS	d. CHEMICALS	e. SOLIDS	f. OTHER
AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT
UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE
X (1) PAINT, PIGMENTS	X (1) OILY WASTES	X (1) HALOGENATED SOLVENTS	X (1) ACIDS	X (1) FLYASH	X (1) LABORATORY, PHARMACEUT.
(2) METALS SLUDGES	(2) OTHER (specify)	X (2) NON-HALOGNTD. SOLVENTS	(2) PICKLING LIQUORS	(2) ASBESTOS	(2) HOSPITAL
(3) POTW		(3) OTHER (specify)	(3) CAUSTICS	(3) MILLING/MINE TAILINGS	(3) RADIOACTIVE
(4) ALUMINUM SLUDGE			X (4) PESTICIDES	(4) FERROUS SMELTING WASTES	X (4) MUNICIPAL
(5) OTHER (specify)			(5) DYES/INKS	(5) NON-FERROUS SMLTG. WASTES	(5) OTHER (specify)
			(6) CYANIDE	(6) OTHER (specify)	
			(7) PHENOLS	Military ammunition	
			(8) HALOGENS		
			(9) PCB		
			X (10) METALS		
			(11) OTHER (specify)		

D. SUBSTANCES OF GREATEST CONCERN WHICH ARE ON THE SITE (place in descending order of hazard)

1. SUBSTANCE	2. FORM (mark 'X')			3. TOXICITY (mark 'X')				4. CAS NUMBER	5. AMOUNT	6. UNIT
	a. SOLID	b. LIQ.	c. VAPOR	a. HIGH	b. MED.	c. LOW	d. NONE			
Tetrachloroethylene		X		X						
Dichloroethylene		X			X					
Trichloroethylene		X			X					
Toluene		X			X					

VIII. HAZARD DESCRIPTION

FIELD EVALUATION HAZARD DESCRIPTION: Place an 'X' in the box to indicate that the listed hazard exists. Describe the hazard in the space provided.

X A. HUMAN HEALTH HAZARDS

c organic compounds present in drinking water aquifer

Continue On Page 5

Continued From Page 4

VII. HAZARD DESCRIPTION (continued)

☐ B. NON-WORKER INJURY/EXPOSURE

☐ C. WORKER INJURY/EXPOSURE

☒ D. CONTAMINATION OF WATER SUPPLY

Documented contamination of base water supply wells. Municipal supply wells within 3 miles.

☐ E. CONTAMINATION OF FOOD CHAIN

☒ F. CONTAMINATION OF GROUND WATER

Substances in VII D. documented in base water supply wells (EPA ground water supply survey).

☐ G. CONTAMINATION OF SURFACE WATER

Continued From Front

VIII. HAZARD DESCRIPTION (continued)

☐ H. DAMAGE TO FLORA/FAUNA

☐ I. FISH KILL

☐ J. CONTAMINATION OF AIR

☐ K. NOTICEABLE ODORS

☐ L. CONTAMINATION OF SOIL

☐ M. PROPERTY DAMAGE

Continue On Page 7

Continued From Page 6

VII. HAZARD DESCRIPTION (continued)

☐ N. FIRE OR EXPLOSION

☐ O. SPILLS/LEAKING CONTAINERS/RUNOFF/STANDING LIQUID

☐ P. SEWER, STORM DRAIN PROBLEMS

Q. EROSION PROBLEMS

☐ R. INADEQUATE SECURITY

☐ S. INCOMPATIBLE WASTES

VIII. HAZARD DESCRIPTION (continued)

☐ T. MIDNIGHT DUMPING

☐ U. OTHER (specify)

IX. POPULATION DIRECTLY AFFECTED BY SITE

A. LOCATION OF POPULATION	B. APPROX. NO. OF PEOPLE AFFECTED	C. APPROX. NO. OF PEOPLE AFFECTED WITHIN UNIT AREA	D. APPROX. NO. OF BUILDINGS AFFECTED	E. DISTANCE TO SITE (specify units)
1. IN RESIDENTIAL AREAS	68,000			
2. IN COMMERCIAL OR INDUSTRIAL AREAS				
3. IN PUBLICLY TRAVELLED AREAS				
4. PUBLIC USE AREAS (parks, schools, etc.)				

X. WATER AND HYDROLOGICAL DATA

A. DEPTH TO GROUNDWATER (specify unit)	B. DIRECTION OF FLOW	C. GROUNDWATER USE IN VICINITY
75-100 ft.		drinking water, commercial, industrial
D. POTENTIAL YIELD OF AQUIFER	**E. DISTANCE TO DRINKING WATER SUPPLY (specify unit of measure)**	**F. DIRECTION TO DRINKING WATER SUPPLY**
500 gpm	0 ft.	

PE OF DRINKING WATER SUPPLY

___ 1. NON-COMMUNITY < 15 CONNECTIONS

☒ 2. COMMUNITY (specify name) > 15 CONNECTIONS Midwest City, Tinker AFB

☐ 3. SURFACE WATER

☐ 4. WELL

Continue On Page 9

Cor From Page 8

X. WATER AND HYDROLOGICAL DATA (continued)

H. LIST ALL DRINKING WATER WELLS WITHIN A 1/4 MILE RADIUS OF SITE

1. WELL	2. DEPTH (specify unit)	3. LOCATION (proximity to population/buildings)	4. NON-COMMUNITY (mark 'X')	5. COMMUNITY (mark 'X')
1-26	125 ft.	Tinker AFB		X
	Garber			
	Wellington			

I. RECEIVING WATER

1. NAME: Canadian River

☐ 2. SEWERS ☒ 3. STREAMS/RIVERS ☐ 4. LAKES/RESERVOIRS ☐ 5. OTHER (specify)

6. SPECIFY USE AND CLASSIFICATION OF RECEIVING WATERS

Contact and non-contact recreation
Propagation of fish and wildlife.

XI. SOIL AND VEGITATION DATA

LOCATION OF SITE IS IN

☐ A. KNOWN FAULT ZONE ☐ B. KARST ZONE ☐ C. 100 YEAR FLOOD PLAIN ☐ D. WETLAND

☐ E. A REGULATED FLOODWAY ☐ F. CRITICAL HABITAT ☒ G. RECHARGE ZONE OR SOLE SOURCE AQUIFER

XII. TYPE OF GEOLOGICAL MATERIAL OBSERVED

Mark 'X' to indicate the type(s) of geological material observed and specify where necessary, the component parts.

'X'	A. OVERBURDEN	'X'	B. BEDROCK (specify below)	'X'	C. OTHER (specify below)
X	1. SAND		Sandstone		
	2. CLAY				
	3. GRAVEL				

XIII. SOIL PERMEABILITY

☐ A. UNKNOWN ☐ B. VERY HIGH (100,000 to 1000 cm/sec.) ☐ C. HIGH (1000 to 10 cm/sec.)
☒ D. MODERATE (10 to .1 cm/sec.) ☐ E. LOW (.1 to .001 cm/sec.) ☐ F. VERY LOW (.001 to .00001 cm/sec.)

G. RECHARGE AREA

☒ 1. YES ☐ 2. NO 3. COMMENTS

H. DISCHARGE AREA

☐ 1. YES ☐ 2. NO 3. COMMENTS

I. SLOPE

1. ESTIMATE % OF SLOPE 2. SPECIFY DIRECTION OF SLOPE, CONDITION OF SLOPE, ETC.

J. OTHER GEOLOGICAL DATA

Continue On Reverse

Continued From Front

XIV. PERMIT INFORMATION

List all applicable permits held by the site and provide the related information.

A. PERMIT TYPE (e.g. RCRA, State, NPDES, etc.)	B. ISSUING AGENCY	C. PERMIT NUMBER	D. DATE ISSUED (mo., day, & yr.)	E. EXPIRATION DATE (mo., day, & yr.)	F. IN COMPLIANCE (mark 'X')		
					1. YES	2. NO	3. UNKNOWN

XV. PAST REGULATORY OR ENFORCEMENT ACTIONS

☒ NONE ☐ YES (summarize in this space)

NOTE: Based on the information in Sections III through XV, fill out the Tentative Disposition *(Section II)* information on the first page of this form.

132 pp

OK 3646

INSTALLATION RESTORATION PROGRAM

PHASE I - RECORDS SEARCH

TINKER AFB, OKLAHOMA

PREPARED FOR

UNITED STATES AIR FORCE
AFESC/DEV
Tyndall AFB, Florida

ES ENGINEERING-SCIENCE

APRIL, 1982

A-1

Reference #3
Installation Restoration Program, Phase I - Records Search.
Tinker AFB, Oklahoma. April 1982.

INSTALLATION RESTORATION PROGRAM
PHASE I: RECORDS SEARCH
TINKER AFB, OKLAHOMA

Prepared For

United States Air Force
AFESC/DEV
Tyndall AFB, Florida

April, 1982

By

ENGINEERING-SCIENCE
57 Executive Park South, NE
Suite 590
Atlanta, Georgia 30329

A-3

This report has been prepared for the U.S. Air Force by Engineering-Science for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the official views of the publishing agency, the United States Air Force or the Department of Defense.

ES ENGINEERING-SCIENCE

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CABLE ADDRESS ENGINSCI
TELEX: 54-2882

9656

April 15, 1982

Mr. Bernard Lindenberg
AFESC/DEVP
Tyndall AFB, Florida 32403

Dear Mr. Lindenberg:

Enclosed is the Engineering-Science, Inc. (ES) final report entitled "Installation Restoration Program, Phase I Records Search, Tinker AFB, Oklahoma." This report has been prepared in accordance with the ES proposal dated July 15, 1981 and Air Force Contract Number F08637-80-G-0009 Call #0008.

Presented in this report are introductory background information on the Installation Restoration Program, a description of the Tinker AFB installation including past activities, mission and environmental setting, a review of industrial activities at Tinker AFB, an inventory of major solid and hazardous waste from past activities, a review of past and present waste handling, treatment and disposal facilities, an evaluation of the pollution potential of waste disposal sites, and recommendations for the Installation Restoration Program, Phase II, Problem Confirmation.

Any questions concerning this report should be refered to the Office of Public Affairs, Tinker Air Force Base, (405) 734-2026.

We appreciate the opportunity to work with you and the other Air Force personnel who contributed information to us for the completion of this assessment.

Very truly yours,

ENGINEERING-SCIENCE, INC.

E J Schroeder

E. J. Schroeder, P.E.
Manager, Solid & Hazardous Waste

EJS/lmr

Enclosure

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Department of Defense (DOD) has developed a program to identify and evaluate past hazardous material sites on DOD property, to control the migration of hazardous contaminants, and to control hazards to health or welfare that may result from these past disposal operations. This program is called the Installation Restoration Program (IRP). The IRP has four phases consisting of Phase I, Initial Assessment/Record Search; Phase II, Problem Confirmation; Phase III, Technology Base Development; and Phase IV, Operations. Engineering-Science (ES) was retained by the Air Force Engineering and Services Center to conduct the Phase I, Initial Assessment/Records Search at Tinker AFB under Contract No. F08637-80-G0009, Call No. 0008, using funding provided by the Air Force Logistics Command.

INSTALLATION DESCRIPTION

Tinker AFB is located in central Oklahoma southeast of Oklahoma City and contiguous with Midwest City. The base covers 4,277 acres and contains approximately 500 buildings. The base was activated in March 1942. The primary mission of the base is serving as a worldwide repair depot for several aircraft and a multitude of weapons and engines. This mission has remained unchanged since the late 1940's.

ENVIRONMENTAL SETTING

The environmental setting data reviewed for this study indicate the following key items concerning the impact of past waste disposal practices on the base:

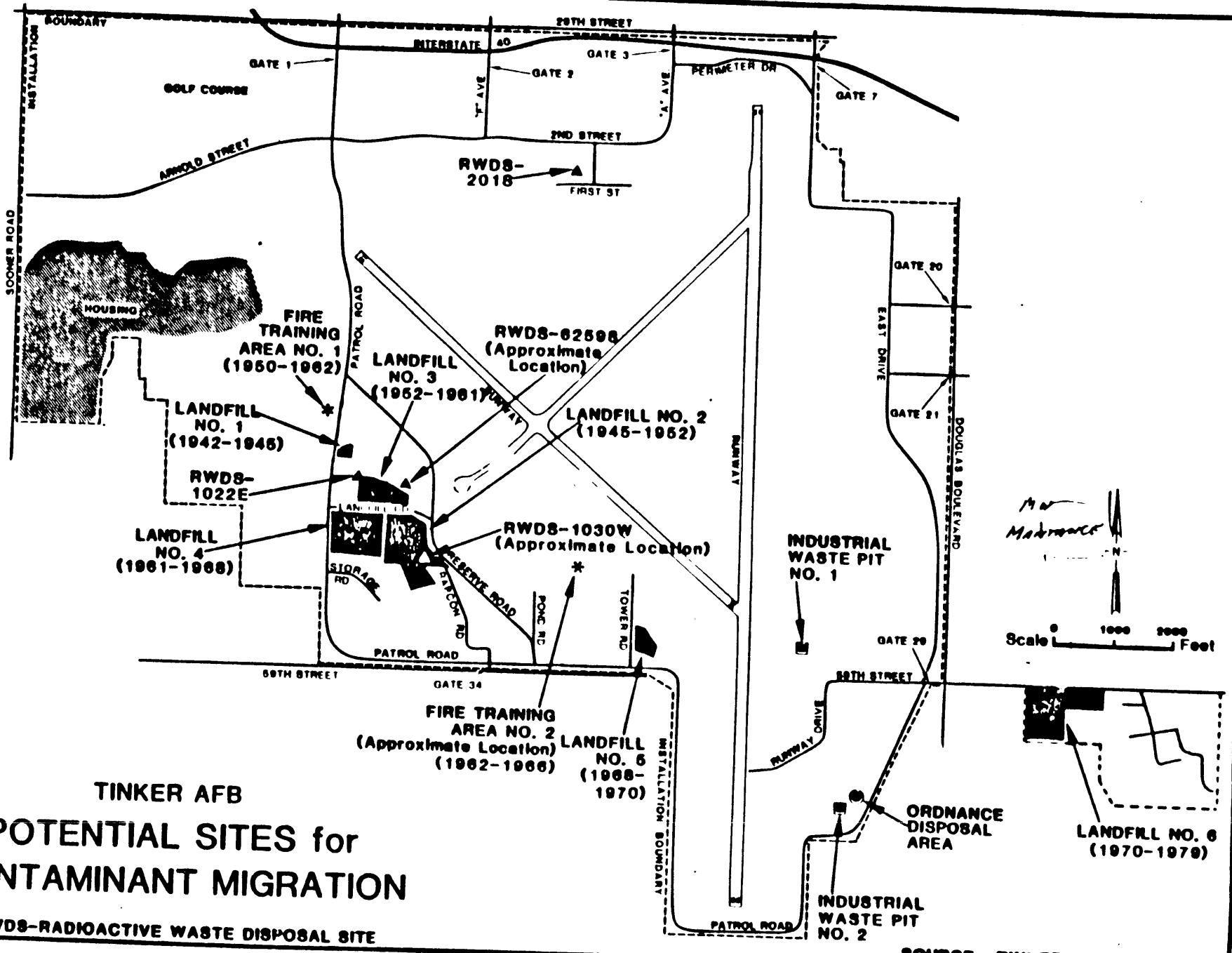
- Surficial soils at Tinker AFB are predominantly sands or silts which characteristically exhibit moderate to high permeabilities.
- The primary regional aquifer, the Garber-Wellington, is present at or near ground-surface over most of the base area. Ground water is encountered within the aquifer at moderate depth (250

feet). The upper section of the aquifer is primarily an unsaturated zone.

- Tinker AFB is located within a recharge area of the primary regional aquifer.
- The historical contamination of base surface waters and associated sediments has been documented. Stream water percolation is known to be one form of recharge to the Garber-Wellington Aquifer.
- The Tinker AFB mean annual precipitation is 32.4 inches, while lake evaporation is given at 60 inches as Tinker AFB is located in a water deficient zone of the U.S. Precipitation events releasing as much as 6.2 inches rainfall in a twenty-four hour period at Tinker AFB have been reported, causing local flooding (Weather Squadron Data).

METHODOLOGY

During the course of this project, interviews were conducted with base personnel (past and present) familiar with past waste disposal practices, file searches were performed for facilities which have generated, handled, transported, and disposed of waste materials, interviews were held with local, state and federal agencies, and site inspections were conducted at facilities that have generated, treated, stored, and disposed of hazardous waste. Fourteen disposal sites located on the Tinker AFB property were identified as containing hazardous waste resulting from past waste disposal activities (Figure 1). These sites have been assessed using a hazardous assessment rating methodology (HARM) which takes into account factors such as site characteristics, waste characteristics, potential for contaminant migration and waste management practices. The details of the rating procedure are presented in Appendix G and the results of the assessment are given in Table 1. The rating system is designed to indicate the relative need for follow-on action.



TINKER AFB

POTENTIAL SITES for CONTAMINANT MIGRATION

NOTE: RWDS-RADIOACTIVE WASTE DISPOSAL SITE

SOURCE: TINKER AFB DOCUMENTS

FIGURE 1

TABLE 1

PRIORITY RANKING OF POTENTIAL CONTAMINATION SOURCES

TINKER AFB

Rank	Site Name	Date of Operation or Occurrence	Overall Total Score
1	Landfill No. 4	1961-1968	70
2	Industrial Waste Pit No. 2	1958-1965	68
3	Landfill No. 2	1945-1952	65
4	Industrial Waste Pit No. 1	1947-1958	61
5	Landfill No. 3	1952-1961	60
6	RWDS 1030W	Prior to 1955	59
7	Landfill No. 6	1970-1979	56
8	Fire Training Area No. 1	1950-1962	55
9	Landfill No. 5	1968-1970	51
10	RWDS 1022E	Mid 1950's	49
11	Fire Training Area No. 2	1962-1966	47
12	Landfill No. 1	1942-1945	45
13	RWDS 62598	Early 1950's	37
14	RWDS 201S	Unknown	35

Note: This ranking was performed according to the Hazardous Assessment Rating Methodology (HARM) described in Appendix G. Individual site rating forms are in Appendix H.

FINDINGS AND CONCLUSIONS

The following conclusions have been developed based on the results of the project team's field inspection, review of base records and files and interviews with base personnel.

The areas determined to have a high potential for contaminant migration are as follows:

- Landfill No. 4
- Industrial Waste Pit No. 2
- Landfill No. 2

The areas determined to have a moderate potential for contaminant migration are as follows:

- Industrial Waste Pit No. 1
- Landfill No. 3
- RWDS 1030W
- Landfill No. 6
- Fire Training Area No. 1
- Landfill No. 5

The areas determined to have a low potential for contaminant migration are as follows:

- RWDS 1022E
- Fire Training Area No. 2
- Landfill No. 1
- RWDS 62598
- RWDS 201S

RECOMMENDATIONS

The detailed recommendations developed for further assessment of potential contaminant migration are presented in Chapter 6. These recommendations are summarized as follows:

- Landfill No. 4 – Conduct geophysical survey and additional groundwater monitoring. Sample and analyze any leachate streams.

o Industrial Waste Pits No. 1 and No. 2	-	Obtain soil borings in and around the waste pits. Conduct geophysical survey to define site boundaries and identify any leachate plumes.
o Landfill No. 3, No. 5 and No. 6	-	Conduct geophysical survey and additional groundwater monitoring.
o Fire Training Area No. 1	-	Obtain soil borings in and around the fire training area. Conduct geophysical survey to define site boundaries and identify any leachate plumes.
o Base Streams	-	Conduct sediment sampling and additional water quality sampling on base streams. Measure stream water levels in conjunction with base monitoring wells to determine if the stream is the source of the shallow aquifer water.
o Water Supply Wells	-	Collect and analyze water samples from well Nos. 6, 7, 16, 18, 22, 23, 24, 25, 27 and 28.

CHAPTER 1

INTRODUCTION

CHAPTER 1
INTRODUCTION

BACKGROUND

The United States Air Force, due to its primary mission, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. Federal, state and local governments have developed strict regulations to require that disposers identify the locations and contents of disposal sites and take action to eliminate the hazards in an environmentally responsible manner. The Department of Defense (DOD) has issued Defense Environmental Quality Program Policy Memorandums 80-6 and 81-5 which require the identification and evaluation of past hazardous material disposal sites on DOD property, the control of migration of hazardous contaminants, and the control of hazards to health or welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP will be a basis for response actions on Air Force Installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

PURPOSE AND SCOPE OF THE ASSESSMENT

The Installation Restoration Program has been developed as a four-phased program as follows:

- Phase I - Initial Assessment/Records Search
- Phase II - Problem Confirmation
- Phase III - Technology Base Development
- Phase IV - Operations (Control Measures)

Engineering-Science (ES) was retained by the Air Force Engineering and Services Center to conduct the Phase I Records Search at Tinker AF Base under Contract No. F08637-80-G0009, Call No. 0008, using funding provided by the Air Force Logistics Command. This report contains a summary and an evaluation of the information collected during Phase I of the IRP.

The goal of the first phase of the program was to identify the potential for environmental contamination from past waste disposal practices at Tinker AFB, and to assess the potential for contaminant migration. The activities undertaken in Phase I included the following:

- Review site records
- Interview personnel familiar with past generation and disposal activities
- Inventory wastes
- Determine quantities and locations of current and past hazardous waste storage, treatment and disposal
- Define the environmental setting at the base
- Review past disposal practices and methods
- Conduct field inspection
- Gather pertinent information from federal, state and local agencies
- Assess potential for contaminant migration

In order to perform the on-site portion of the records search phase, ES assembled the following core team of professionals:

- E. J. Schroeder, Environmental Engineer and Project Manager, MSCE, 14 years of professional experience
- J. R. Absalon, Hydrogeologist, BS Geology, 8 years of professional experience
- D. G. Johnson, Environmental Engineer, MSCE, 4 years of professional experience
- M. I. Spiegel, Environmental Scientist, BS Environmental Science, 5 years of professional esperience
- R. M. Reynolds, Chemical Engineer, BSChE, 8 years of professional experience

More detailed information on these individuals is presented in Appendix A.

METHODOLOGY

The methodology utilized in the Tinker AFB Records Search began with a review of past and present industrial operations conducted at the

base. Information was obtained from available records such as shop files and real property files, as well as interviews with past and present base employees from the various operating areas of the base. Those interviewed included current and past environmental personnel associated with the Civil Engineering Squadron, the Bioenvironmental Engineering Services Division office, and the Directorate of Maintenance. Several current or past personnel associated with the wastewater treatment plant, the pesticide operations, fuels management and the base solid waste disposal areas were interviewed extensively. Experienced personnel from the tenant organizations were also interviewed. Formal interviews were conducted with 71 individuals to obtain the needed past activity information.

Concurrent with the base interviews the applicable federal, state and local agencies were contacted and interviewed for pertinent base related environmental data. The agencies contacted are listed as follows:

- Oklahoma Geological Survey, Norman, Oklahoma
- U.S. Geological Survey, Water Resources Division, Oklahoma City, Oklahoma
- Oklahoma Water Resources Board, Oklahoma City, Oklahoma
- US Environmental Protection Agency, Region VI, Dallas, Texas
- University of Oklahoma Health Sciences Center, Department of Environmental Health, Oklahoma City, Oklahoma

The next step in the activity review was to determine the past management practices regarding the use, storage, treatment, and disposal of hazardous materials from the various operations on the base. Included in this part of the activities review was the identification of all known past disposal sites and any other possible sources of contamination such as fuel-saturated areas resulting from large fuel spills.

An aerial overflight and a general ground tour of identified sites were then made by the ES Project Team to gather site specific information including (1) visual evidence of environmental stress, (2) the

presence of nearby drainage ditches or surface-water bodies, and (3) visual inspection of these water bodies for any obvious signs of contamination or leachate migration.

A decision was then made, based on all of the above information, whether a potential exists for hazardous material contamination at any of the identified sites using the decision tree shown in Figure 4.1. If no potential exists, the site was deleted from further consideration. For those sites where a potential for contamination was identified, a determination of the potential for migration of the contamination was made by considering site-specific conditions. If the potential for contaminant migration was considered significant, then the site was evaluated and prioritized using the hazardous assessment rating methodology (HARM).

The HARM score indicates the relative potential for contaminant migration at each site. For those sites showing a high potential, recommendations are made to quantify the potential contaminant migration problem under Phase II of the Installation Restoration Program. For those sites showing a moderate potential, a limited Phase II program may be recommended to confirm that a contaminant migration problem does or does not exist. For those sites showing a low potential, no further follow-up Phase II work would be recommended.

CHAPTER 2

INSTALLATION DESCRIPTION

CHAPTER 2

INSTALLATION DESCRIPTION

LOCATION, SIZE AND BOUNDARIES

Tinker AFB is located approximately in the center of the State of Oklahoma and contiguous with Oklahoma City (Figures 2.1, 2.2 and 2.3). The Base is within the North Canadian River drainage basin and drains principally into Crutcho and Soldier Creeks. The boundaries of the base cover 4,277 acres and contain approximately 500 buildings with 9.4 million square feet of floor space dedicated to operational, industrial, administrative and ordnance functions. Present land areas adjacent to the base are primarily as follows:

North - residential and commercial;
West - residential
South - residential, commercial and agricultural
East - residential, commercial and agricultural

The most prominent physiographic feature of the area is the North Canadian River.

BASE HISTORY

The initial construction of Midwest Air Depot (what is now Tinker AFB) began in July 1941, and the base was activated in March 1942. During World War II, the depot was responsible for reconditioning, modifying and modernizing aircraft, vehicles and equipment and the civilian employment peaked at 14,925 employees.

At the conclusion of World War II, the Douglas Aircraft Plant located east of the north-south runway was combined with the Base. Tinker became involved in jet engine overhaul and later modification of aircraft out of storage in a program to rebuild the nation's airpower. In 1948 Tinker Air Force Base became a worldwide repair depot for several aircraft and a multitude of other weapons and engines. The level of activity has fluctuated during history of the base, however the primary mission has

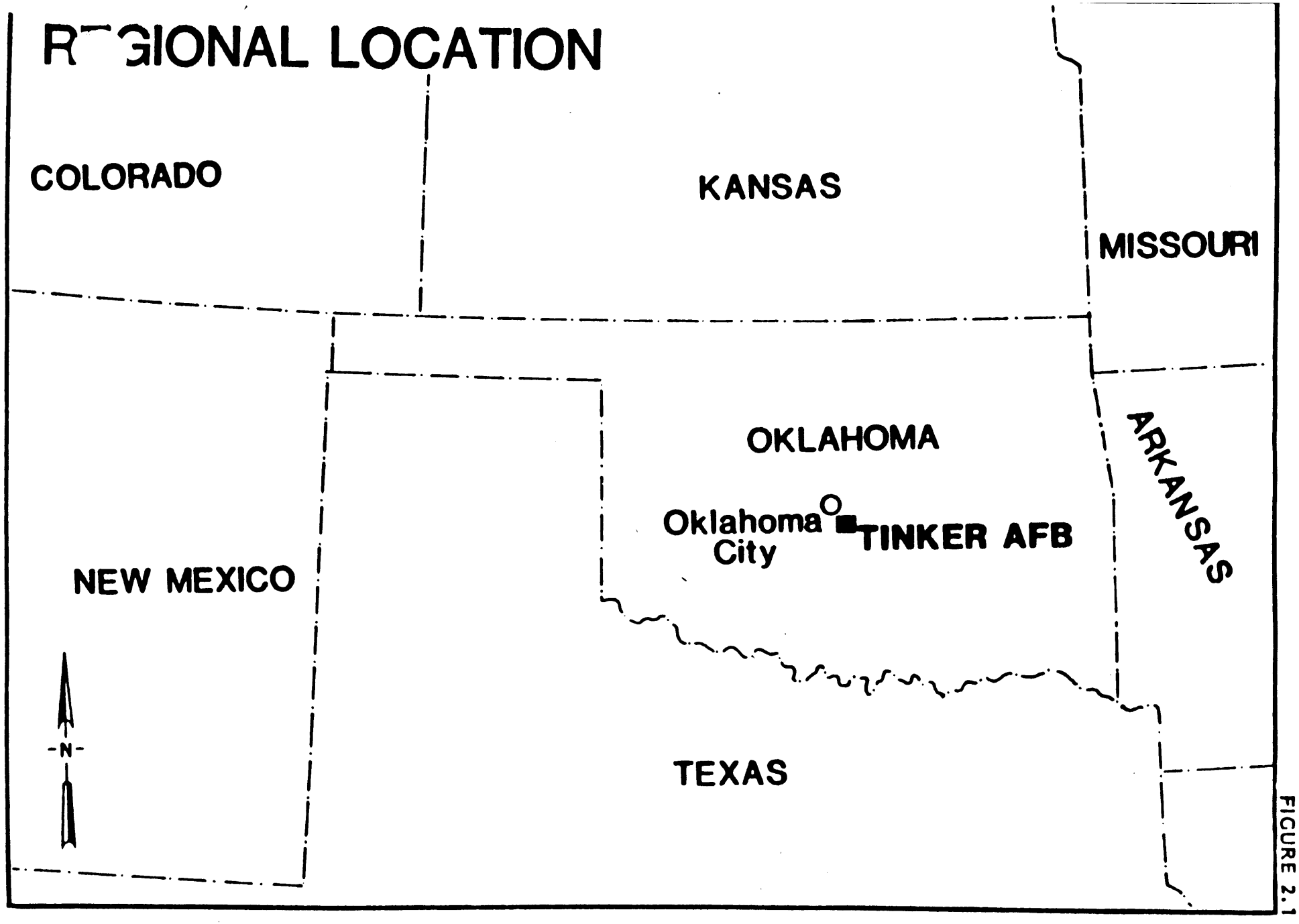


FIGURE 2.1

ES ENGINEERING-SCIENCE

FIGURE 2.2

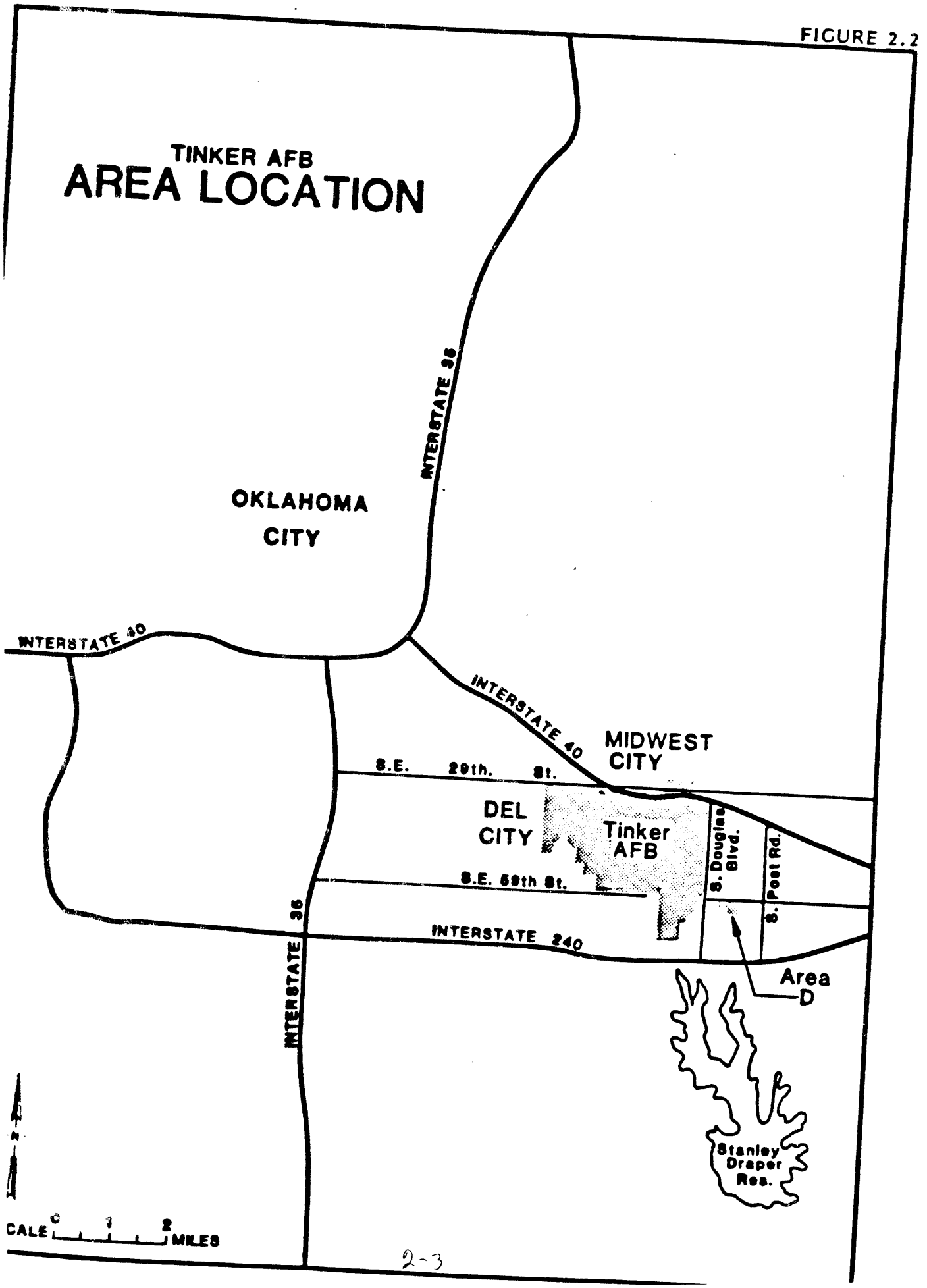
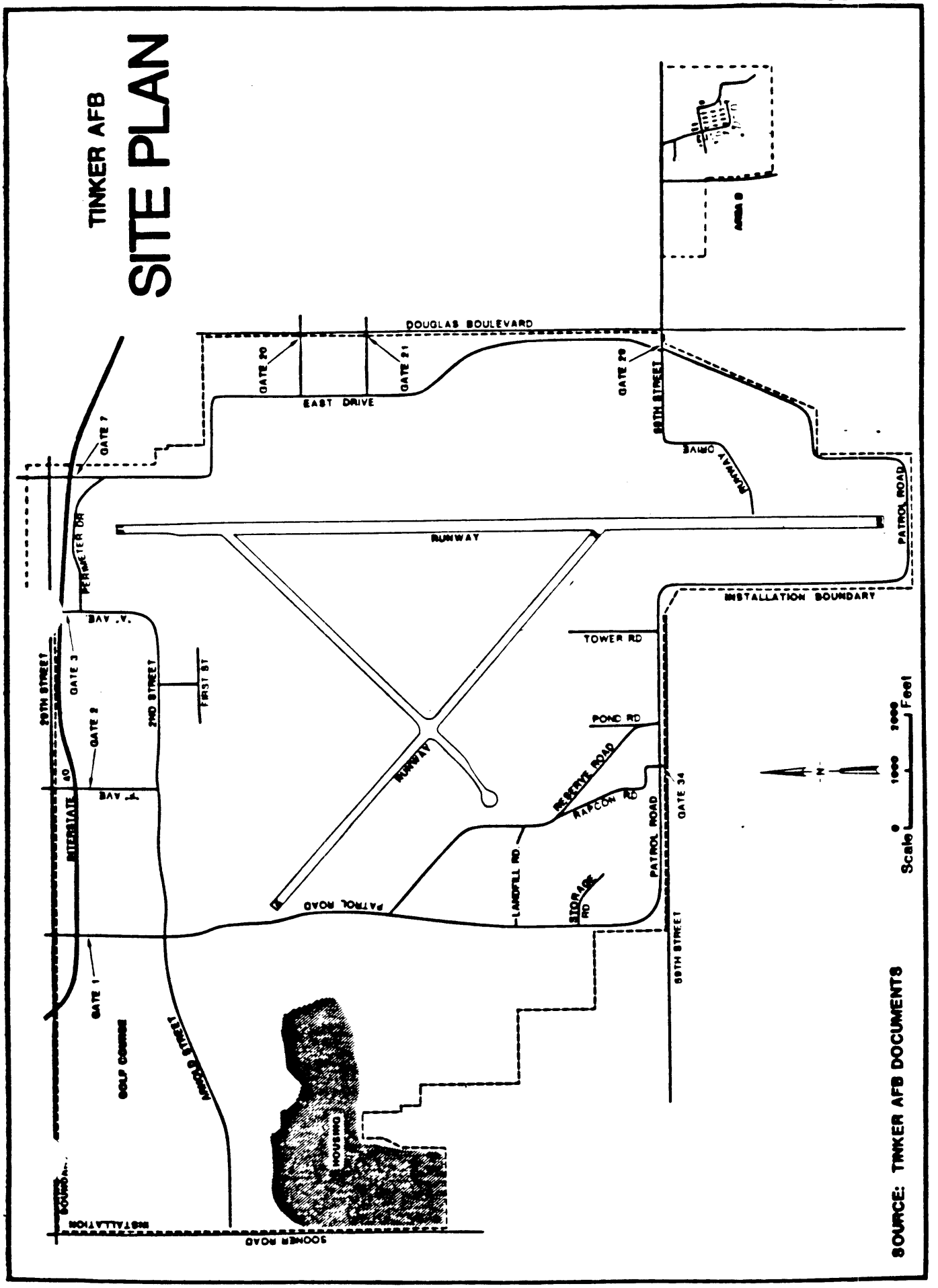

TINKER AFB
AREA LOCATION
OKLAHOMA CITY
INTERSTATE 35
INTERSTATE 40
INTERSTATE 40
MIDWEST CITY
S.E. 29th. St.
DEL CITY
Tinker AFB
S. Douglas Blvd.
S. Post Rd.
S.E. 59th St.
INTERSTATE 35
INTERSTATE 240
Area D
Stanley Draper Res.
N
SCALE 0 1 2 MILES

FIGURE 2.3

TINKER AFB SITE PLAN



SOURCE: TINKER AFB DOCUMENTS

not changed and Tinker AFB is still a major industrial complex for overhauling, modifying, and repairing military aircraft, aircraft engines, and accessory items.

The base has made several land acquisitions besides the Douglas Aircraft Plant. During 1951 the Air Force acquired a parcel of land located one half mile east of the southeast corner of Tinker AFB (Area "D"). The area was named the Oklahoma City Air Force Station and was supported by Tinker AFB. In 1956, the area officially became a separate entity; however support was still provided by Tinker AFB. The area was initially occupied by the 33rd Air Division and is presently occupied by the Engineering Installations Center, part of the Air Force Communications Command. In 1954 the base acquired a parcel of land south of the 59th Street boundary to extend the existing main runway. The land acquisition consisted of approximately 300 acres. During 1956, the base acquired additional land in the same area completing the parcel of land south of 59th Street presently within Tinker AFB jurisdiction. In 1957, a 638 acre tract of land immediately west of the original air base was acquired to develop permanent military housing and community support facilities. In 1975 the base acquired an additional 187 acres of land situated contiguous to the westside of Air Depot Boulevard between SE 59th Street and SE 44th Street.

A complete history of Tinker Air Force Base is presented in Appendix B.

ORGANIZATION AND MISSION

Tinker AFB has a multi-fold flying mission consisting of logistics support, administrative flight and pilot proficiency training. Production flight checks of aircraft that have undergone depot maintenance, repair and/or modification comprises the major portion of the logistic support flight mission. The 552nd Airborne Warning and Control Group (AWACW) operates and maintains the E-3A Sentry aircraft. The 552nd's mission includes training flights as well as support of the Tactical Air Commands worldwide mobile strike force. The Det 507, 301 Tactical Fighter Group (Reserves) performs tactical fighter training in the F-4 Aircraft. The reserve unit maintains combat proficiency and readiness of the personnel and aircraft.

The support function for the base is performed by the 2854th Air Base Wing which contains all administrative, security, maintenance, housekeeping, housing, fire protection, legal assistance and logistical support for the base.

The Oklahoma City Air Logistics Center (OCALC) is the major organization at Tinker AFB. The mission of the OCALC is to provide logistic support to the operating commands of the USAF. The OCALC is the logistic support manager for almost all of the Strategic Air Command's bomber and tanker fleet, three air-launched missiles, a substantial portion of the jet engines in the Air Force inventory, and approximately 140,000 items in the hydraulics, pneumatics and instrument areas. The Center also supports a huge industrial complex to overhaul, modify and repair the aircraft, aircraft engines and a vast number of accessory items.

A description of the tenants and their missions is presented in Appendix B. The tenants of the 2854th Air Base Group include the following units:

- 552 Airborne Warning and Control Group (AWACG)
- Engineering and Installation Center
- Det 507, 301 Tactical Fighter Group
- 3rd Combat Communications Group
- Communications Computer Programming Center
- 6th Weather Squadron Mobile
- Air Force Audit Agency Office
- Defense Logistics Agency, Memphis Region
- Defense Property Disposal Office, Oklahoma City
- USAF Hospital, Tinker
- 2953rd Combat Logistics Support Squadron
- Det, 3025 AFLC Mgt Engr Team
- 1985th Communications Squadron
- AF Office of Special Investigation
- Corps of Engineers, Resident Engineer
- Dept of Transp, Federal Aviation Administration
- Det 1, 60th Military Airlift Wing
- Det 1, 17th Weather Squadron
- Det 15, 1365th Audio Visual Squadron
- Military Air Traffic Coord. Office

- General Services Administration
- U.S. General Accounting Office
- 403rd Combat Logistics Support Squadron (Reserves)
- OLCA 2400 Reserve Readiness and Mobile Squadron
- 72nd Aerial Port Squadron (Reserves)

CHAPTER 3

ENVIRONMENTAL SETTING

CHAPTER 3

ENVIRONMENTAL SETTING

The environmental setting of Tinker Air Force Base is described in this section with the primary emphasis directed toward identifying features that affect the movement of hazardous waste contaminants. A summary of the environmental setting pertinent to this study is presented at the end of the section.

METEOROLOGY

Temperature, precipitation and other relevant data furnished by Detachment 1, 17th Weather Squadron, Tinker AFB is presented in Table 3.1. The indicated period of record is 30 years. The summarized data indicate that mean annual precipitation is 32.4 inches and that mean annual snowfall is eleven inches. According to the Climatic Atlas of the United States, annual lake evaporation for the Oklahoma City area is estimated to be 60 inches.

GEOGRAPHY

The Oklahoma City area is located within the Central Redbed Plains section of the Central Lowland Physiographic Province (Curtis and Ham, 1972). The area is characterized by nearly level to gently rolling hills, broad flat plains and well-entrenched main streams. The valleys of secondary streams may exhibit a sag and swale appearance, indicative of the erosion of somewhat cohesive residual soils.

Topography

The topography of Oklahoma City and surrounding area varies from generally level to gently rolling in appearance. Local relief is primarily the result of dissection by erosional activity or stream channel development. At Oklahoma City, surface elevations are typically in the range of 1,070 to 1,400 feet MSL. At Tinker Air Force Base ground surface elevations vary from 1,210 feet MSL at the point where

the east branch of Crutcho Creek intersects the base boundary to approximately 1,320 feet MSL at Area D, located on 59th Street, east of the main installation.

Drainage

Drainage of Tinker Air Force Base land areas is accomplished by overland flow of runoff to diversion structures and thence to area surface streams, which flow intermittently. The northeast portion of the base is drained primarily by Soldier Creek, a tributary of Crutcho Creek. The north and west sections of the base including the main instrument runway, drain to Crutcho Creek, a tributary of the North Canadian River. Two small unnamed intermittent streams crossing installation boundaries south of the main instrument runway generally do not receive significant quantities of base runoff due to site grading designed to preclude such drainage. These streams, when flowing, extend to Stanley Draper Lake, approximately one half mile south of the base. Installation drainage and the flow directions of surface streams are depicted on Figure 3.1.

Surface Soils

The surface soils of Tinker Air Force Base have been studied by the USDA, Soil Conservation Service (1969) and by several soil boring projects conducted for geotechnical (foundation construction) investigations. Three major soil associations have been mapped within installation limits and are depicted on Figure 3.2. The individual soil types are summarized on Table 3.2. The surface soils of the installation area are predominantly of two basic types: residual and alluvial. The residual soils associations, Darrell-Stephenville and Renfrow-Vernon-Bethany are the product of the weathering of underlying bedrock. The alluvial materials are stream-deposited silts and sands, whose occurrence is typically restricted to the floodplains of area streams.

GEOLOGY

The geology of the Oklahoma City area has been reported by Miser et al. (1954), Bingham and Moore (1975), Johnson and Luza (1980), among others. A brief review of the published information has been summarized in support of this investigation.

TABLE 3.1

SUMMARY OF WEATHER DATA AT TINKER AFB, OK

MONTH	TEMPERATURE (°F) MEAN DAILY MAX	MEAN DAILY MIN	MEAN MONTHLY	EXTREME MAX	EXTREME MIN	PRECIPITATION (IN) MONTHLY MEAN	MONTHLY MAX	MONTHLY MIN	MAX 24 HRS	SNOWFALL (IN) MONTHLY MEAN	MONTHLY MAX	MAX 24 HRS	SURFACE WINDS PREVAILING DIRECTION (16 PT)	MEAN SPEED (KT)
JAN	47	28	37	80	-7	1.2	6.1	0	2.2	4	25	6	S	11
FEB	52	32	42	85	-1	1.3	2.8	0	1.7	2	8	5	S	11
MAR	59	38	49	90	-1	2.0	5.2	.1	1.8	2	18	9	S	13
APR	71	51	61	94	25	3.3	8.7	.7	2.9	0	1	1	S	13
MAY	78	59	69	98	35	5.6	11.4	.3	5.7	0	0	0	S	11
JUN	87	68	78	105	52	4.2	13.5	.4	5.1	0	0	0	S	12
JUL	92	72	82	107	53	3.3	8.2	.1	3.7	0	0	0	S	10
AUG	92	71	82	107	56	2.4	9.3	0	2.8	0	0	0	S	10
SEP	84	64	74	107	40	3.5	11.3	0	6.2	0	0	0	S	10
OCT	74	53	64	98	26	2.5	7.5	0	2.7	0	0	0	S	10
NOV	60	40	50	83	11	1.6	7.3	0	2.0	1	6	2	S	11
DEC	50	31	41	85	0	1.5	3.5	0	2.3	2	11	6	S	11
ANN	71	50	61	107	-7	32.4	13.5	.0	6.2	11	25	9	S	11

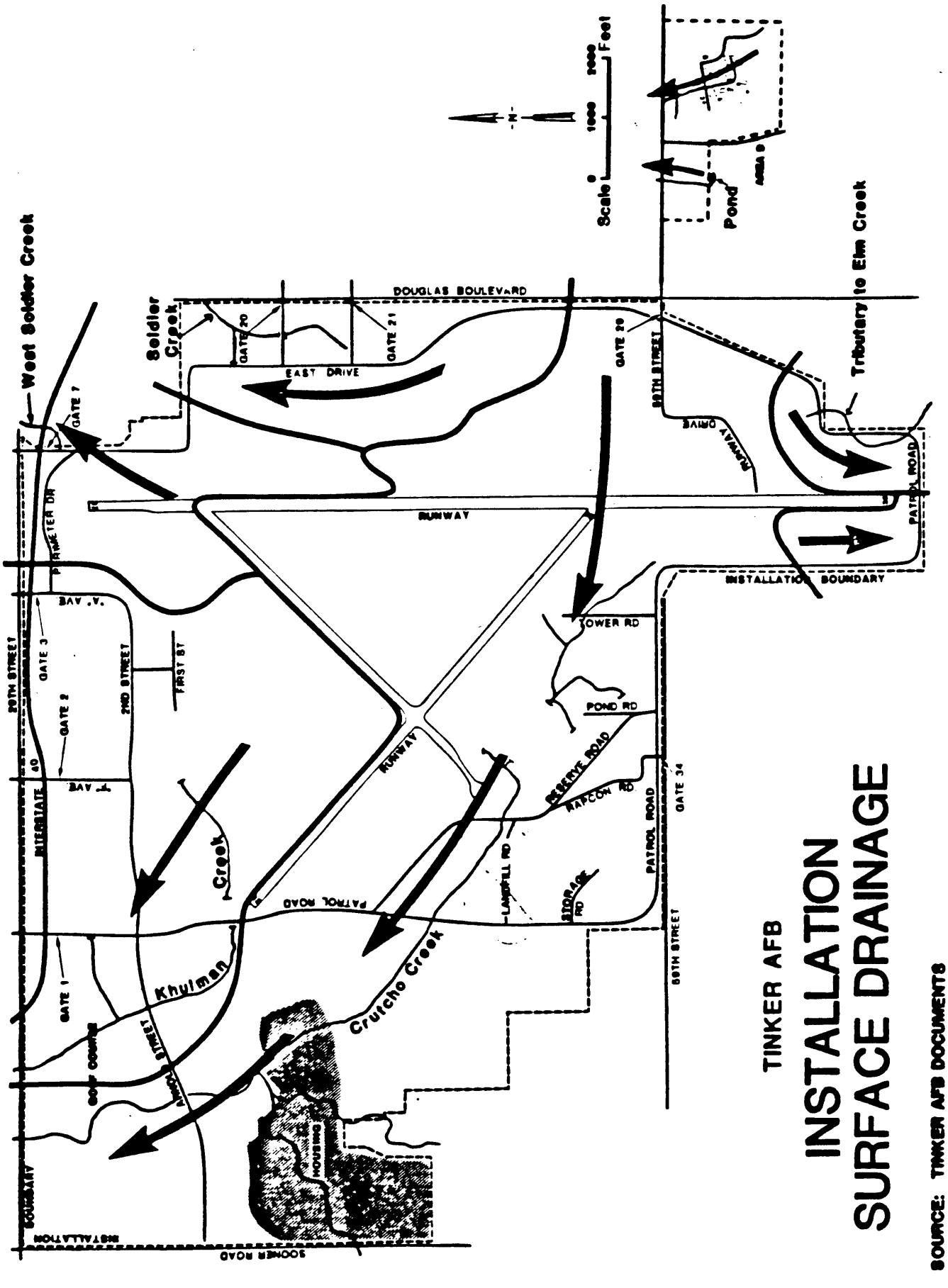
Base Elevation: 1,291 feet
Period of Record: 1942-1972
0: trace amount

SOURCE: Detachment 1, 17th Weather Squadron

[illegible]
[illegible]
[illegible] 4.[illegible]
13.1 [illegible]
[illegible] (USDC [illegible], 1977 Climatic Atl.)
15° - 3 mo.

15
- 13.1
1.9"

FIGURE 3.1



TINKER AFB
INSTALLATION
SURFACE DRAINAGE

SOURCE: TINKER AFB DOCUMENTS

FIGURE 3.2

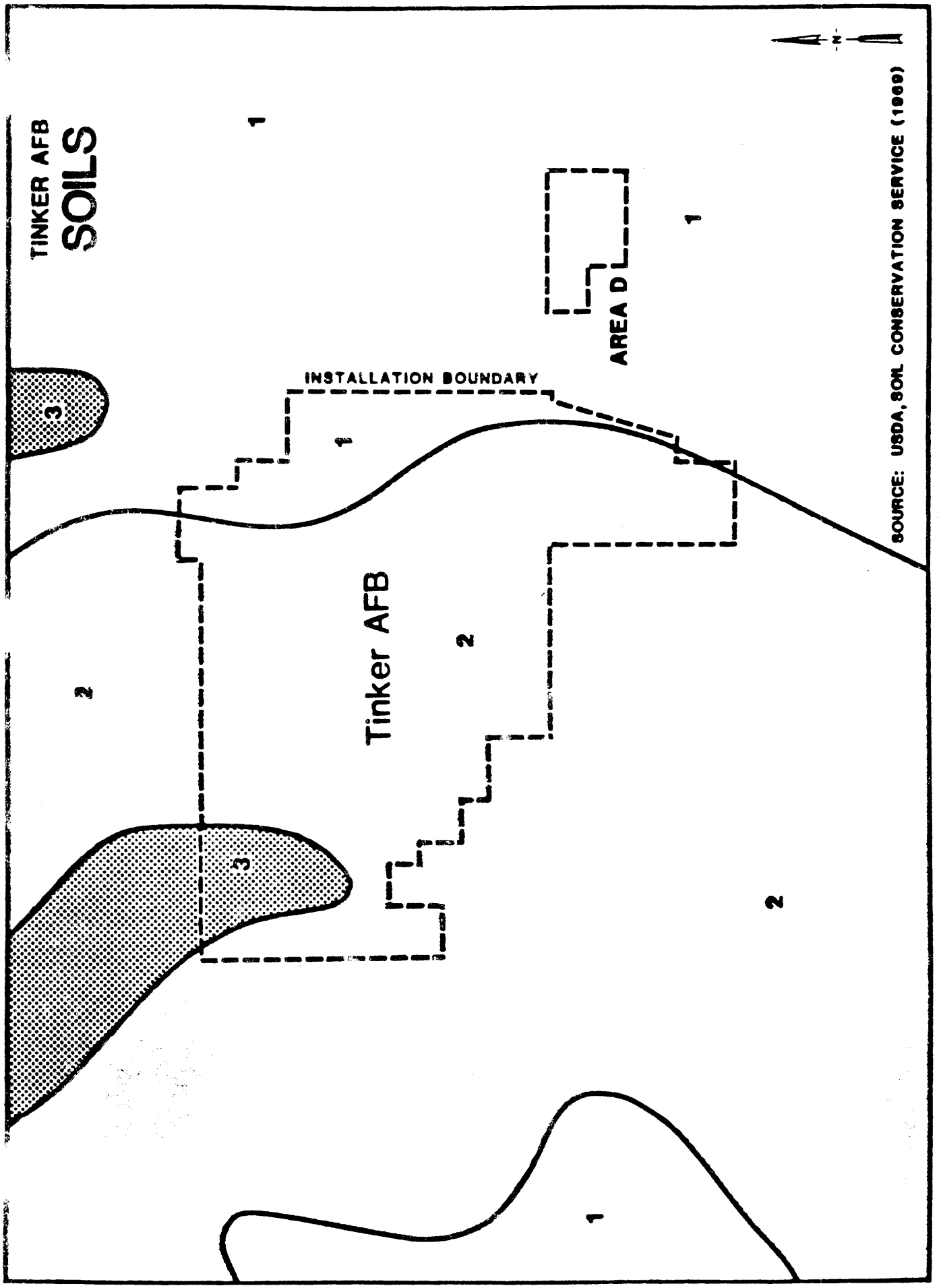


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TABLE 3.2

TINKER AIR FORCE BASE SOIL ASSOCIATIONS

Symbol	Name	Description	Thickness in.	Unified Class.	Permeability in/hr*
1	Darrell-Stephenville: loamy soils of wooded uplands.	Sandy loam. Sandy clay loam. Soft sandstone. (Garber Sandstone)	12 - 54	SM,ML,SC	2.0 - 6.30
2	Renfrow-Vernon-Bethany: loamy and clayey soils on prairie uplands.	Silt loam - clay. Clay loam. Shale. (Fairmont Shale)	12 - 60	ML, CL MH, CH	<0.06 - 0.20
3	Dale-Canadian-Port: loamy soils on low benches near large streams.	Fine sandy loam. Silty clay loam. Loam. Clay loam	12 - 60	SM, ML CL	0.05 - 6.30

Source: USDA, SCS (1969).

* Although this characteristic of base soils is called "Permeability" by the Soil Conservation Service, it is actually a description of infiltration rates - the speed that water moves through unsaturated earth materials.

Stratigraphy

Geologic units ranging in age from Permian to Quaternary have been described in the Oklahoma County area and are summarized as Table 3.3. The lithologies of these units include unconsolidated deposits and sedimentary rocks.

Distribution

The physical distribution of significant geologic units relevant to this study are mapped as Figure 3.3, which has been modified from the work of Bingham and Moore (1975). Tinker Air Force Base geologic units are summarized on Table 3.4. Generally, the surficial geology of the north section of the installation is dominated by the Garber Sandstone, which crops out across a broad area of Oklahoma County. Weathering of the Garber has probably produced Darrell-Stephenville soils. The south portion of the base's surficial geology is reportly dominated by the Kingman Siltstone and the Fairmont Shale (as indicated on geologic maps by Miser (1959) and Bingham & Moore (1975). An inspection of the base and a review of available drilling information has failed to confirm the presence of the siltstone unit on base. Drilling information obtained as a result of geotechnical investigations and monitoring well installation does indicate the presence of the Fairmont Shale separating surface soils from the underlying Garber Sandstone. At some locations, however, the shale appears to be thin and/or discontinuous. In other base areas, the shale is absent as shown on Figure 3.3. The stratigraphic relationships of major geologic units present on base are presented on Figures 3.4 and 3.5, the logs of base monitoring wells.

Structure

Tinker Air Force Base lies within a tectonically stable area. No major faults or fracture zones have been mapped near the base. Most of the consolidated rock units of the Oklahoma City area are nearly flat-lying. The reported regional dip is forty feet per mile in a generally westward direction (Bingham and Moore, 1975).

HYDROLOGY

Ground-water hydrology of the Tinker Air Force Base - Oklahoma City area has been reported by Jacobsen and Reed (1949), Wood and Burton (1968), Bingham and Moore (1975), Bedinger and Sniegocki (1976) and

MAJOR GEOLOG' 'ITS OF OKLAHOMA COUNTY

System	Series	Stratigraphic Unit	Thickness (feet)	Description and Distribution	Water-bearing Properties
QUATERNARY	RECENT	Dune sand	0-20	Fine-to coarse-grained wind-blown sand. Consists chiefly of subrounded quartz grains. Forms a thin mantle or hummocky surface that obscures older rocks. Most extensive deposits on north side of North Canadian River near Lake Overholser.	Moderately to highly permeable, but mostly above the water table and saturated only locally. Where saturated, yields water readily to domestic or stock wells, but supply may not be permanent. Water most likely to occur in this unit where underlain by poorly permeable redbeds. Provides infiltration areas for recharge to underlying rocks.
	PLEISTOCENE AND RECENT	Alluvium	0-70	Unconsolidated and interfingering lenses of sand, silt, clay, and gravel in the flood plains and channels of streams.	Moderately permeable. Yields small to moderate quantities of water to wells in valleys of larger streams. Water is very hard, but suitable for most uses, unless contaminated by industrial wastes or oil-field brines.
		Terrace deposits	0-100	Unconsolidated and interfingering lenses of sand, silt, gravel, and clay that occur at one or more levels above the flood plains of the principal streams.	Moderately permeable. Locally above the water table and not saturated. Where deposits have sufficient saturated thickness, they are capable of yielding moderate quantities of water to wells. Water is moderately hard to very hard, but less mineralized than water in other aquifers. Suitable for most uses unless contaminated by oil field brines.
PERMIAN	LOWER PERMIAN	Chickasha Formation and Duncan Sandstone	200 ±	Beds of reddish-brown sandstone, siltstone, shale, and siltstone conglomerate. Individual beds of sandstone highly cross-bedded and well cemented, in western part of area between Canadian and North Canadian Rivers.	Poorly permeable. Tapped by only a few small-capacity wells for domestic or stock use. Water is hard and in places highly mineralized.
		Hennessey Group (Includes Kingman Siltstone and Fairmont Shale)	700	Deep-red clay shale containing thin beds of red sandstone and white or greenish bands of sandy or limy shale. Forms relatively flat to gently rolling grass-covered prairies.	Poorly permeable. Yields meager quantities of very hard, moderately to highly mineralized water to shallow domestic and stock wells. In places water contains large amounts of sulfate.
		Garber Sandstone	500 ±	Deep-red to reddish-orange, massive and cross-bedded fine-grained sandstone interbedded with and interfingered with red shale and siltstone.	Poorly to moderately permeable. Important source of ground water in Cleveland and Oklahoma Counties. Yields small to moderate quantities of water to deep wells; heavily pumped for industrial and municipal uses in the Norman and Midwest City areas. Water from shallow wells hard to very hard; water from deep wells moderately hard to soft. Lower part contains water too salty for domestic and most industrial uses.
		Wellington Formation	500 ±	Deep-red to reddish-orange massive and cross-bedded fine-grained sandstone irregularly interbedded with red, purple, maroon, and gray shale. Base of formation not exposed in the area.	

Source: Modified from Wood and Burton, 1968

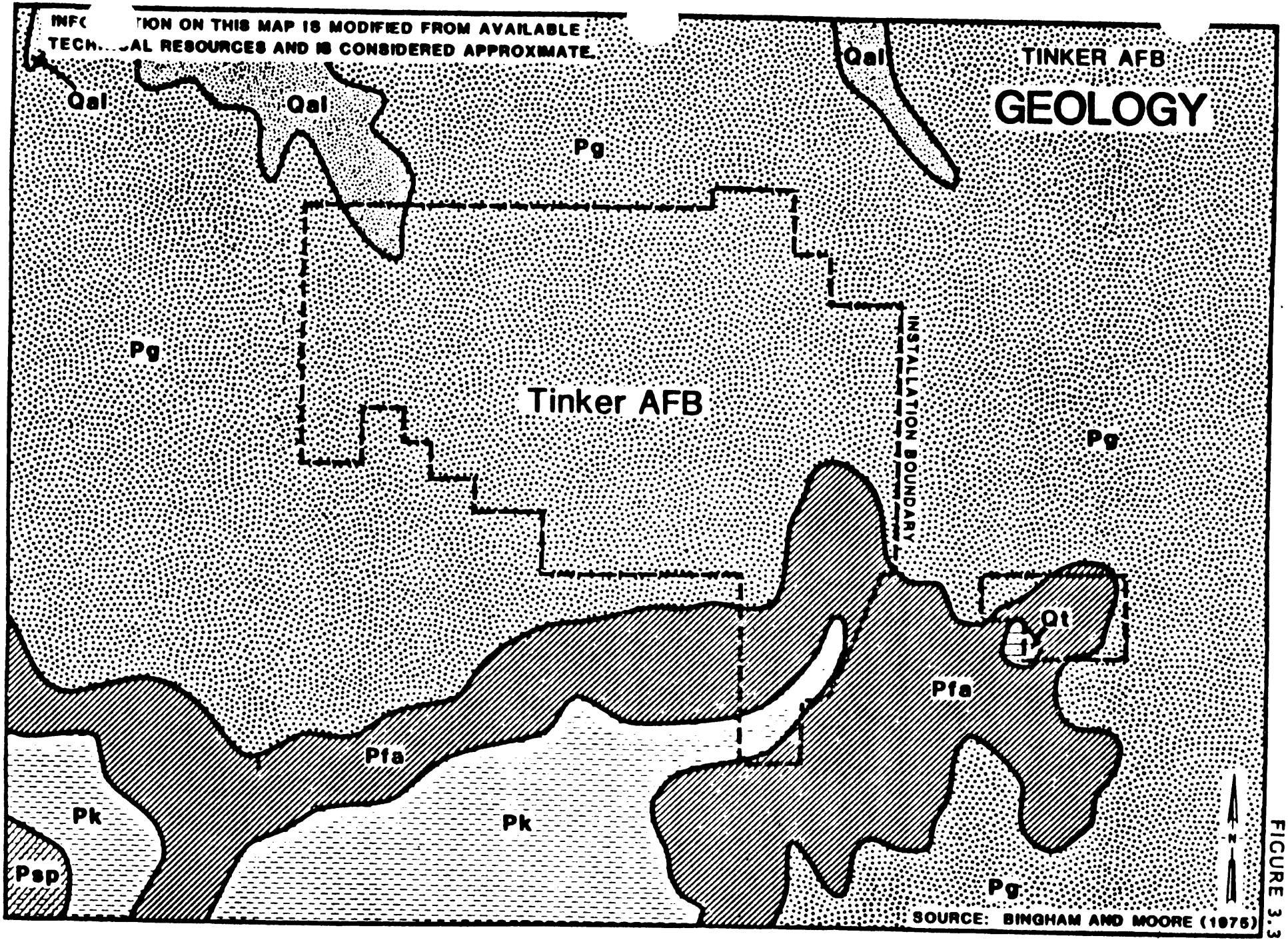

INFO TION ON THIS MAP IS MODIFIED FROM AVAILABLE
TECH AL RESOURCES AND IS CONSIDERED APPROXIMATE.
TINKER AFB
GEOLOGY
Qal
Qal
Qal
Pg
Pg
Pg
Pg
Tinker AFB
INSTALLATION BOUNDARY
Qt
Pfa
Pfa
Pk
Pk
Psp
N
SOURCE: BINGHAM AND MOORE (1975)

FIGURE 3.3

TABLE 3.4

TINKER AIR FORCE BASE GEOLOGIC UNITS (PERMIAN)

Map Symbol	Unit	Lithology	Thickness, ft.	Structure	Geomorphic Features	Remarks
Qal	Alluvium	Sand, silt, clay, gravel	5-100	varies	Floodplains, low areas near streams	Local aquifer
Qt	Terrace Deposits	Sand, silt, clay, gravel	10-100	varies	Upland areas, benches near streams	Local aquifer
Pk	Kingman	Even-bedded siltstones; some sandstone and shale	30	flat-lying	Gently rolling plains	Aquitard
Pfa	Fairmont	Blocky shale; thin sandstone interbeds	30	flat-lying	Gently rolling plains	Aquitard
Pg	Garber	Fine-grained sandstone; shale, chert and mudstone conglomerate	150-400	flat-lying	Gently rolling and broad flat plains	Major regional aquifer
Psp	Salt Plains	Blocky shale and siltstone	200	flat-lying	Not exposed	Aquiclude

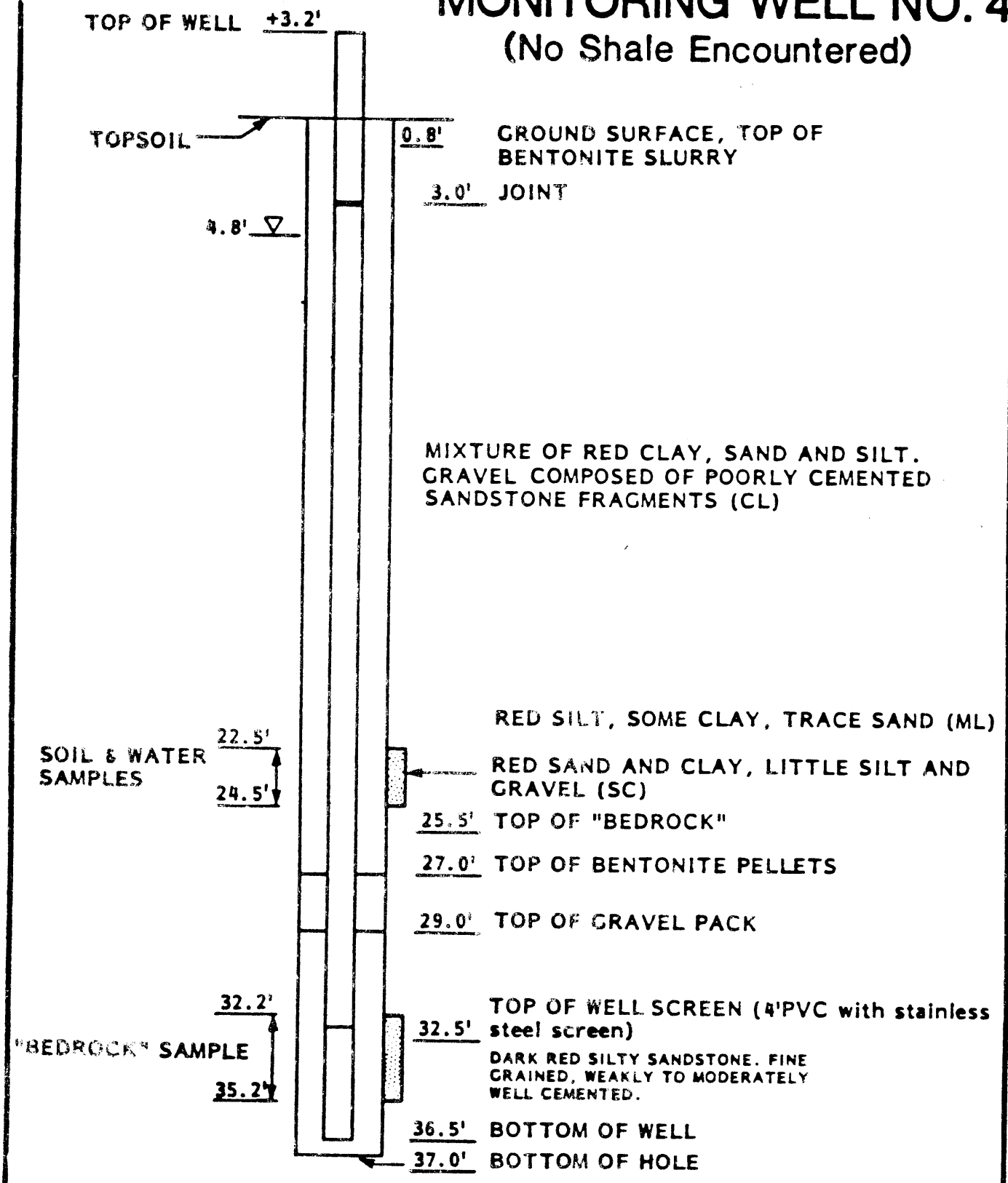
Source: Bingham and Moore (1975)
Johnson and Luza (1980)

FIGURE 3.4

TINKER AFB

MONITORING WELL NO. 4

(No Shale Encountered)

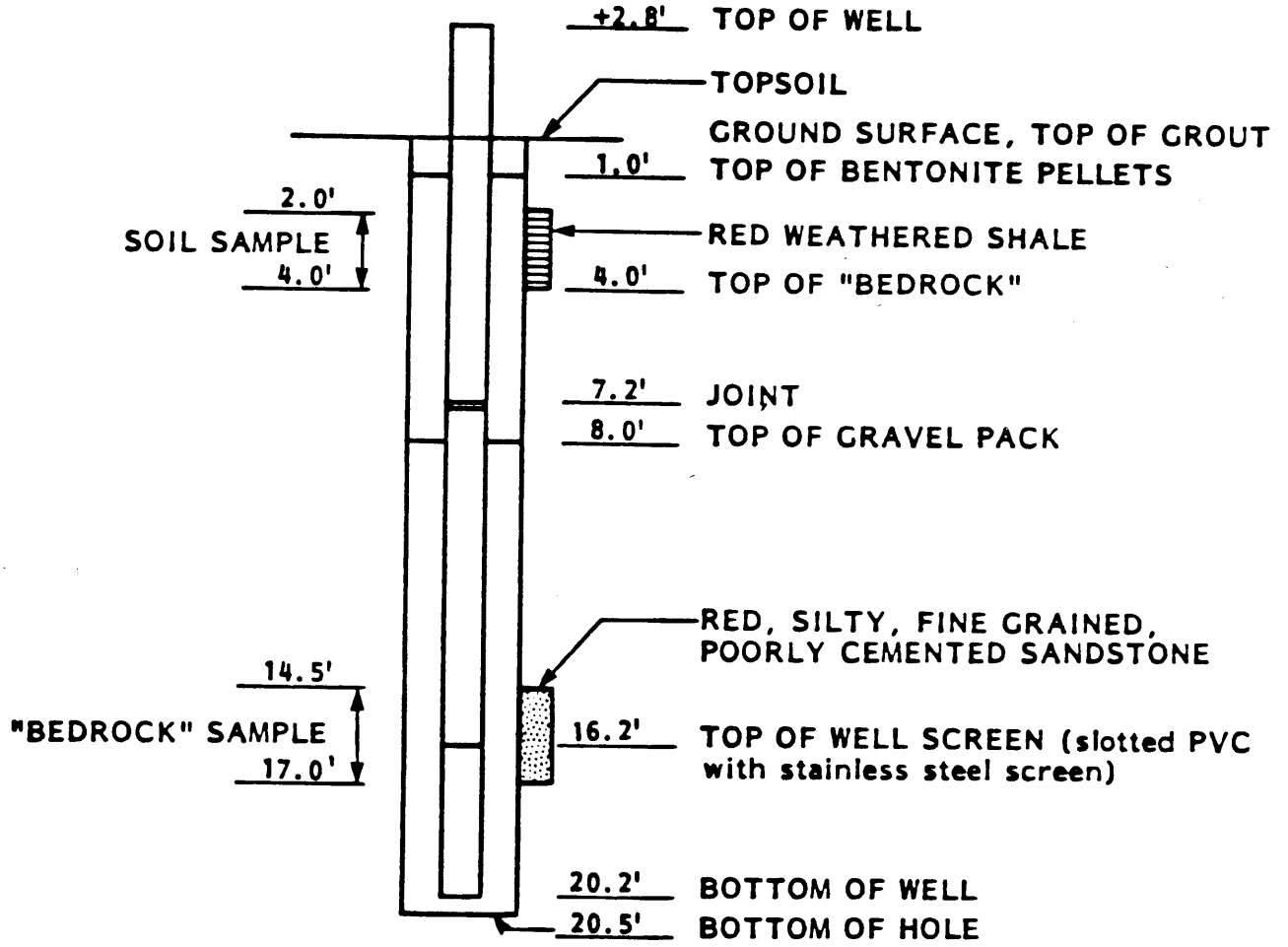


NOTE: GROUND-WATER LEVEL MEASURED AT TIME OF DRILLING AT 4.8'. THIS MAY ONLY REFLECT THE WATER LEVEL OF A NEARBY POND NOTED ON DRILLER'S LOG.

SOURCE: TINKER AFB DOCUMENTS

TINKER AFB

MONITORING WELL NO. 8
(Shale Encountered)



NOTE: DRY WELL - NO GROUND WATER ENCOUNTERED.

SOURCE: TINKER AFB DOCUMENTS

Wickersham (1979). Additional information has been obtained from interviews with officials of the Oklahoma Water Resources Board and the District Office, U.S. Geological Survey Water Resources Division and from the ground-water quality monitoring program presently being implemented at Tinker AFB.

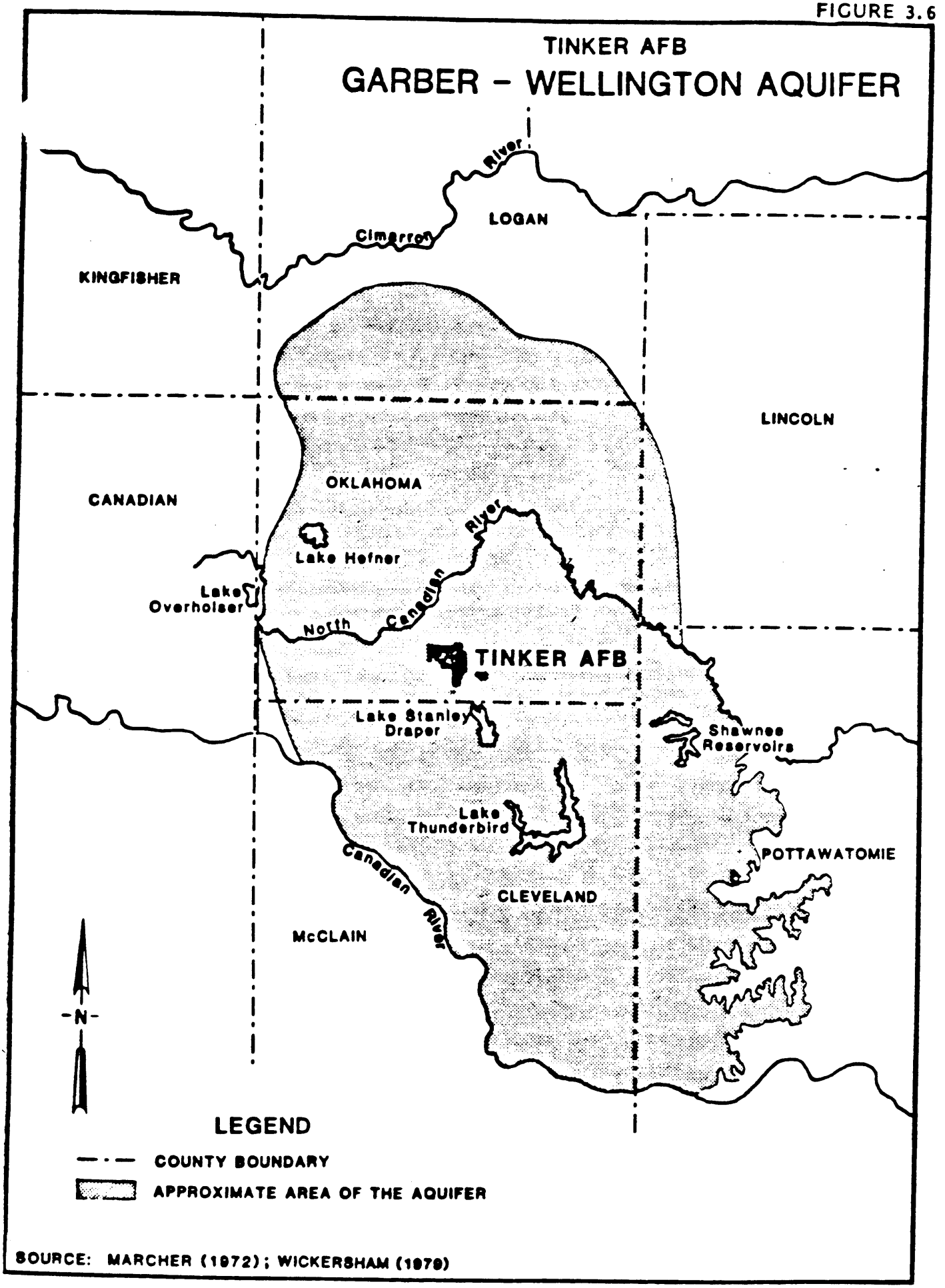
Garber-Wellington Aquifer

Tinker Air Force Base lies within the limits of the Garber-Wellington Ground-Water Basin. The Garber Sandstone and the Wellington Formation are considered to be a single aquifer and provide the most significant source of ground-water supplies in the Oklahoma City area. At the present time, Tinker Air Force Base derives most of its water supplies from this aquifer and supplements the supply by purchasing from the Oklahoma City Water Department. The nearby communities of Midwest City, and Del City derive water supplies from both surface sources and wells tapping the aquifer. Industrial operations, individual homes, farm irrigation, and small communities not served by a municipal distribution systems also depend on the Garber-Wellington Aquifer. Communities presently depending upon surface supplies such as Oklahoma City also maintain a well system drilled into the Garber-Wellington as a standby source of water in the event of drought. The aquifer area is depicted in Figure 3.6.

The Garber Sandstone and the Wellington Formation are considered to be a single aquifer as they were deposited under similar conditions and consist of lenticular beds of sandstone, siltstone and shale that tend to vary in thickness over relatively short horizontal distances (Wood and Burton, 1968). The sediments constituting the aquifer tend to be loosely cemented and have a maximum thickness of some 1,000 feet. In the area of outcrop, ground water occurs under water table (unconfined) conditions and may occur at relatively shallow depths below ground surface (100 to 150 feet). In areas overlain by younger geologic units, ground water occurs in the aquifer under artesian (confined) conditions and wells must be drilled deeper (200-250 feet) in order to encounter it (Wickersham, 1979).

The Garber-Wellington aquifer is exposed at ground surface or mantled by a thin soil over the northern two-thirds of Tinker Air Force Base. It is believed that the aquifer is overlain by a thin,

FIGURE 3.6



SOURCE: MARCHER (1972); WICKERSHAM (1979)

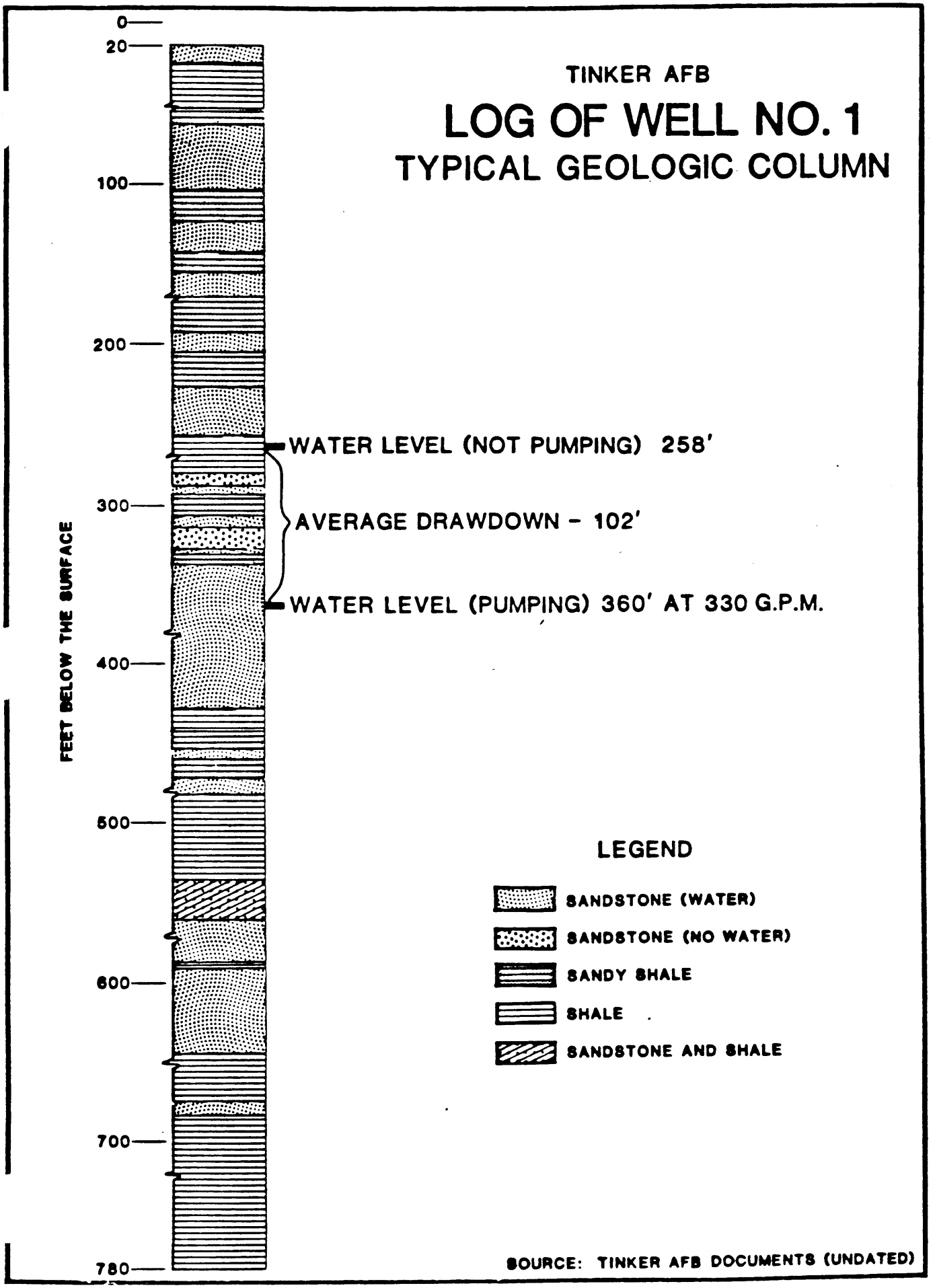
discontinuous sequence of Hennessey Group sediments (Kingman Siltstone and Fairmont Shale) over the southern portion of the base. Water in the Garber-Wellington is normally encountered at a depth of some 100 feet at Tinker Air Force Base. Figure 3.7, a Tinker AFB well log, depicts local hydrogeology. A geologic cross-section of base wells developed by Wickersham (1979) is presented as Figure 3.8. This figure graphically depicts the lenticular nature of the sandy zones. Although most of the aquifer is believed to be saturated, multiple screened wells are usually constructed in order to obtain water from the more productive zones.

Recharge of the Garber-Wellington Aquifer is accomplished principally by percolation of surface waters crossing the area of outcrop and by rainfall infiltration in this same area. Because most of Tinker Air Force Base is located in an aquifer outcrop area, it is therefore assumed that this portion of the base is situated in a recharge zone (Havens, 1981). The aquifer is susceptible to contamination in the study area. Ground-water levels and flow directions (1976 data) are presented as Figure 3.9. According to the indicated hydraulic gradients, ground-water flow at Tinker AFB is presently directed to the northwest and south.

According to Wood and Burton (1968) and Wickersham (1979), the quality of ground water derived from the Garber-Wellington Aquifer is generally good, although wide variations in the concentrations of some constituents are known to occur. Wells drilled to excessive depths may encounter a saline zone, generally greater than 900 feet below ground surface. Wells drilled to such depths or those accidentally encountering the saline zone are either grouted over the lowest screens or may be abandoned.

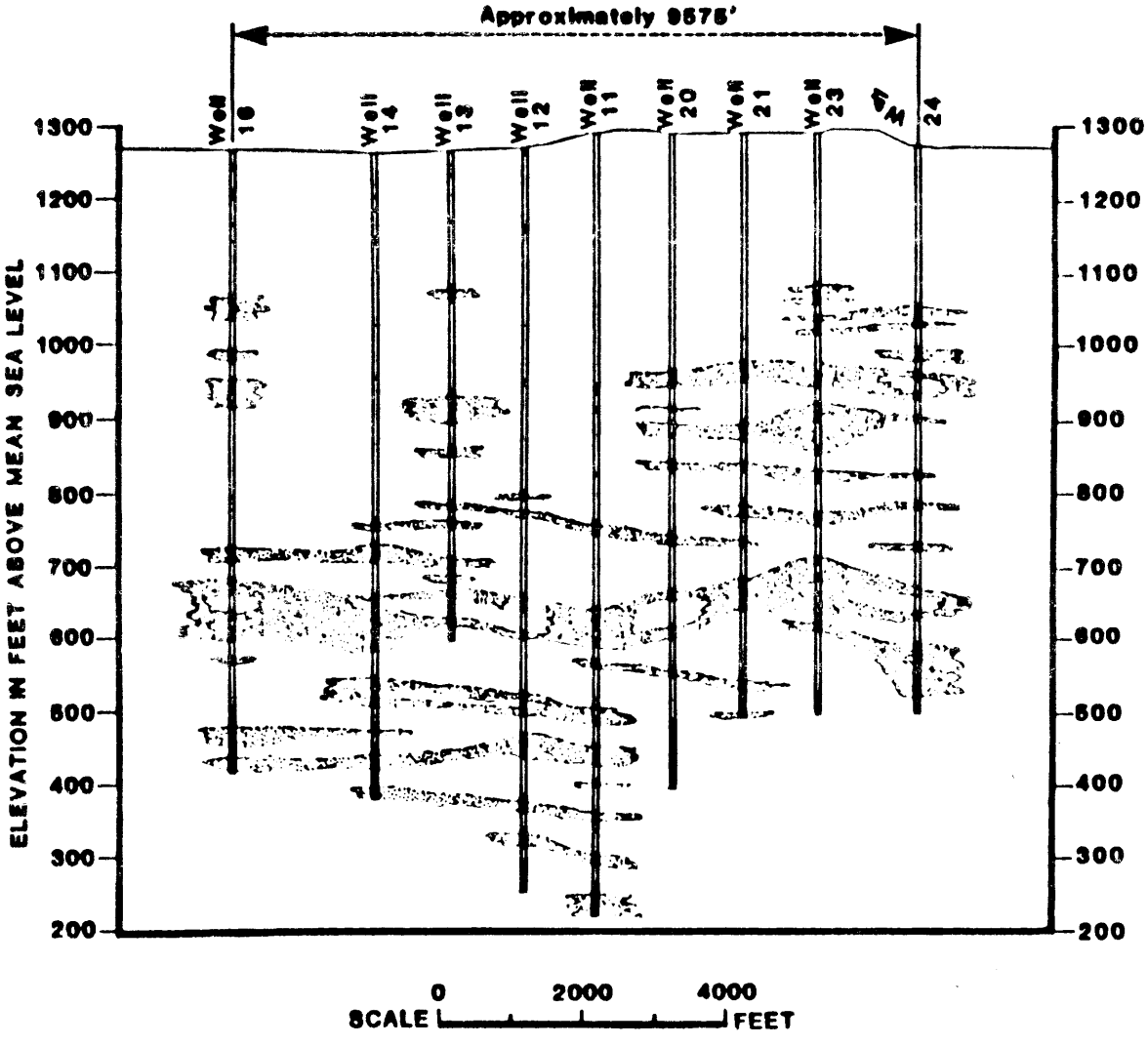
Tinker Air Force Base presently obtains its water supplies from a distribution system comprised of 27 water wells constructed along the east and west base boundaries, as shown by Figure 3.10 and by purchase from the Oklahoma City Water Department. All base wells are finished into the Garber-Wellington Aquifer. Base wells range from 700 to 900 feet in finished depth, with yields ranging from 205 to 250 gallons per minute. The wells incorporate multiple screens, deriving water supplies from sand zones that vary in thickness from 103-184 feet (Wickersham, 1979).

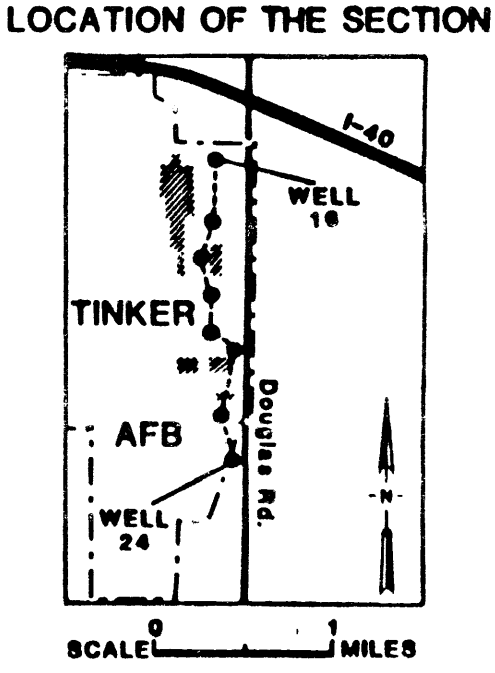
FIGURE 3.7



SOURCE: TINKER AFB DOCUMENTS (UNDATED)

GEOLOGIC SECTION OF THE GARBER-WELLINGTON AQUIFER AT TINKER AFB





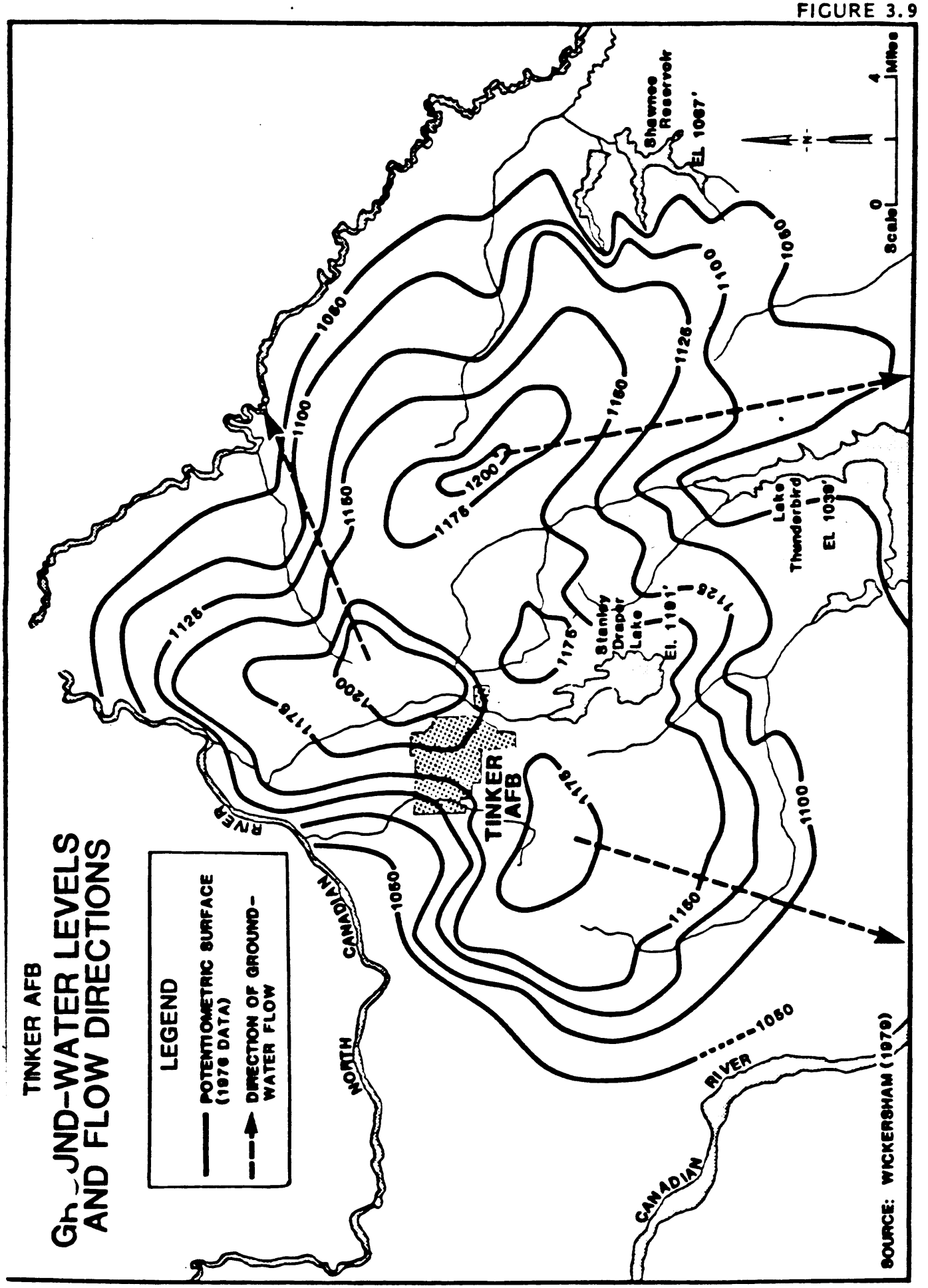
LEGEND

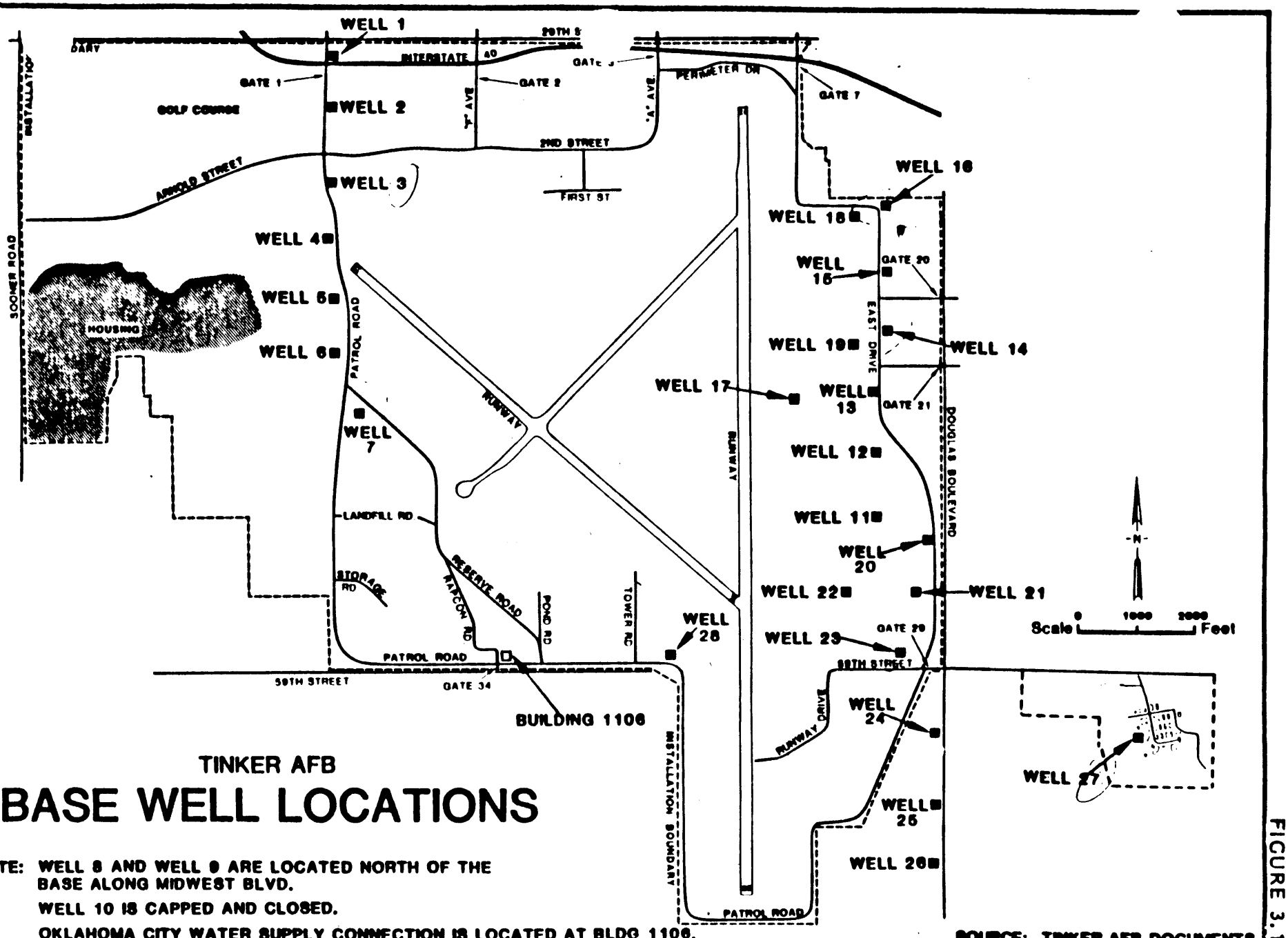
- WATER-PRODUCING ZONE (SAND)
- NONPRODUCING ZONE (SHALE/SILTSTONE)

SOURCE: WICKERSHAM (1979)

FIGURE 3.8

FIGURE 3.9


TINKER AFB
GROUND-WATER LEVELS
AND FLOW DIRECTIONS
LEGEND
POTENTIOMETRIC SURFACE (1976 DATA)
DIRECTION OF GROUND-WATER FLOW
TINKER AFB
NORTH CANADIAN RIVER
CANADIAN RIVER
Shawnee Reservoir
EL 1067'
Stanley Draper Lake
EL 1181'
Lake Thunderbird
EL 1038'
1050
1100
1125
1150
1175
1200
Scale 0 4 Miles
N
SOURCE: WICKERSHAM (1979)



TINKER AFB

BASE WELL LOCATIONS

NOTE: WELL 8 AND WELL 9 ARE LOCATED NORTH OF THE BASE ALONG MIDWEST BLVD.

WELL 10 IS CAPPED AND CLOSED.

OKLAHOMA CITY WATER SUPPLY CONNECTION IS LOCATED AT BLDG 1106.

SOURCE: TINKER AFB DOCUMENTS

FIGURE 3.10

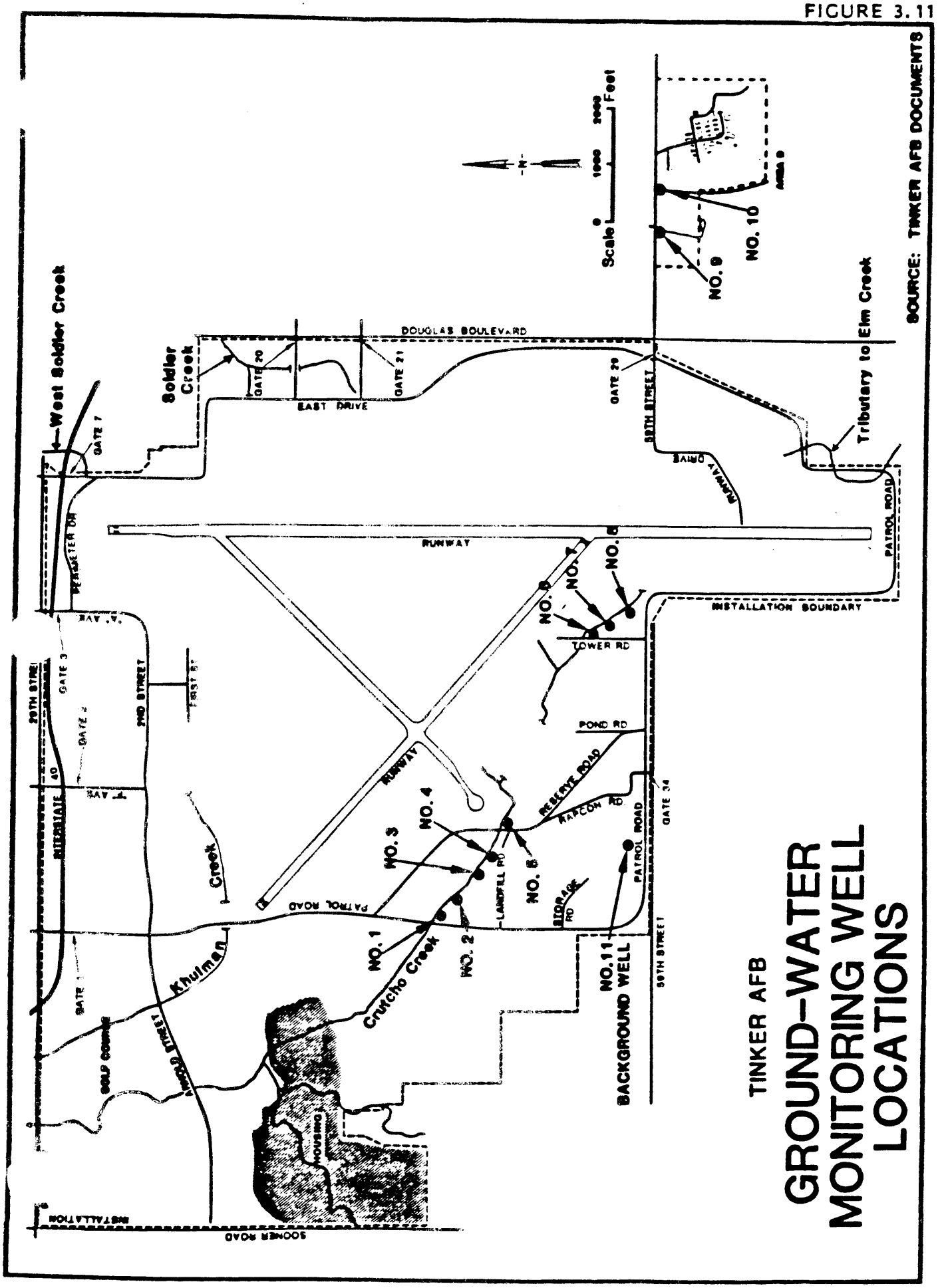
Shallow Aquifer Zones

Shallow aquifers may exist temporarily within the study area where zones of alluvium border streams or where shallow sandy residual soils may collect precipitation. At Tinker AFB, sandy residual soils overlying bedrock at shallow depths may form such an ephemeral aquifer. Soil aquifers are typically recharged directly by precipitation, gradually running dry seasonally as base flow to local streams and recharging of underlying rock aquifers deplete limited supplies. A local soil aquifer was encountered during ground-water quality monitoring recently underway at Tinker, AFB. Locations of the ground-water monitoring wells on base are shown in Figure 3.11. It is apparently perched above the Fairmont Shale at some locations and absent at others. The soil unit is moderately to highly permeable. Thickness of the soil unit varies from four to thirty feet and the depth to ground water in this unit varies from three to seventeen feet. In some cases, monitoring well logs indicated the absence of ground water in this unit. The significance of the shallow aquifer is that it may facilitate the contamination of important lower aquifers or surface waters by generation and mobilization of wastes. The shallow aquifer may not facilitate the detection of developing ground-water contamination problems because of their localized nature and ephemeral character. It is not known, to what degree if any, this aquifer communicates with base surface waters.

SURFACE WATER QUALITY

Tinker AFB has several streams and surface drainage systems which originate or flow through the base property. These streams have been monitored routinely at several locations by the base Bioenvironmental Engineering Office (BESD). In addition, special sampling studies have been conducted by the US Geological Survey, Oklahoma Water Resources Board and a student at the University of Oklahoma conducting research for his Ph.D dissertation (Frank, 1969). The on-base sampling stations are depicted on Figure 3.12 and summaries of the data evaluated are included in Appendix C. The data are discussed in the following paragraphs by sub-basins. In most instances there were no water quality limits on these surface streams in the past.

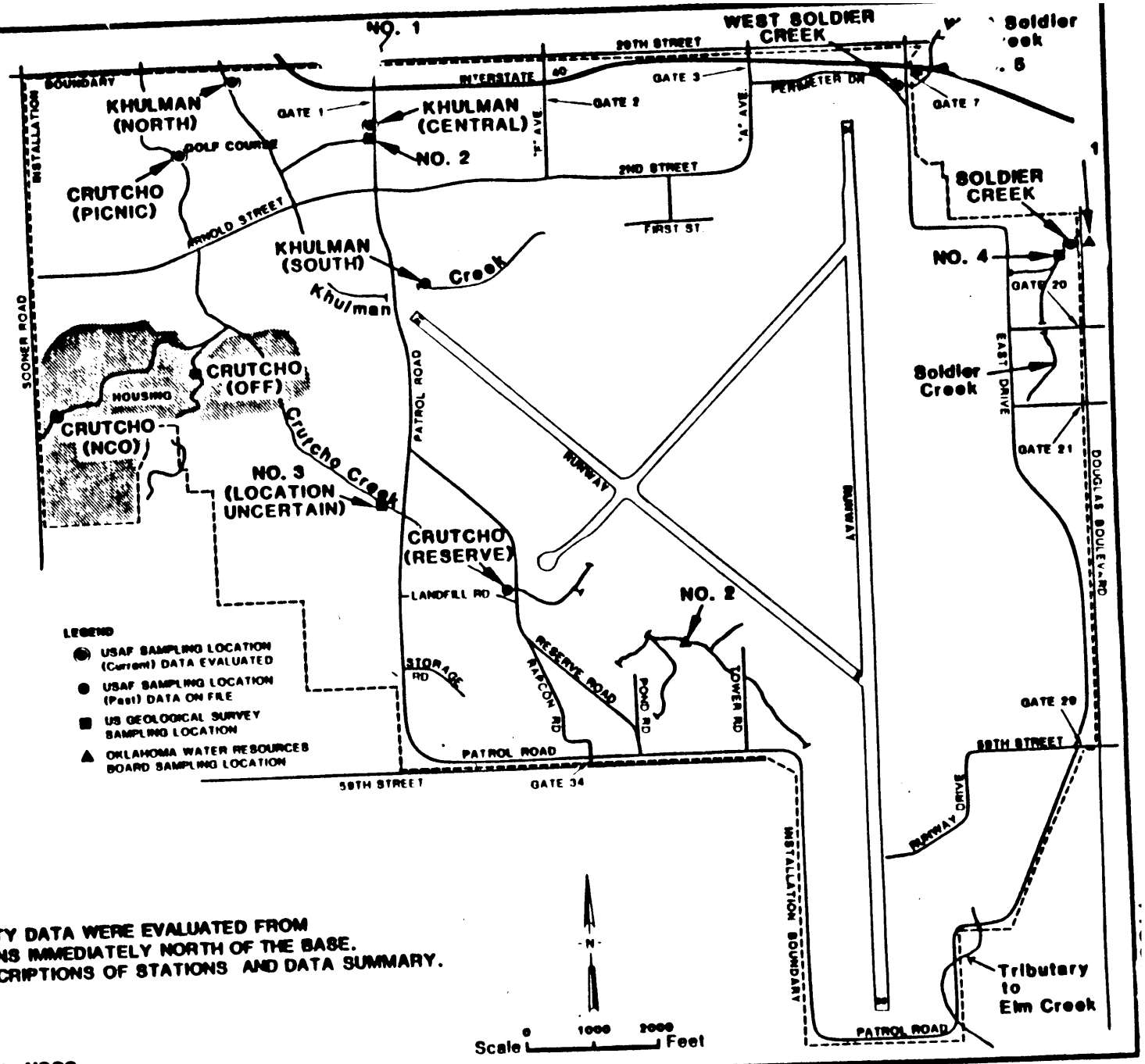
FIGURE 3.11



ES ENGINEERING-SCIENCE

TINKER AFB

WATER QUALITY SAMPLING LOCATIONS



NOTE: ADDITIONAL WATER QUALITY DATA WERE EVALUATED FROM THREE SAMPLING LOCATIONS IMMEDIATELY NORTH OF THE BASE. SEE APPENDIX C FOR DESCRIPTIONS OF STATIONS AND DATA SUMMARY.

SOURCE: TINKER AFB DOCUMENTS; USGS

Crutcho Creek and its tributaries traverse the southern and western portions of the base. The earlier water quality data evaluated (USGS data collected during 1963) revealed lead values of 45 µg/l. Data collected from Crutcho Creek in 1968 (Frank, 1969) indicated concentrations of total chromium ranging from 50 to 1,800 µg/l and concentrations of cadmium ranging from 80 to 300 µg/l. Recent data collected by the base BESD (1980) indicated the levels of chromium were typically below 50 µg/l (the detectable limit of the test procedure used). One monthly sample during 1980 did however indicate 54 µg/l of chromium. Cadmium concentrations for Crutcho Creek were consistently below 10 µg/l during 1980.

Khulman Creek originates on base from surface drainage and storm runoff and drains the north central portion of the base. The 1963 USGS data revealed chromium values of 129 µg/l and cadmium values of 26 µg/l. The 1980 data showed iron concentrations ranged from 0.12 to 3.1 mg/l and manganese concentrations ranged from <0.050 to 4.5 mg/l. On occasions, oil and grease were also detected in the 1980 samples. West Soldier Creek originates on base and drains the northeast portion of the base. The 1963 USGS data revealed high metals contamination in the creek. The cadmium concentration was in the range of 46,000 µg/l and the chromium concentration was in the range of 31,000 µg/l. Aluminum, iron manganese and nickel were also analyzed and their respective concentrations were 620, 540, 1,400 and 242 µg/l. These high metals concentrations may have originated from direct discharge of industrial wastes and industrial spillage into the stream. Since the 1963 sampling, new controls and treatment measures have been implemented on base reducing the metal concentrations in the streams. By 1968, the surface water discharge contained chromium and cadmium concentrations of 7,200 µg/l and 2,000 µg/l respectively (Frank, 1969). The 1979 BESD data indicated a significant reduction of chromium and cadmium concentrations had occurred in the creek. Occasionally elevated levels of oil and grease and phenol were detected.

Soldier Creek originates on base and drains the eastern portion of the base. The domestic and industrial wastewater treatment plants presently contribute the majority of the creek's flow. The 1963 USGS data revealed chromium concentrations of 2,950 µg/l and cadmium concentrations of 2,180 µg/l. Nickel and manganese were detected at 129 and 58 µg/l, respectively. The 1968 University of Oklahoma data detected chromium concentrations within the range of 250 to 3,400 µg/l. Cadmium ranged from 30 to 2,800 µg/l, nickel ranged from 200 to 6,500 µg/l and iron range from 0.44 to 14 mg/l. BESD data collected in 1980 detected consistently high concentrations of total chromium; however hexavalent chromium, the valence state considered to be toxic, was consistently below the primary drinking water standard (50 µg/l). Cadmium concentrations were at or below the 10 µg/l drinking water standards. Nickel was the only parameter which was consistently detected at levels higher than the recent EPA ambient water quality criterion of 13.4 µg/l.

In addition to the water quality sampling conducted on the base, in 1981, the Oklahoma Water Resources Board collected sediment samples from Soldier Creek and soil samples from Crutcho Creek. The Soldier Creek samples had high levels of chromium, nickel and cadmium. The Crutcho Creek sample was collected near the fire training area and had levels of COD, oil and grease, and lead above background levels.

SUMMARY OF ENVIRONMENTAL SETTING

The environmental setting data reviewed for this study indicate the following key items concerning the impact of past waste disposal practices on the base:

- Surficial soils at Tinker AFB are predominantly sands or silts which characteristically exhibit moderate to high permeabilities.
- The primary regional aquifer, the Garber-Wellington, is present at or near ground-surface over most of the base area. Ground water is encountered within the aquifer at moderate depth (250 feet). The upper section of the aquifer is primarily an unsaturated zone.
- Tinker AFB is located within a recharge area of the primary regional aquifer.

- The historical contamination of base surface waters and associated sediments has been documented. Stream water percolation is known to be one form of recharge to the Garber-Wellington Aquifer.
- The Tinker AFB mean annual precipitation is 32.4 inches, while lake evaporation is given at 60 inches as Tinker AFB is located in a water deficient zone of the U.S. Precipitation events releasing as much as 6.2 inches rainfall in a twenty-four hour period at Tinker AFB have been reported, causing local flooding (Weather Squadron Data).

From these conditions it may be concluded that the potential for the contamination of the major regional aquifer exists. This potential exists because recharge of aquifer occurs where rainfall directly contacts the aquifer or where streams cross the area of outcrop. The aquifer is exposed at Tinker AFB and is therefore vulnerable to contamination at the base. Contaminant transport would primarily result from heavy rainfall events causing rapid overland flow and localized flooding. Contaminants would be expected to infiltrate through the unsaturated position of the aquifer with recharging meteoric waters, eventually reaching the ground-water reservoir.

CHAPTER 4

FINDINGS

CHAPTER 4

FINDINGS

To assess hazardous waste management at Tinker Air Force Base, waste generation and disposal methods were reviewed. This chapter summarizes the hazardous waste generated by activity, describes waste disposal methods, identifies the disposal sites located on the base and evaluates the potential for contaminant migration. Figure 4.1 presents the decision tree methodology used in the review of waste practices. The methodology provides a logical algorithm for the consistent evaluation of all base practices.

PAST SHOP AND BASE ACTIVITY REVIEW

To identify past base activities that resulted in generation and disposal of hazardous waste, a review was conducted of current and past waste generation and disposal methods. This review consisted of interviews with base employees, a search of files and records, and site inspections.

The sources of most hazardous waste that are generated on Tinker AFB can be associated with one of the following activities:

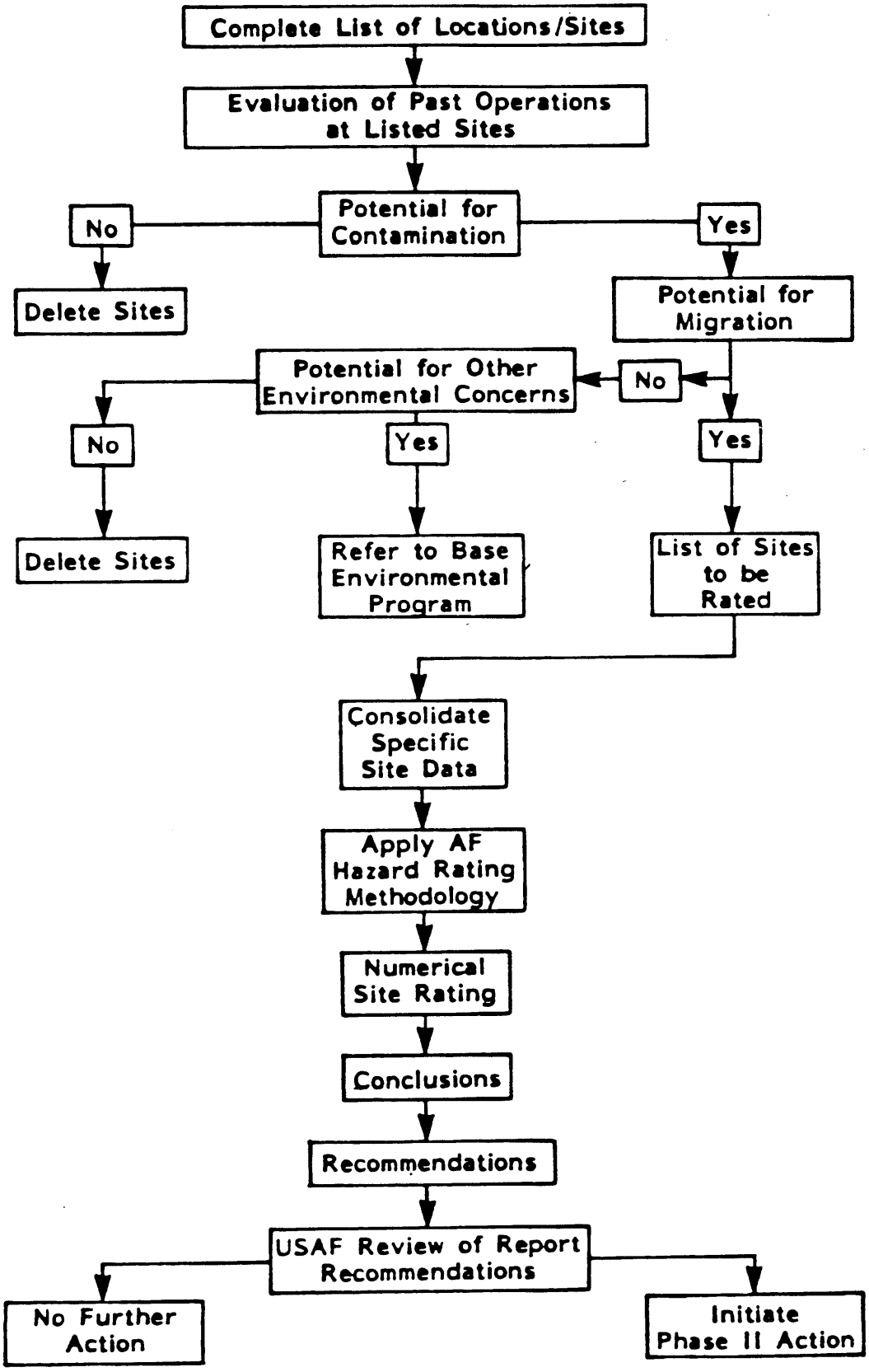
- Industrial shops
- Fire control training
- Pesticide utilization
- Fuels management
- Industrial Waste Treatment

The following discussion addresses only those wastes generated on base which are either hazardous or potentially hazardous. In this discussion a hazardous waste is defined as hazardous by the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) or by the Tinker AFB documents which have been reviewed. A potentially hazardous waste is one which is suspected of being hazardous although insufficient data are available to fully characterize the waste material.

FIGURE 4.1

PHASE I INSTALLATION RESTORATION PROGRAM

DECISION TREE



Industrial Shops

The industrial operations at Tinker AFB can be divided into two major groups as follows: The Directorate of Maintenance and other base maintenance support activities. The Directorate of Maintenance provides facilities for servicing and repairing various types of aircraft and jet engines. Five major divisions embody most of the shop activities for the Directorate of Maintenance. The divisions include the Aircraft Division, Plant Management Division, Propulsion Division, Quality Division and Accessories Division. The greatest quantity of waste materials generated at Tinker AFB were from the Directorate of Maintenance areas.

Other base maintenance support activities are the industrial shops from the Directorate of Distribution, the 2854 Air Base Group, the 2854 Civil Engineering Squadron, the 3rd Combat Communications Group, the 6th Weather Squadron, the 507 Tactical Fighter Group and the 552 Aircraft Warning and Control Wing. These industrial operations include primarily vehicle, electrical and aircraft maintenance and repair.

To assess those shops which handle hazardous materials and/or generate hazardous waste, a review was made of the Bioenvironmental Engineering Office shop files. The results of this file review are shown in Appendix D, Master List of Industrial Shops.

Following the compilation of a master list of industrial shops, personnel within the Directorate of Maintenance and other base maintenance support functions were interviewed. A timeline of disposal methods was established for major waste generated. The information from the interviews with base personnel is summarized in Table 4.1. This table shows the building locations as well as the waste material names, waste quantities, and disposal method timeline.

TABLE 4.1

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY (1)	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 – 1960 – 1970 – 1980)
DIRECTORATE OF MAINTENANCE				
THE FOLLOWING PETROLEUM WASTE ITEMS HAVE BEEN CONSOLIDATED FOR ALL DIVISION SHOPS	NA	RECLAIMABLE WASTE OIL	22,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
		RECLAIMABLE WASTE FUEL	30,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
		WASTE FUELS AND FLUIDS	250,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
		WASTE CALIBRATION FLUID	140,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
		CHLORINATED SOLVENTS (2)	15,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
AIRCRAFT DIVISION				
COMPOSITE - ALL SHOPS	2122, 2280 3001	PAINT STRIPPER, PHENOLIC	400 GALS./DAY	STORM SEWERS → DISCHARGE TO IWTP (3)
		METHYL ETHYL KETONE (MEK)	55 GALS./DAY	INDUSTRIAL WASTE PITS → DRUMMED TO MADE (4) CONTRACTOR
		PAINT STRIPPER SLUDGES	150 GALS./DAY	INDUSTRIAL WASTE PITS → DRUMMED TO MADE CONTRACTOR
PROPULSION DIVISION				
ELECTROPLATING AREAS	3001	CHROME PLATING WASTES	30,000 GALS./YR.	INDUSTRIAL WASTE PITS → ON-BASE IWTP OR OFF-BASE MADE CONTRACTOR (5)
		ALKALINE-CYANIDE WASTES	37,300 GALS./YR.	INDUSTRIAL WASTE PITS → ON-BASE IWTP OR OFF BASE MADE CONTRACTOR
		MIXED WASTE ACIDS	77,000 GALS./YR.	INDUSTRIAL WASTE PITS → IWTP OR MADE CONTRACTOR
		VARIOUS PLATING SOLUTIONS	2,000 GALS./YR.	INDUSTRIAL WASTE PITS → MADE CONTRACTOR
		PERCHLOROETHYLENE/WAX	7,300 GALS./YR.	INDUSTRIAL WASTE PITS → MADE CONTRACTOR
		CONTAMINATED VAT RIM HOODS	150 DRUMS/YR.	1950 BASE LANDFILLS → MADE CONTRACTOR
CLEANING AREAS	3001	CARBON REMOVER (6)	18,900 GALS./YR.	INDUSTRIAL WASTE PIT 1955 → IWTP OR MADE CONTRACTOR
		ALKALINE CLEANERS	22,400 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		CHROMIC/PHOSPHORIC ACID	3,500 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

(1) BASED ON CURRENT RATES AND BEST ESTIMATES OF PAST RATES. PAST RATES ARE ESTIMATED TO BE BETWEEN 40% AND 70% OF VALUES SHOWN.

(2) INCLUDING TRICHLOROETHANE, PERCHLOROETHYLENE AND FREON.

(3) IWTP - INDUSTRIAL WASTE TREATMENT PLANT.

(4) MADE - PLANT MANAGEMENT DIVISION OFFICE SYMBOLS, RESPONSIBLE FOR DISPOSAL CONTRACTORS.

(5) INDICATES A CHOICE IS MADE BY "MADE" TO EITHER TREAT THE WASTES ON BASE AT THE IWT FACILITY OR OBTAIN AN OFF BASE CONTRACTOR TO TRANSPORT AND DISPOSE OF THE WASTE.

(6) CONTAINS ORTHO DICHLOROBENZENE AND CRESYLIC ACID.

TABL (cont'd.)

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 – 1960 – 1970 – 1980)
PROPULSION DIVISION (cont'd.)				
CLEANING AREAS (cont'd.)	3001	RUBBER REMOVER	1,100 GALS./YR.	1976 → MADE CONTRACTOR
		PHOSPHORIC ACID	95,000 GALS./YR.	INDUSTRIAL WASTE PIT → IWTP OR MADE CONTRACTOR
		HOT TANK STRIPPER	5,000 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		EMULSION CLEANER	5,000 GALS./YR.	1976 → MADE CONTRACTOR
		NITRIC/HYDROFLUORIC ACID	1,000 GALS./YR.	INDUSTRIAL WASTE PIT → IWTP OR MADE CONTRACTOR
		PERCHLOROETHYLENE WASTES	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
NON-DESTRUCTIVE INSPECTION	3001	PENETRANT	1,800 GALS./YR.	INDUSTRIAL WASTE PIT 1955 → MADE CONTRACTOR
		DEVELOPER	1,500 GALS./YR.	INDUSTRIAL WASTE PIT 1955 → MADE CONTRACTOR
		EMULSIFIER	16,300 GALS./YR	INDUSTRIAL WASTE PIT 1955 → IWTP OR MADE CONTRACTOR
PAINT AREAS	3001	THINNERS	1,700 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		WASTE PAINTS	7,000 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		ACETONE	1,375 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
MACHINE SHOP AREAS	3001	COOLANT OIL	80,000 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		MAGNESIUM THORIUM	600 LBS./YR.	NEVADA AEC DISPOSAL SITE 1968 – 1975
ACCESSORIES DIVISION				
COMPOSITE - ALL SHOPS	229, 230, 3001, 3113	CARBON REMOVER[6]	2,100 GALS./YR.	INDUSTRIAL WASTE PIT → IWTP OR MADE CONTRACTOR
		ALKALINE CLEANERS	5,600 GALS./YR.	INDUSTRIAL WASTE PIT → IWTP OR MADE CONTRACTOR

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

TABLE 4.1 (cont'd.)

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 1960 1970 1980)
ACCESSORIES DIVISION (cont'd.)				
COMPOSITE - ALL SHOPS (cont'd.)	229, 230, 3001, 3113	PERCHLOROETHYLENE	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		TRICHLOROETHANE	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		FREON	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		PAINT WASTES	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		THINNERS	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		STRIPPERS, PHENOLIC	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → IWTP OR MADE CONTRACTOR
		COOLANT OIL	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
MERCURY SHOP	230	MERCURY CONTAMINATED WASTES & FILTERS	5 LBS./2 MOS.	UNKNOWN (1950) → FORT McCELLAN RECOVERY → DPDO
2854 AIR BASE GROUP				
PHOTO LAB	1	FIXER SOLUTIONS	300 GALS./5 MOS.	SILVER RECOVERY THROUGH DPDO (1953) → IN-HOUSE SILVER RECOVERY
		OTHER PHOTOGRAPHIC SOLNS.	50 GALS./MO.	DISCHARGE TO SANITARY SEWER (1953)
VEHICLE TRANSPORTATION DIVISION	2101	WASTE OILS	300 GALS./MO.	INDUSTRIAL WASTE PIT → DRUMMED TO CES CONTRACTOR
		WASTE FUELS	100 GALS./MO.	INDUSTRIAL WASTE PIT → PUMP OUT TO CES CONTRACTOR
		O/W[7] SEPARATOR SLUDGE	20 GALS./MO.	INDUSTRIAL WASTE PIT → PUMP OUT TO CES CONTRACTOR
2854 CIVIL ENGINEERING SQUADRON (CES)				
LIQUID FUEL SYSTEMS MAINTENANCE	206	FUEL STORAGE TANK SLUDGE	90 GALS./YR.	TANK SLUDGE SPREAD AREA → DRUMMED TO CES CONTRACTOR
ENTOMOLOGY UNIT	773	SPRAYER RINSE WATER	300 GALS./MO.	DISCHARGE TO STORM SEWER (1950) → DRUMMED TO CES CONTRACTOR
		METAL RINSED CONTAINERS (5 GALS.)	5 EA./MO.	ON-BASE LANDFILL (1950) → DPDO

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

[7] O/W: OIL/WATER

TABLE 4.1 (cont'd.)

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 1960 1970 1980)
3 COMBAT COMMUNICATIONS GROUP (CCG)				
VEHICLE MAINTENANCE	1001	WASTE OIL	300 GALS./WK.	INDUSTRIAL WASTE PIT → DRUMMED TO CES CONTRACTOR (1955)
6 WEATHER SQUADRON				
VEHICLE MAINTENANCE	2101	WASTE OILS, PAINT THINNERS	110 GALS./YR.	INDUSTRIAL WASTE PIT → DRUMMED TO CES CONTRACTOR (1955)
		CLEANING SOLVENTS	110 GALS./YR.	INDUSTRIAL WASTE PIT → DRUMMED TO CES CONTRACTOR (1955)
507 TACTICAL FIGHTER GROUP (TFG)				
THE PETROLEUM PRODUCTS LISTED AT RIGHT ARE CONSOLIDATED FOR ALL SHOPS.	1030, 1041, 1070	RESALABLE JET FUEL	1,000 GALS./MO.	DRUMMED TO DPDO (1957)
		WASTE JET FUEL	100 GALS./MO.	ON-BASE LANDFILL → PUMP OUT TO CES CONTRACTOR (1957)
		SYNTHETIC OILS	16 GALS./MO.	ON-BASE LANDFILL → PUMP OUT TO CES CONTRACTOR (1957)
		HYDRAULIC FLUID ON RAGS, etc.	55 GALS./YR.	ON-BASE LANDFILL → CITY LANDFILL (1957)
CORROSION CONTROL	1030	PAINT THINNERS, MEK	55 GALS./90 DAYS	ON-BASE LANDFILLS (1957) → DRUMMED TO DPDO
NON-DESTRUCTIVE INSPECTION (NDI)	1030	PENETRANT	55 GALS./YR.	(NO NDI FUNCTION) 1972 → DPDO
		DEVELOPER	55 GALS./YR.	(NO NDI FUNCTION) 1972 → DPDO
		HYPOPHOTOGRAPHIC SOLUTION	55 GALS./YR.	(NO NDI FUNCTION) 1972 → DPDO
ARMAMENT/GUN SHOP	1030	PD-680	55 GALS./YR.	ON-BASE LANDFILL → PUMP OUT TO CES CONTRACTOR (1957)

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

TABLE . (cont'd.)

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1965 / 1970 / 1975 / 1980)
552 AIRCRAFT WARNING & CONTROL WING (AWACW)				
AIRCRAFT GENERATION SQUADRON (AGS)				
E3A & C135 AIRCRAFT MAINT. UNITS	230	WASTE OILS, FUELS, FLUIDS	400 GALS./MO.	DRUMMED TO CES CONTRACTOR → 1977
COMPONENT REPAIR SQUADRON (CRS)				
CORROSION CONTROL	289	SEPARATOR WASTE SLUDGE	50 GALS./MO.	PUMP OUT TO CES CONTRACTOR → 1977
		PAINT STRIPPERS	20 GALS./WK.	IWTP → 1977
		SOLVENTS, THINNERS	55 GALS./3 MOS.	DRUMMED TO ON BASE STORAGE[8] → 1977
FUEL CELL SECTION	230	WASTE JET FUELS	20 GALS./MO.	DRUMMED TO CES CONTRACTOR → 1977
AIRCRAFT GROUND EQUIPMENT BRANCH	228	WASTE OILS, PD-680, HYDRAULIC FLUIDS, SOLVENTS	100 GALS./WK.	DRUMMED TO CES CONTRACTOR → 1977
		SEPARATOR WASTE SLUDGE	30 GALS./MO.	PUMP OUT TO CES CONTRACTOR → 1977

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

[8] ON-BASE STORAGE OF HAZARDOUS WASTES IS PROVIDED AT THE OLD WASTEWATER TREATMENT PLANT PENDING FINAL DISPOSAL OFF BASE

Many wastes generated from industrial operations were disposed of in waste disposal pits located south of Building 2121 from 1947 to 1965. These waste included: phenols, plating wastes, acids, and cyanide waste. When the waste disposal pits were closed, Civil Engineering Squadron (CES) began providing contractor pickup and disposal for waste materials off-base. In 1969 the Directorate of Maintenance began arranging for outside contractor pickup of waste materials from their shops and divisions. At this point the Civil Engineering Squadron provided outside contractor waste pickup and disposal only for on-base tenant Air Force units.

Fire Protection Training

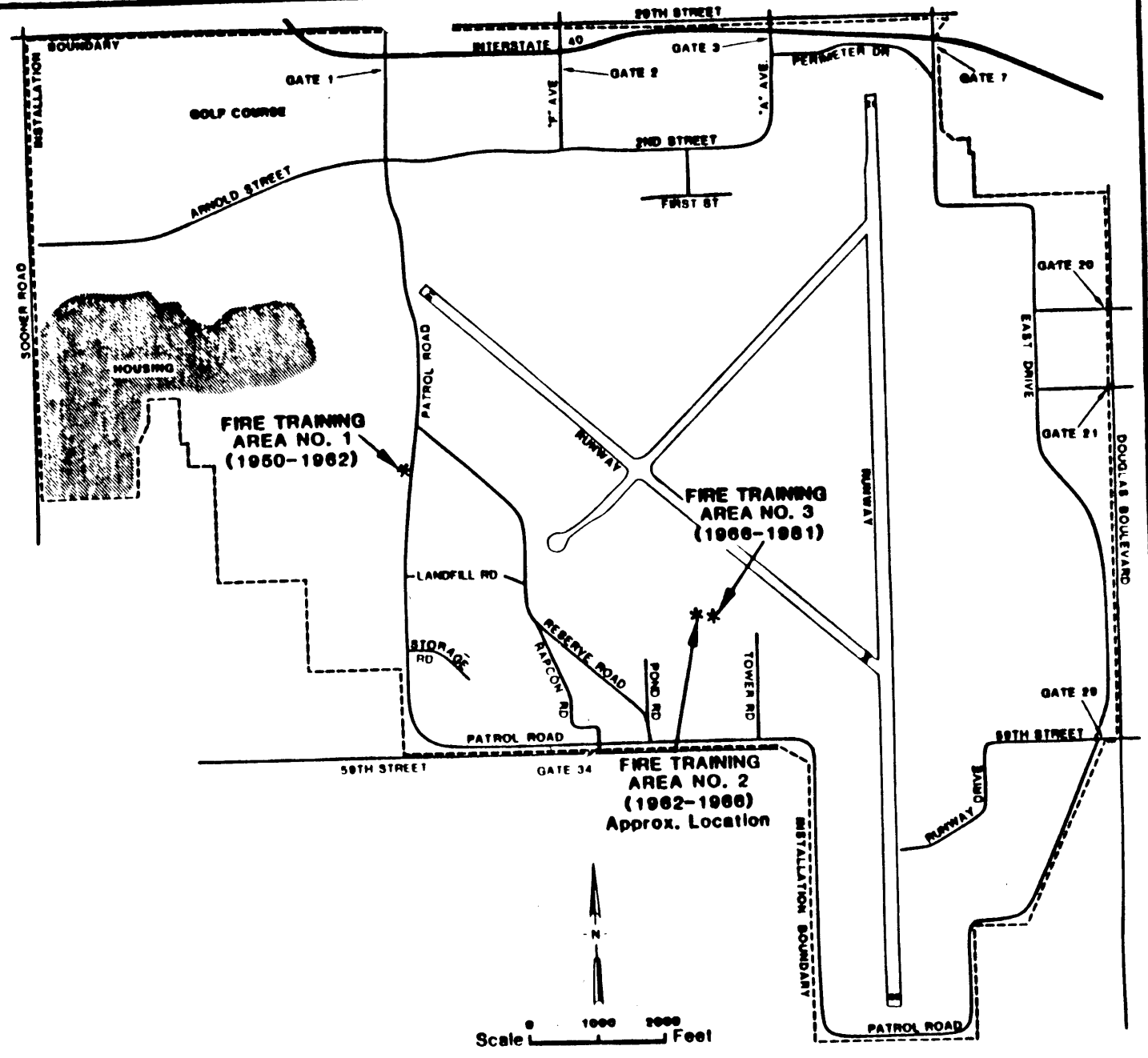
Fire Protection Training (FPT) activities of the Fire Department on Tinker AFB commenced about 1950. Since that time, three Fire Training Areas (FTA) have been utilized, as shown on Figures 4.2.

FTA No. 1 was located directly south of the abandoned wastewater treatment facility, north of Crutcho Creek, and west of Air Depot Boulevard as shown on Figure 4.3. The training pit was diked and had a gravel bottom, but was unlined. FPT activities were conducted from approximately 1950 to 1962 at this location, with the heaviest usage occurring in the early 1950's. The procedure was to first add water to the pit to saturate the soil and reduce infiltration and then fuel was added on top of the water. Although fuel oil was often burned in the fire training practice, sometimes the operation included the burning of waste material from 55-gallon drums. No information is available concerning the types of materials contained in these drums; however, it is likely that materials such as solvents and waste oils were consumed in FTA No. 1. After waste materials and/or fuel were added to the pit, it was ignited and then extinguished with water and/or a protein-based foam. The residual mixture remaining in the pit would evaporate or infiltrate into the soil prior to the next training exercise.

After closure of FTA No. 1, fire control training activities were conducted in a temporary pit (FTA No. 2) located several hundred feet west of the present site, as shown on Figure 4.4. The training pit, diked but unlined, was used infrequently between 1962 and 1966. The practice of disposing of drummed waste in the fire training area was discontinued at this time. Fuel was brought in by tank truck, ignited

TINKER AFB

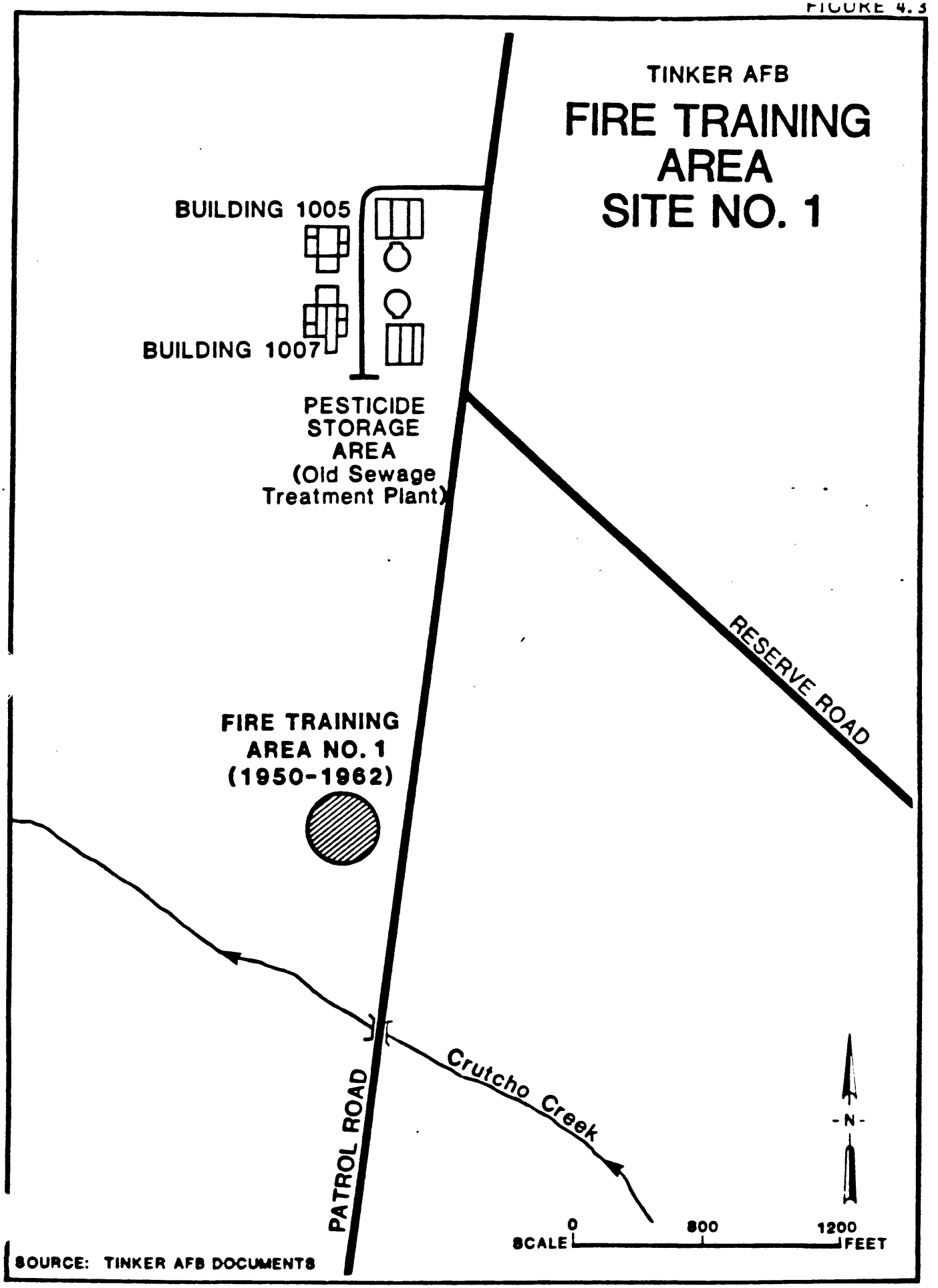
FIRE TRAINING AREAS



SOURCE: TINKER AFB DOCUMENTS

FIGURE 4.2

FIGURE 4.3



SOURCE: TINKER AFB DOCUMENTS

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and extinguished in the training pit in the same location. The residue was left in the pit to evaporate and infiltrate prior to the next exercise.

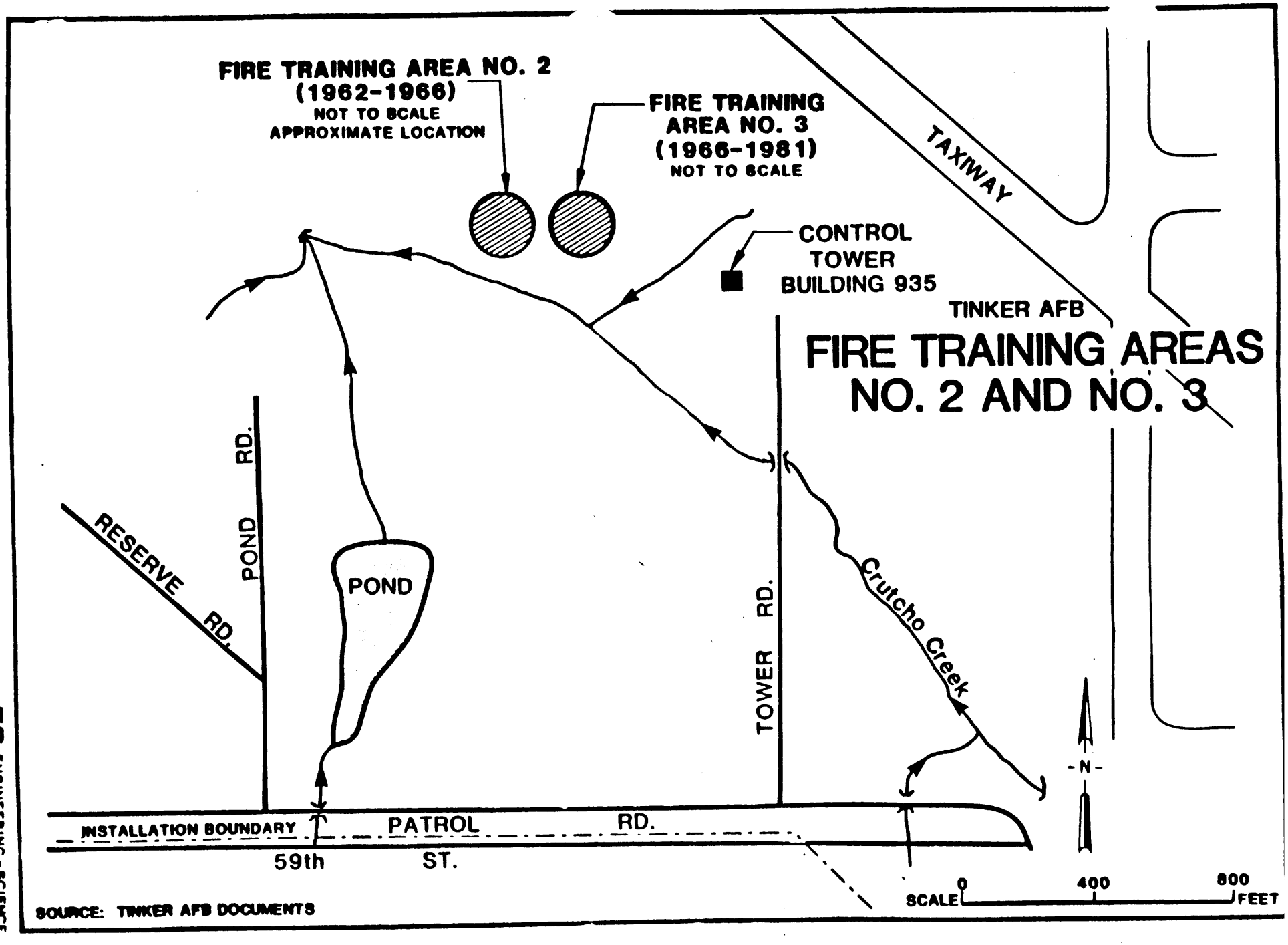
The Fire Department conducts training activities in FTA No. 3 located in the south central portion of the base, as shown on Figure 4.4. This site operated from 1966 to 1981. The training pit was unlined prior to the summer of 1981. The pit is presently being replaced with a concrete-lined training pit in the same location. Prior to training exercises, water was added to the pit to minimize infiltration. Both contaminated and uncontaminated JP-4 fuel have been used at this site. Approximately 600 to 700 gallons of fuel are used during a typical training exercise. After ignition, the fire is extinguished with water and a protein based foam. Training exercises occured only twice during 1979 and about once per month during 1980.

Although diked, overflow from FTA No. 3 had entered Crutcho Creek, according to a 1981 NPDES Compliance Inspection by the Oklahoma Water Resources Board. An area of dead vegetation was noted in the runoff path from the pit to West Crutcho Creek, and soil samples indicated high concentrations of COD and oil and grease were present. The base personnel implemented an excavation project to remove contaminated soil in the area of this training pit prior to constructing a new concrete lined facility as a result of the inspection and soil samples. Contaminated soil was also removed from the area between the pit and Crutcho Creek.

Pesticide Utilization

The pesticide program on Tinker AFB began in the early 1950's. Initially, the Entomology Shop conducted the insecticide program and the Grounds and Pavements Shop managed the herbicide program. In 1979, the Grounds and Pavements Shop transferred the responsibilities of the herbicide program to the Entomology Shop. Both shops are presently located in Building 773. Since 1975, all chemicals have been stored and mixed at the old domestic wastewater treatment plant along Air Depot Boulevard as shown in Figure 4.3. Both large truck-mounted sprayers and hand held sprayers are utilized. A variety of pest and weed control chemicals are used throughout the year.

The Entomology Shop personnel interviewed stated that poor quality chemicals are returned to the manufacturing company for disposal. Some



SOURCE: TINKER AFB DOCUMENTS

off-specification chemicals may have been disposed in the landfills during the 1950's and early 1960's.

Prior to 1975, there were no procedures for collecting rinse water. All cleaning water was allowed to run off to areas adjacent to Building 773, which eventually drains to Khulman Creek. Since 1975, batches of spray equipment rinse water have been drained into an underground storage tank. The rinse water has been pumped from the underground tank approximately once a month by a contractor for off-base disposal.

Prior to 1971, pesticide containers were usually single rinsed, mashed and disposed with the base refuse in the base landfills which were in use. In 1971, the base started a procedure for triple rinsing the pesticide containers and collecting the rinse water in an underground tank. The containers were either punched with holes, crushed or cut up prior to their disposal with general base refuse. Beginning approximately 1978, all metal pesticide containers were taken to DPDO for disposal.

Fuels Management

Numerous aboveground and underground storage tanks are contained in the fuels management system at Tinker AFB. Avgas, mogas, alcohol, fuel oil, diesel, solvents, lube oil, JP-4, and JP-5 are all used on base. The fuel used in the greatest quantities is JP-4 at approximately 5,500,000 gallons per month. Two large storage tanks, for JP-4 and for fuel oil are located in the central base area. Many smaller storage tanks are located throughout the base. A summary of storage capacities for fuels and other products compiled from the base Spill Prevention, Control and Countermeasures (SPCC) Plan is shown in Table 4.2.

A pipeline between the central and east base areas has been used to transfer fuels. The pipeline was periodically pressure tested to identify leakage. Underground tanks were also tested for leakage by monitoring tank levels over a 48-hour period. Most aboveground tanks on base are diked or have other spill control measures.

Fuel spills occur periodically on base. A majority of these are minor spills on the order of several gallons per incident. Spill records from late 1978 to 1981 were reviewed to identify significant spills (defined as greater than 1000 gallons). Four significant spills were identified during this time period. Summary information on these

TABLE 4.2

TINKER AIR FORCE BASE FUELS STORAGE

Product	Number of Tanks	Max. Tank Vol. (gals.)	Min Tank Vol (gals.)	Approx. Storage (gals.)
JP-4, JP-5	35	2,314,000	1,000	5,094,400
Alcohol	1	25,000	25,000	25,000
Avgas	8	25,000	25,000	200,000
Mogas	13	18,000	4,000	145,000
Diesel	9	50,000	2,400	129,200
Solvents and Lube Oil & Calibration Fluid	15	18,000	1,300	128,500
Fuel Oil	10	1,050,000	12,850	1,436,600
Waste Oil/JP-4	4	12,000	12,000	48,000
Calibration Fluid	1	30,000	30,000	30,000

Source: Tinker AFB Documents

spills appears in Table 4.3. Reference was also found to a chemical spill in Crutcho Creek on March 22, 1981, although the magnitude of the spill was undetermined. Records of spills prior to 1978 could not be located, although long-time base personnel did not remember any major spills occurring in previous years.

The major waste items from fuels management area are used fuel line filters and tank bottom sludge. The used filters have been disposed as general refuse, and are eventually buried in the sanitary landfills. Sludge residue accumulates as tank bottoms in leaded fuel storage tanks. At Tinker AFB, leaded tank bottoms were weathered in a small area on top of landfill No. 4. This practice was discontinued in 1977. Since that time, leaded sludges have been handled by contractor disposal.

DESCRIPTION OF PAST ON-SITE DISPOSAL METHODS

The on-site facilities which have been used for management and disposal of waste can be categorized as follows:

- Landfills
- Industrial Waste Pits
- Radioactive Waste Disposal Sites
- Industrial Wastewater Treatment Plant
- Sanitary Wastewater Treatment Plant
- Storm Sewer System
- Ordnance Disposal Sites
- Defense Property Disposal office

These waste management facilities are discussed individually below.

Landfills

Six landfills used for the disposal of refuse were identified at Tinker AFB. Landfill locations on-base are shown on Figure 4.5. Five of the landfills are located on the base, and one is located on leased property adjoining Area "D" east of the base. Table 4.4 contains a summary of information on each landfill.

Landfill No. 1

Landfill No. 1 is a small area, approximately 1 acre in size, south of Crutcho Creek along Air Depot Boulevard (as shown on Figure 4.6). This landfill was used from the formation of Tinker AFB in 1942 until 1945. Primarily general refuse from the base was disposed in the landfill, although the site may also have received waste solids from the

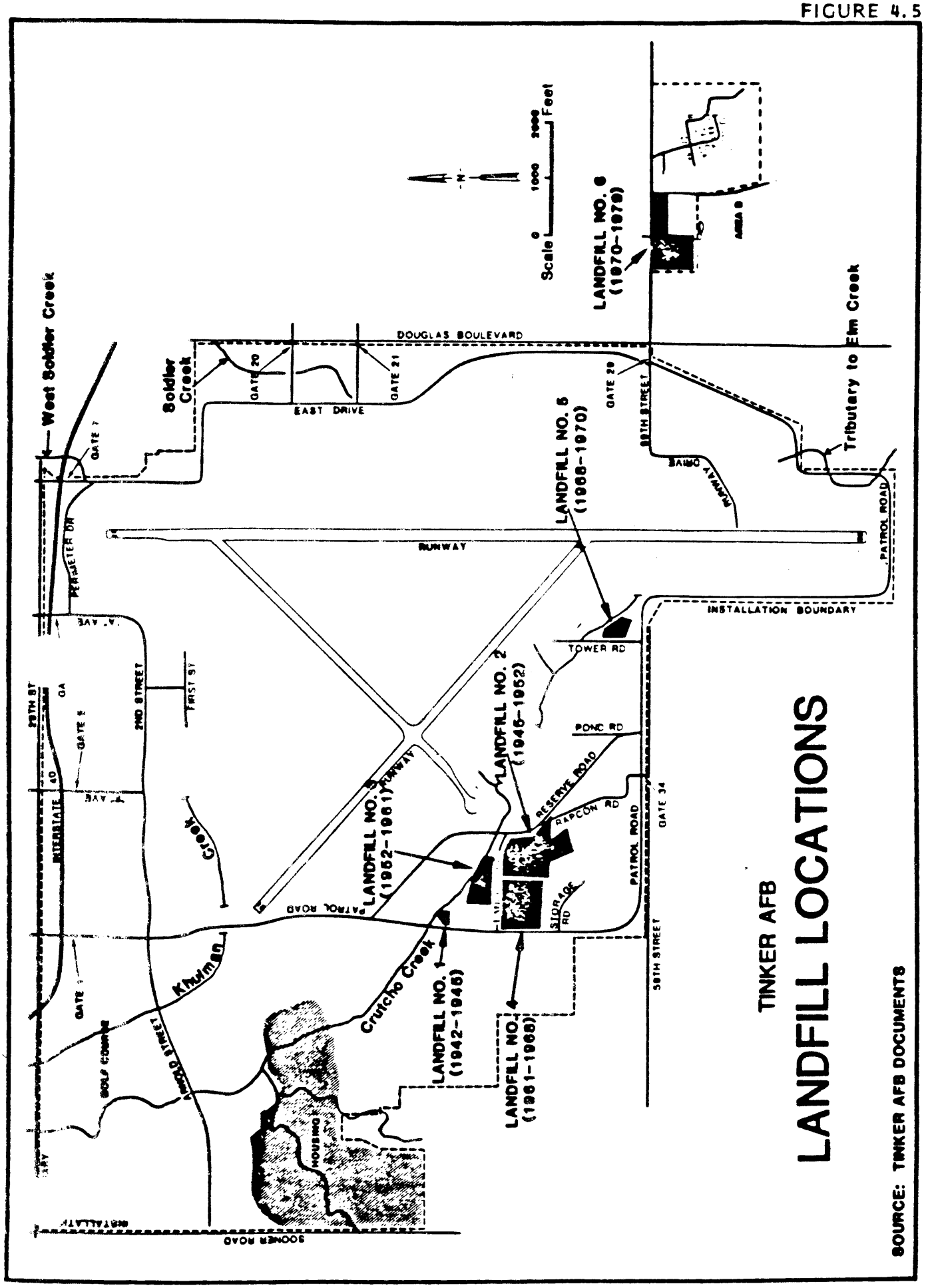
TABLE 4.3

TINKER AIR FORCE BASE SIGNIFICANT SPILLS, 1978-1981

Date	Location	Liquid Spills	Quantity Spilled	Comments
November 28, 1978	Facility 273	JP-4	1,200 gallons	Contained in dike and recovered
August 3, 1979	Building 3001	Acid scale conditioner	1,100 gallons	Neutralized
January 29, 1980	Building 486 (Hydrant System)	JP-4	1,500 gallons	No environmental damage
March 30, 1981	Building 486 (Hydrant System)	JP-4	2,500 gallons	No environmental damage

Source: Tinker AFB documents and employee interviews

FIGURE 4.5



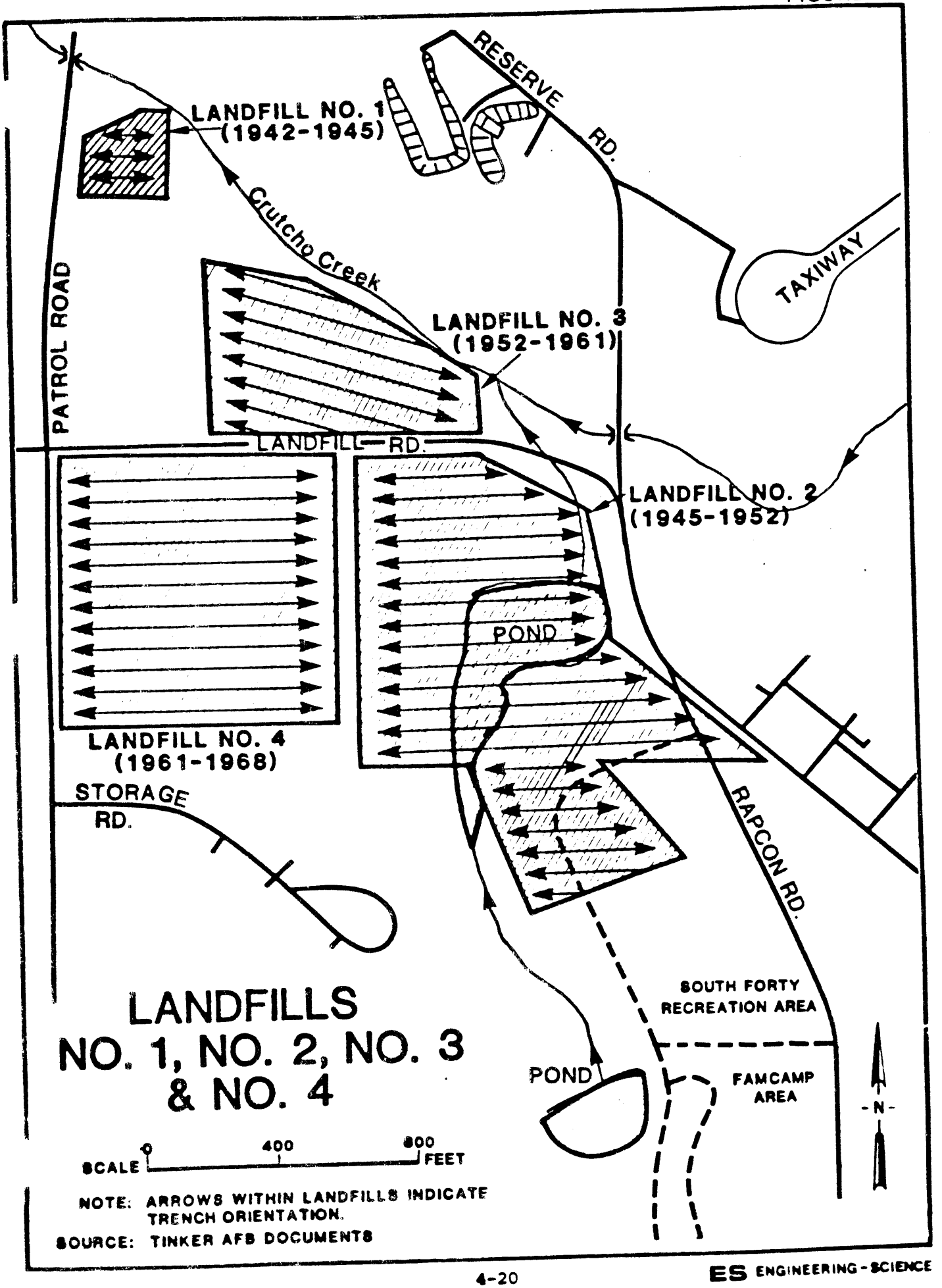
TINKER AFB
LANDFILL LOCATIONS
SOURCE: TINKER AFB DOCUMENTS
LANDFILL NO. 1 (1942-1945)
LANDFILL NO. 2 (1945-1952)
LANDFILL NO. 3 (1952-1961)
LANDFILL NO. 4 (1961-1968)
LANDFILL NO. 5 (1968-1970)
LANDFILL NO. 6 (1970-1979)
Scale 0 1000 2000 Feet
N
West Soldier Creek
Soldier Creek
Tributary to Elm Creek
Crutcho Creek
Khuiman Creek
DOUGLAS BOULEVARD
EAST DRIVE
RUNWAY
INSTALLATION BOUNDARY
TOWER RD
POND RD
RESERVE ROAD
RAPCON RD
STORAGE RD
PATROL ROAD
59TH STREET
2ND STREET
FIRST ST
INTERSTATE 40
GOLF COURSE
ARNOLD STREET
SOONER ROAD
HOUSING
GATE 7
GATE 20
GATE 21
GATE 29
GATE 34
GATE 5
GATE 1

TABLE 4.4

SUMMARY OF LANDFILLS AT TINKER AIR FORCE BASE

Landfill	Period of Operation	Approximate Area (Acres)	Types of Wastes	Estimate Quantity (YD^3)	Method of Operation	Closure Status	Geological Setting	Surface Drainage	Comments
1	1942-1945	1.2	General Refuse	30,000	Burning, Trench	Closed, covered with earth, vegetation	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Some water ponding due to differential settling in trenches
2	1945-1952	20	General refuse, probably some industrial waste	500,000	Trench	Closed, covered with earth, vegetation	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	A large pond is present above the landfill
3	1952-1961	8	General refuse, probably some industrial waste	200,000	Trench	Closed, covered with earth	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Now used as storage area for hardfill and dirt
4	1961-1968	16	General refuse, probably some industrial waste, and POL sludges	400,000	Trench	Closed, covered with earth, partial vegetation	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Leachate visible along westside of landfill. Past leachate samples show high mercury and phenols
5	1968-1970	3	General Refuse, probably some industrial waste	75,000	Trench	Closed, covered with earth, vegetation	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Some leachate visible along side of landfi near creek
6	1970-1979	11	General Refuse, probably some industrial waste, and industrial waste treatment sludge	500,000	Trench	Closed, covered with earth, partial vegetation	Terrace; sand, silt, clays	To Soldier Creek	Covered and graded. No waste visible.

FIGURE 4.6



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domestic wastewater treatment plant. Refuse was disposed in trenches running east-west, and was typically burned to reduce volume. The trenches extended to a depth of 10 to 25 feet, through a 6 to 8 foot clay layer into a sand/rock zone. Landfill No. 1 is well covered and shows no exposure of the disposal cells; however, settlement in the trenches has resulted in surface depressions where water collects from rainfalls. This water evaporates or percolates through the landfill.

Landfill No. 2

After closure of landfill No. 1, landfill No. 2 was opened south of Landfill Road and west of Reserve Road (Figure 4.6). This landfill was utilized from 1945 until its closure in 1952. Approximately 20 acres were filled during this time period. Although most of the waste disposed of consisted of general refuse from the base, small quantities of paints and solvents were also buried. The waste was disposed of in trenches approximately 20 feet in depth and 35 to 40 feet wide, in an east-west orientation. The refuse was covered daily with several inches of excavated material, and completed trenches were covered with 3 to 4 feet of material.

Landfill No. 2 is well covered and vegetated with grasses and shows no erosion or exposure of landfill material. Several surface depressions with collected rain water caused by material settlement in the trenches are evident on the landfill. A pond, several acres in area, is also located on landfill No. 2. The pond was constructed in the mid-1960's either partly on top or adjacent to the landfill area. From the air, the outlines of trenches can be seen along the boundary of the pond where the water level is high enough to inundate portions of the trenches. Overflow from the pond enters the upper reaches of Crutcho Creek. It is presently unknown to what extent the pond waters percolate through the landfilled material.

Landfill No. 3

During the time period 1952-1961, wastes were disposed of in an eight acre area designated as landfill No.3. This area is located adjacent to landfill No. 2 north of Landfill Road and south of Crutcho Creek (Figure 4.6). The type of waste disposed of and disposal methods were similar to previous landfills. The landfilled material consisted primarily of general refuse, but did include paint buckets, insecticide cans, and empty barrels. A number of low-level radioactive vacuum tubes

were also disposed of at this site. Landfill material were disposed of in trenches running the length of the landfill. Trenches were approximately 25 feet deep, and extended through a surface clay layer into a sand/rock layer. The refuse was covered daily, and a final cover of 3 to 4 feet of excavated material was placed on completed trenches.

Additional radioactive material was reported to have been disposed of in a deep pit adjacent to the northwest corner of landfill No. 3. The area was formerly posted with radioactivity warning signs, which have been destroyed. Radioactive burial is discussed in greater detail later in a subsection of this chapter.

Landfill No. 3 shows no evidence of erosion along the creek or elsewhere around the landfill. At present, additional dirt and hardfill are being stored on top of the landfill. This practice has been in effect for approximately 5 years.

Landfill No. 4

After closure of the landfill No. 3, a 16-acre site south of Landfill Road between landfill No. 2 and Air Depot Boulevard was utilized for refuse disposal and designated landfill No. 4 (Figure 4.6). Disposal practices were essentially the same as previous landfills, with a daily cover of 3 to 6 inches of compacted excavated material applied to the refuse and a final cover of several feet of soil used for completed trenches. The landfill was closed in 1968.

Surface leachate and associated gases have been observed along the west slope of the landfill along Air Depot Boulevard on several occasions since closure. A major problem with leachate from the west bank of landfill No. 4 occurred during 1979. Unusually heavy rainfall occurred during that year. Leachate occurred in a drainage ditch eventually leading to Crutcho Creek. Leachate and drainage ditch wastewater samples analysis data, shown in Table 4.5, indicated high concentrations of COD, oil and grease, phenols, and heavy metals. Unusually high concentrations of mercury (Hg) were also found in the leachate and drainage ditch samples, indicating that significant hazardous wastes quantities may be present in landfill No. 4.

Although the landfill area was covered up with a layer of top soil, small discharges of leachate are still observeable along the west and

TABLE 4.5

1979 ANALYSIS OF DRAINAGE CREEK AND LEACHATE FROM LANDFILL NO. 4

Parameter	Leachate Conc. (mg/l)	Drainage Creek Conc. (mg/l)
COD	29,000	910
Oil and Grease	400	76
Phenols	9.6	1.2
Ba	8.0	24.0
Fe	24.0	21.0
Mn	9.6	9.8
Hg	5.3	7.2
Ni	1.1	0.65
Zn	11.0	9.8

Source: Tinker AFB BESD Files

north banks of landfill No. 4. Surface runoff from these areas, including leachate, enters the drainage ditch and eventually enters Crutcho Creek.

Landfill No. 5

Landfill No. 5 located north of Patrol Road and east of Tower Road, (Figure 4.7) was used during the period 1968-1970. The disposal practices and types of wastes were the same as at Landfill No. 4. The three acre site is well covered and no waste material is exposed; however, waste compaction in the trenches has resulted in surface depressions which collect and hold rain water. A small area of seepage is noticeable on the north eastern edge of the landfill adjacent to West Crutcho Creek.

Landfill No. 6

Landfill No. 6 was used for the disposal of refuse from 1970 to 1979. This landfill, shown on Figure 4.8. is located adjacent to Area "D" approximately 1/2 mile east of Tinker AFB along S.E. 59th Street on land leased from Oklahoma City. Although 40 acres are available at the site, only about 20 acres on the western half of the landfill were used prior to the closing of the site during 1979. Base refuse since that time has been disposed of off-site by private contractor.

Materials disposed in landfill No. 6 consisted primarily of general refuse with small quantities of industrial waste materials such as paint buckets, insecticide cans, etc. Industrial wastewater treatment plant sludge was also intermittently disposed of in this landfill. The refuse was covered daily with 6 to 8 inches of compacted soil, and several feet of compacted cover was used as a final trench covering. Highly permeable river sand was used for daily cover for several years, although other areas had a cover of excavated clay and sand/rock. After closure, the site was revegetated with grasses. Field reconnaissance of the site indicated moderate surface erosion and no observed leachate.

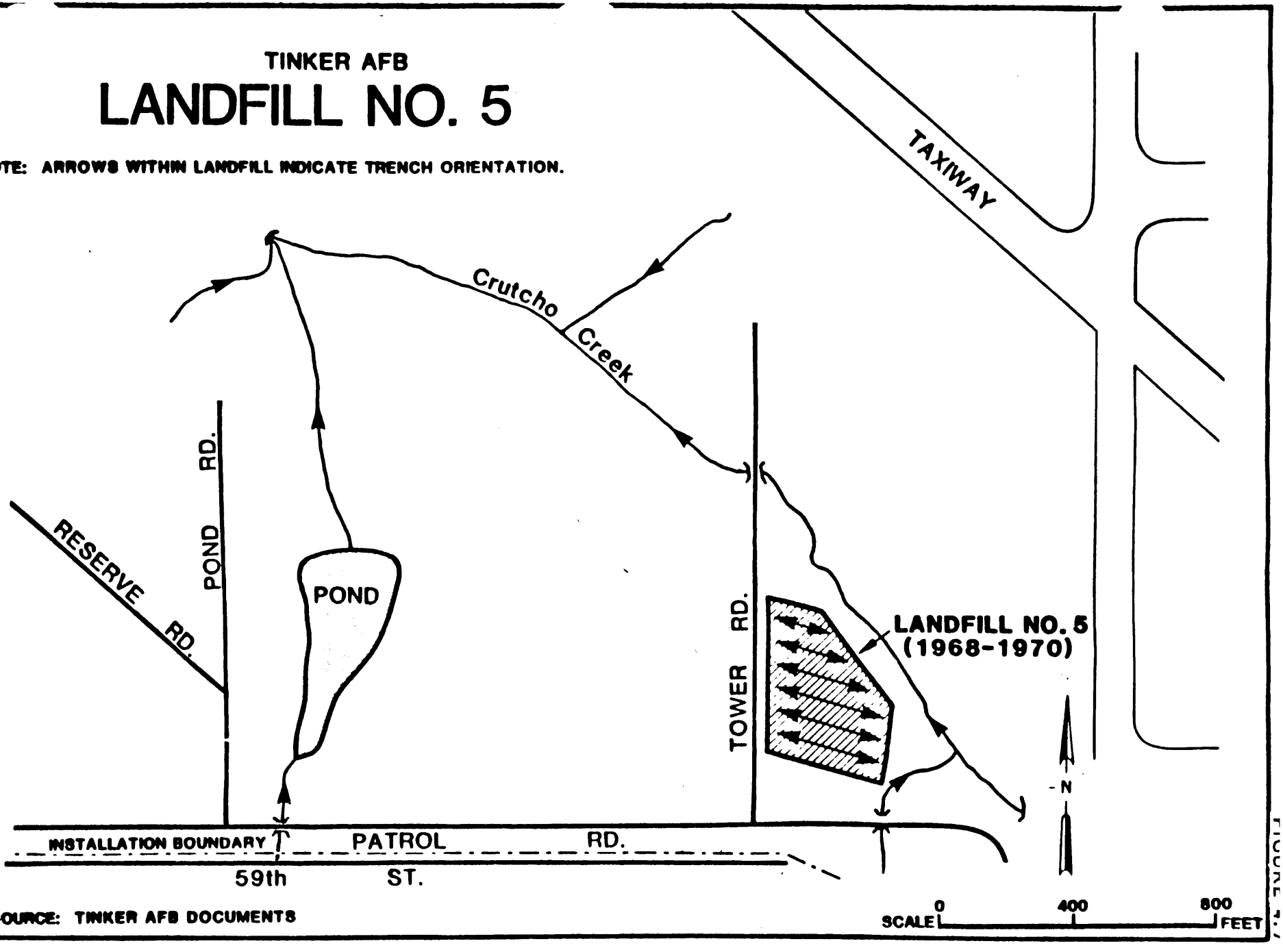
Waste Disposal Pits

Prior to the establishment of an industrial wastewater collection and treatment system, some of the industrial wastes were disposed of in large, open pits. Two waste disposal pit areas, shown on Figure 4.9, were located on the east side of the base south of the aircraft

TINKER AFB

LANDFILL NO. 5

NOTE: ARROWS WITHIN LANDFILL INDICATE TRENCH ORIENTATION.



SOURCE: TINKER AFB DOCUMENTS

FIGURE 4-

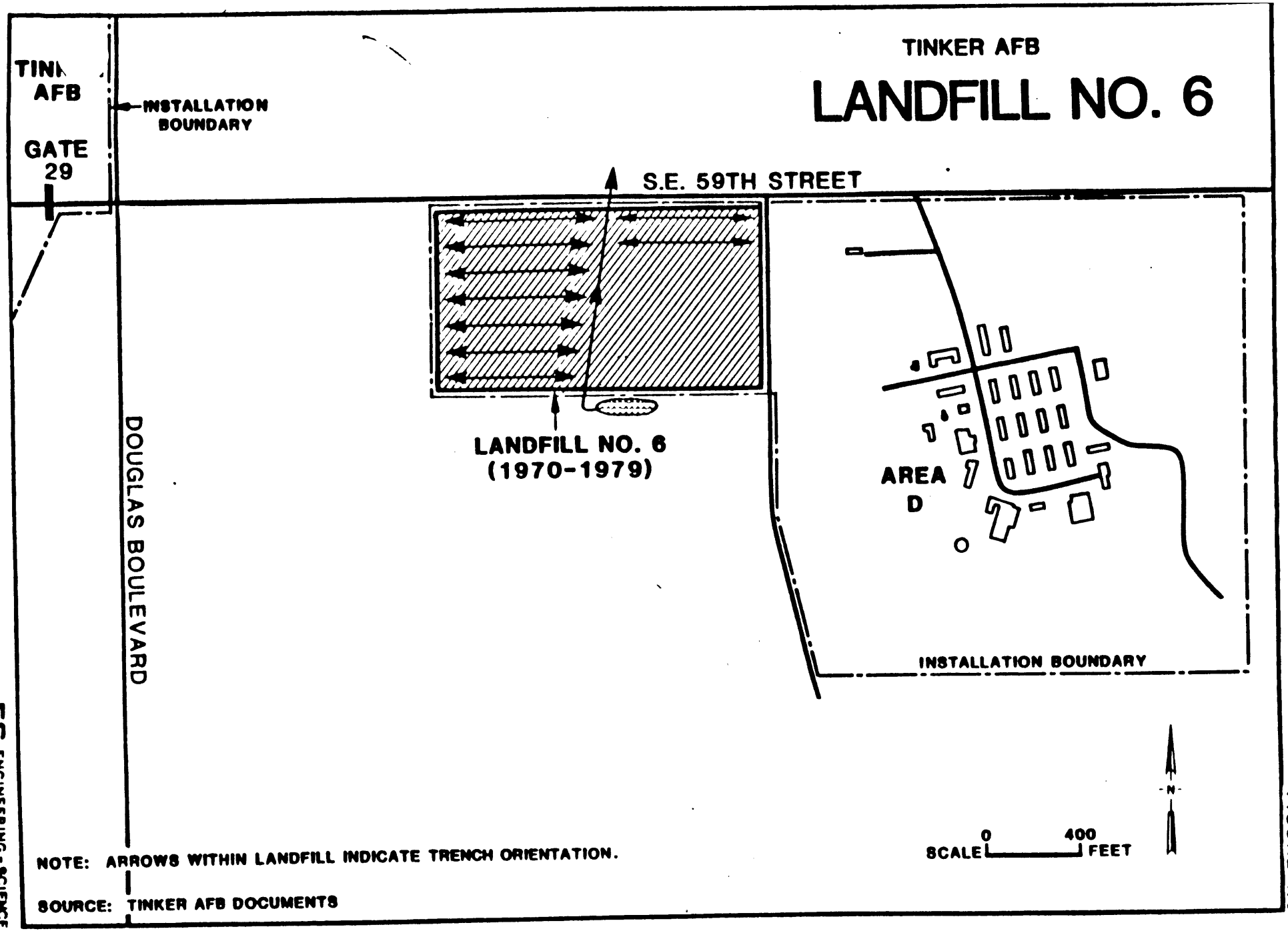
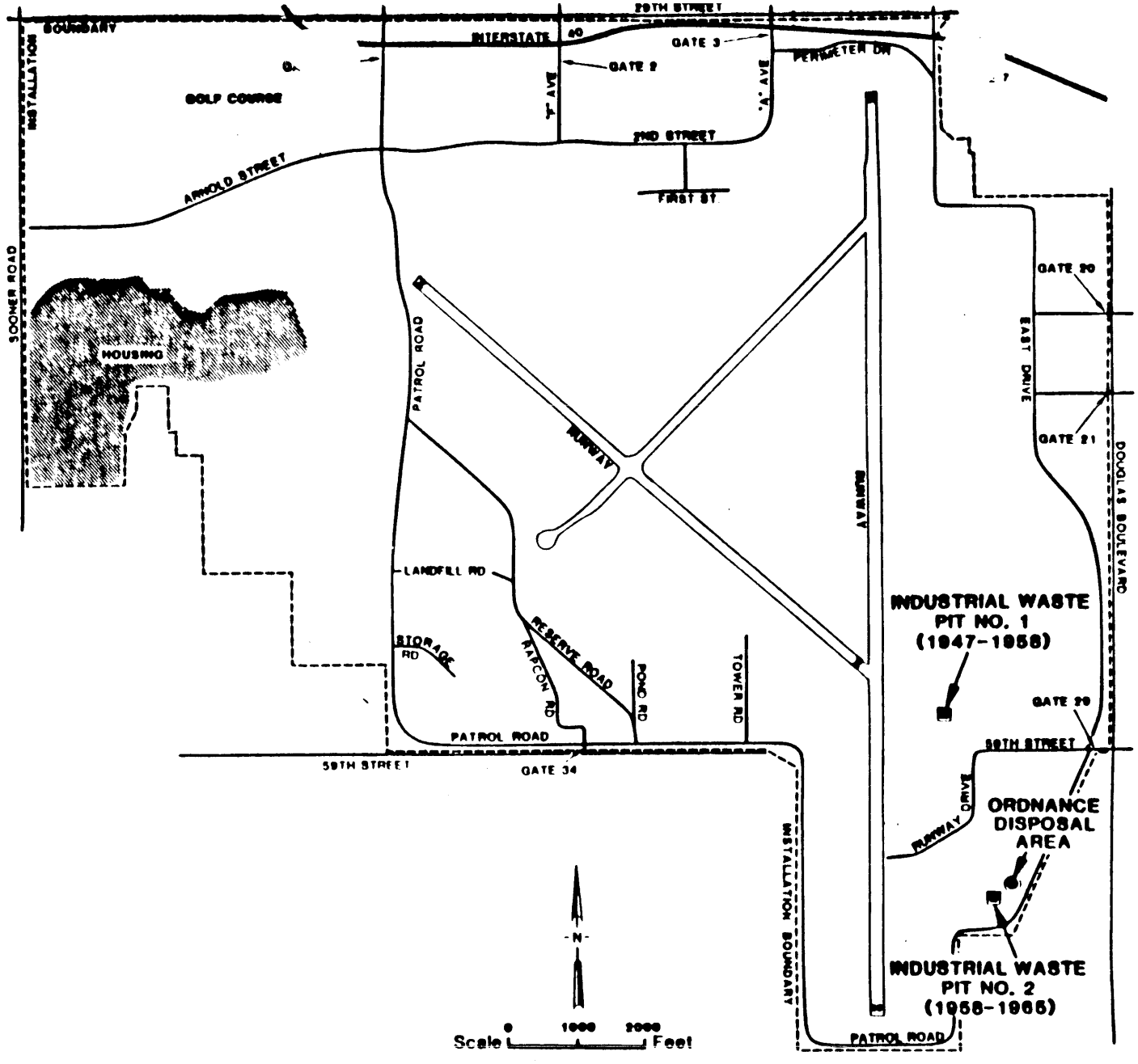

TINKER AFB
LANDFILL NO. 6
TINKER AFB
GATE 29
INSTALLATION BOUNDARY
S.E. 59TH STREET
DOUGLAS BOULEVARD
LANDFILL NO. 6
(1970-1979)
AREA D
INSTALLATION BOUNDARY
N
SCALE 0 400 FEET
NOTE: ARROWS WITHIN LANDFILL INDICATE TRENCH ORIENTATION.
SOURCE: TINKER AFB DOCUMENTS

FIGURE 4.0

TINKER AFB

INDUSTRIAL WASTE PITS and ORDNANCE DISPOSAL AREA



SOURCE: TINKER AFB DOCUMENTS

maintenance area. The pits were used for the disposal of industrial wastes between 1947 and 1965.

Industrial waste pit No. 1 was located southwest of Building 2121, as shown in Figure 4.10. Waste disposal occurred during the period 1947-1958. During the base records search, no written information was located to indicate what was placed in the pit, although interviews with several base personnel indicated large quantities of waste oils, contaminated fuels, chromates, phenols, cyanides, and waste acids and bases generated by plating and maintenance activities were disposed in this facility. The petroleum based contents of the pit may have been burned routinely.

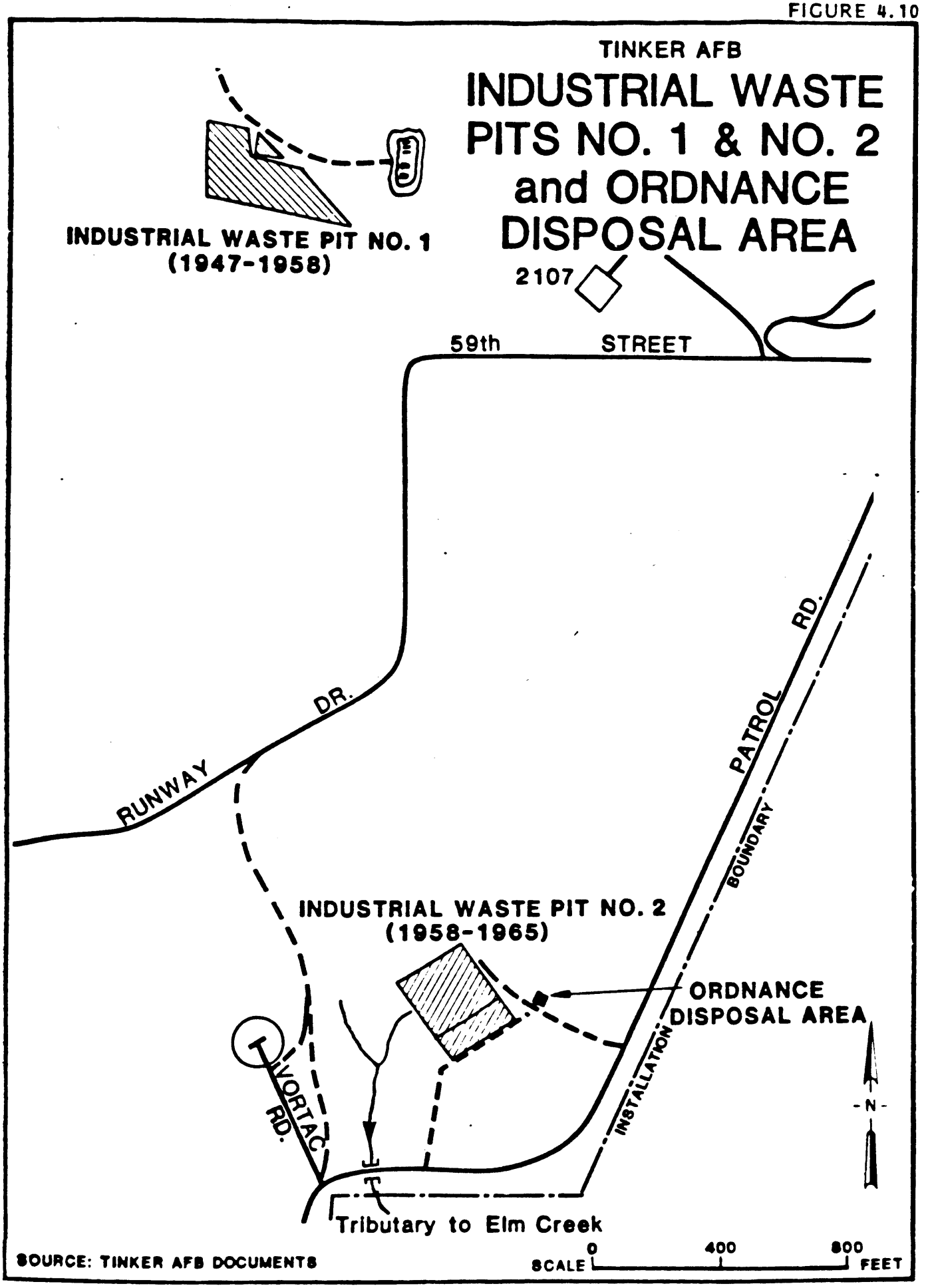
The pit was unlined, and unknown quantities of wastes may have migrated through the soil beneath and around the pit. Surface runoff from the No. 1 pit, if any, would have entered the headwaters of Crutcho Creek. Waste residue may still be present at the site, as there is no evidence that the pit was dredged to remove residual material when the pit was covered and graded over in 1958. There are no visible surface features to indicate exactly where pit No. 1 was located. However, aerial photographs obtained from the base historian and shown in Appendix E show the pit location during operation.

In 1958, industrial waste pit No. 1 was abandoned and a second pit was constructed on a hill between Patrol Road and the airfield runway (Figure 4.10). Industrial waste pit No. 2 also received hazardous wastes such as waste oils, cyanides, chromates, phenols, solvents, and waste acids and alkalies. During the records search, no information was found concerning the construction of the pit. If the pit were unlined, hazardous wastes may have migrated beyond the original pit area. Aerial photographs reveal that the waste pit may have an overflow discharge which drained into Elm Creek. Disposal of hazardous wastes in the pit continued until the early 1960's, and the pit was filled and graded in 1965. There was no information indicating that the waste pit was dredged before it was covered. A photograph of industrial waste pit No. 2 is also shown in Appendix E.

Radioactive Waste Disposal Sites

Radioactive wastes are reported to have been disposed at four locations within Tinker AFB. The burial sites identified as containing

FIGURE 4.10



SOURCE: TINKER AFB DOCUMENTS

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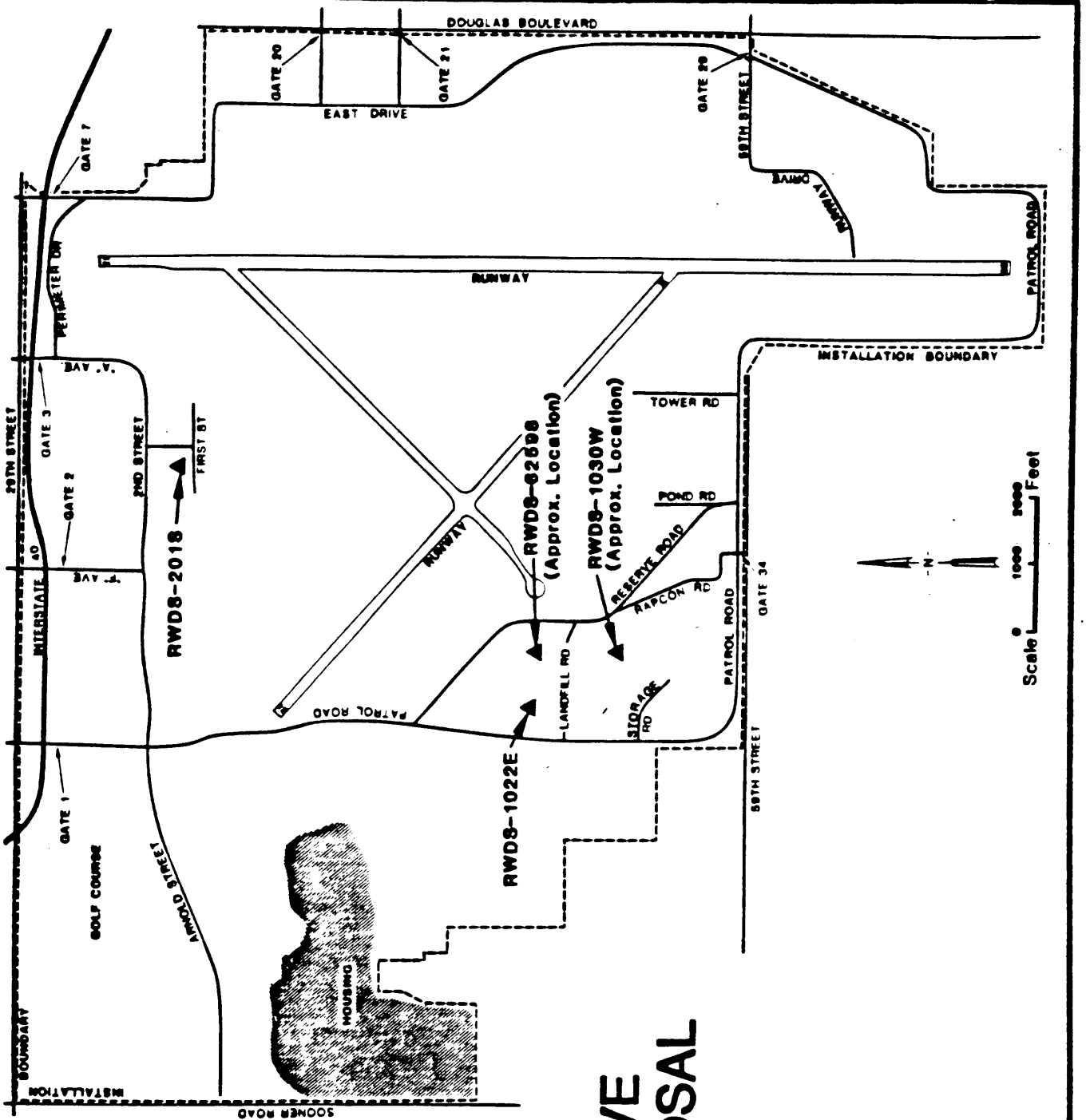
radioactive wastes are shown on Figure 4.11. A summary of information on each radioactive waste disposal site is contained in Table 4.6.

Radioactive Waste Disposal Site (RWDS) 201S is located adjacent to the overhead conveyor south of Building 201 as shown in Figure 4.12. The site is marked by a concrete post, although radiation warning signs are not posted. Very little information is available concerning radioactive waste disposal at this site. The burial area encompasses approximately 10 square feet and was used for the disposal of radium paint dials and radium paint solids. The dates of operation of this disposal site are not known, and the area is no longer used for disposal of radioactive wastes. No information is available concerning the construction of the disposal pit, depth of burial, or quantity of waste disposed. Radiological monitoring of the site by the Bioenvironmental Engineering Services Division in October 1981 indicated no radioactivity in excess of natural background levels.

A second radioactive waste disposal site, RWDS 62598, is located south of Facility 1025 and north of Crutcho Creek (Figure 4.13). A concrete post with attached radiation warning sign marks the general disposal area. The site contains a "lead still" made of sheet lead used to evaporate methyl ethyl ketone (MEK) or acetone for reuse. The MEK and acetone were contaminated with radium paint from cleaning radium dials. After use, a residue of radium paint solids remained in the still. Following a period of usage, the lead still became radioactive due to the accumulation of solids In the early 1950's, the lead still was reportedly buried in the general area marked by the concrete post. The depth of burial is not known. One Air Force document states the waste may later have been removed; however, no conclusive evidence exists for either the presence or absence of the waste. Recent radiological monitoring has identified no area of increased radioactivity near the site.

Another radioactive waste disposal site, RWDS 1022E, is located adjacent to the northwest corner of landfill No. 3 south of West Crutcho Creek (Figure 4.13). During the mid-1950's approximately 8 to 10 containers of radioactive material from Building 230 were disposed of at the site. The material was placed in a hole approximately 30 feet deep

FIGURE 4.11



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RADIOACTIVE WASTE DISPOSAL SITES

SOURCE: TINKER AFB DOCUMENTS

TABLE 4.6

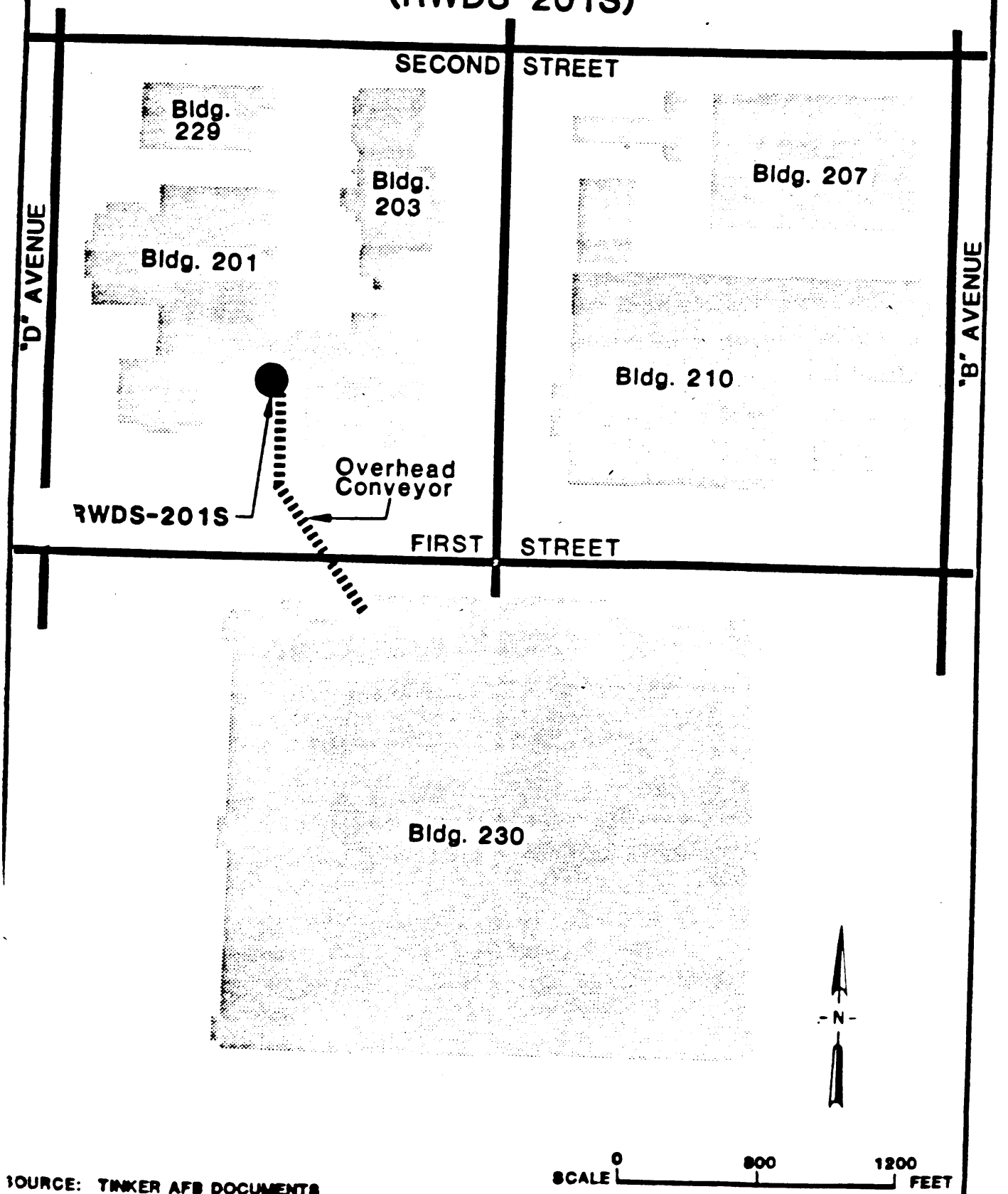
SUMMARY OF RADIOACTIVE WASTE DISPOSAL SITES

Landfill	Period of Operation	Approximate Area (Acres)	Types of Wastes	Estimate Quantity (YD^3)	Method of Operation	Closure Status	Geological Setting	Surface Drainage	Comments
NWDS 6259B	Unknown	<0.1	Radioactive "lead still" used for distilling acetone	<10	Pit	Closed (Possibly removed)	Fine-grained sandstone; shale and mudstone	To Khulman Creek	Buried lead still behind Bldg 1025 and creek. Exact location not known.
NWDS 2018	Unknown	<0.1	Low-level radioactive radium paint solids	<10	Pit	Closed	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Radium paint solids buried in pit. Concrete cap.
NWDS 1022E	Late 1950's	<0.1	Low-level radioactive wastes	<10	Pit	Closed	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	8 to 10 kegs of low-level radioactive material buried.
NWDS 1030W	Prior to 1955	<0.1	Low-level radioactive wastes.	<10	Pit	Closed (Possibly Removed)	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Rags and acetone solutions which contained radium

FIGURE 4.12

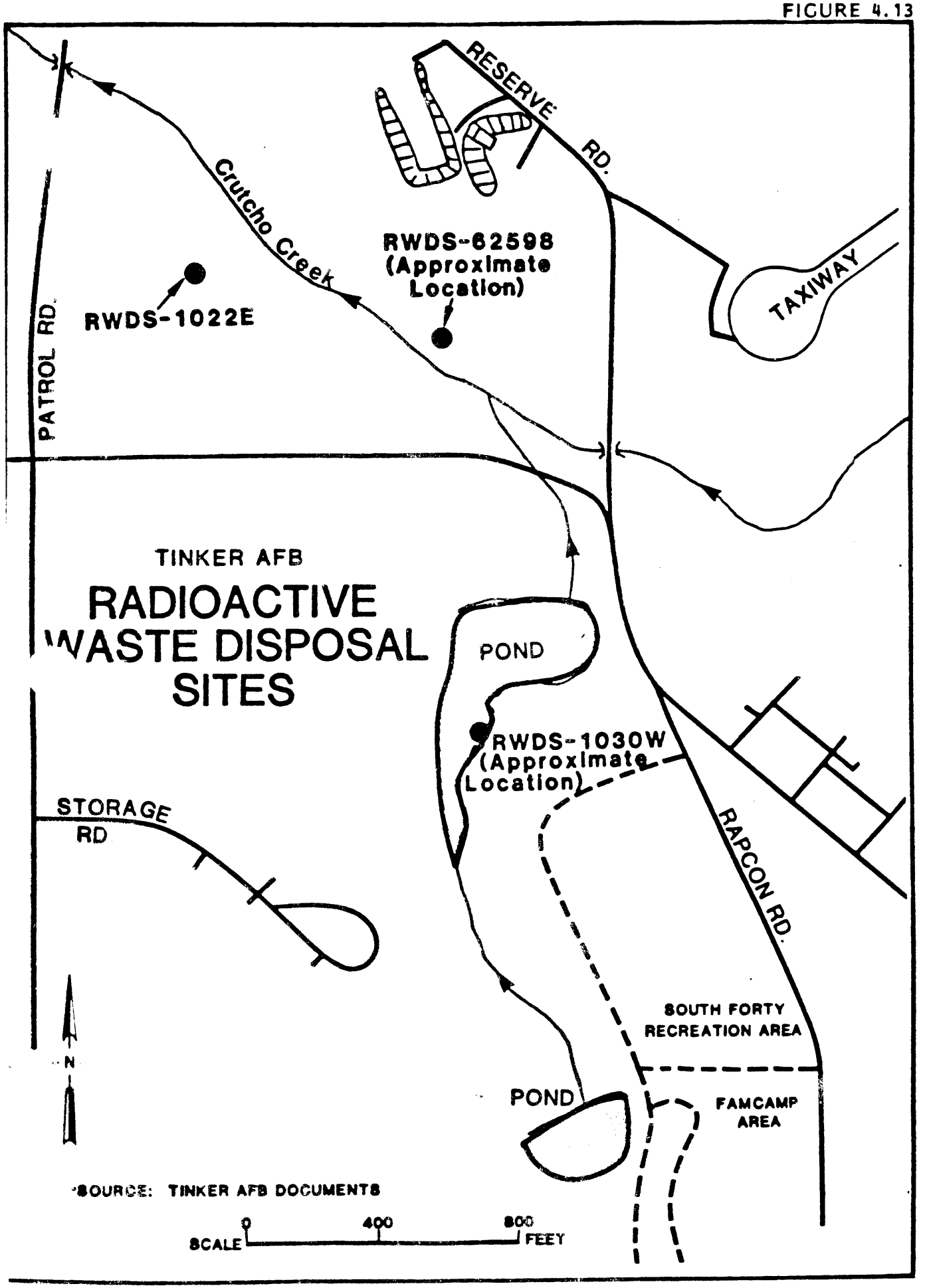
TINKER AFB

RADIOACTIVE WASTE DISPOSAL SITE (RWDS-201S)



SOURCE: TINKER AFB DOCUMENTS

FIGURE 4.13


RESERVE RD.
Crutcho Creek
RWDS-62598
(Approximate
Location)
RWDS-1022E
PATROL RD.
TAXIWAY
TINKER AFB
RADIOACTIVE
WASTE DISPOSAL
SITES
POND
RWDS-1030W
(Approximate
Location)
STORAGE
RD
RAPCON RD.
SOUTH FORTY
RECREATION AREA
N
POND
FAMCAMP
AREA
SOURCE: TINKER AFB DOCUMENTS
0
400
800
SCALE
FEET

located next to landfill No. 3, which was operative during the period 1952-1961. The area was marked with radiation warning signs, although none are now present. The area was surveyed with beta/gamma radioactivity detector equipment during November 1981. Radiation levels of 0.03 mr/hr above a background of 0.02 mr/hr were detected; indicating radioactive materials are present, but do not result in radioactivity levels hazardous to human health.

The fourth radioactive waste burial site was identified as being located 1200 feet west and 550 feet north of Building 1030. The site is under water in one of the base's fishing ponds. The area purportedly contained radium dial wastes. A verbal report referenced in an Air Force document asserts that all radioactive wastes were removed in 1955, when the sanitary landfill was established.

Industrial Wastewater Treatment Facilities

Treatment of industrial liquid waste streams began in 1963 and was located in the northeast corner of the base near Gate 19. The treatment facility has discharged treated wastewater to Soldier Creek. The waste facilities were designed to treat approximately 290,000 gallons per day of primarily waste electroplating solutions. In 1969, additional industrial sewer lines were installed to collect dilute streams of electroplating cleaning, and other maintenance area waste streams for treatment. Major improvements in the treatment system were completed in 1971 which increased the design capacity to 1.8 million gallons per day (MGD). Major concentrated streams of electroplating and cleaning solutions from the Directorate of Maintenance were treated by the upgraded facility.

The wastewater treatment units included batch processing of phenols, cyanides, and chrome solutions. Oil/water separators, equalization basins, chemical reduction units, solids contact clarifiers, biological treatment, and chlorine contact chambers are utilized.

Sludge from the industrial waste treatment facility has been disposed of off-base by a contract service. The sludge was occasionally disposed in base landfills through 1979.

Sanitary Wastewater Treatment Facilities

Domestic sewage has been treated on-base since 1942 by an actived sludge system and a single stage trickling filter system. The activated

sludge system served the north central and west base areas until the early 1970's. This system discharged treated effluent into a tributary to Crutcho Creek. This system is located on Patrol Road at Reserve Road and is now used for storage of pesticide chemical and drummed hazardous waste. This sewage treatment system may have received infrequent batches of oil and grease for treatment from the aircraft maintenance areas located in the north central base area. Domestic sewage from the north central and west base areas presently are connected to the Oklahoma City sanitary sewer system.

The single stage trickling filter treatment facility is located adjacent to the industrial waste treatment facility. This system treats domestic sewage from the east base area. The design capacity of the plant is 0.9 MGD, however normal discharge flow is estimated to be 60 percent of design flow. This treatment facility treated quantities of industrial waste streams from the early 1960's to the early 1970's prior and during the expansion of the industrial waste treatment facility. However, no process unit design changes were initiated for treatment of industrial wastes.

Storm Sewer System

Evidence of hazardous liquid waste disposal in the base storm sewer systems was obtained primarily through a report prepared by USAF Occupational and Environmental Health Laboratory (OEHL) in April 1980 (Huang, 1980). This report summarized water quality sampling data collected and analyzed during dry weather conditions in the storm sewer systems around Buildings 3001, 3102, 3105, 3108, 3705 and 3703. High concentration of phenols, chromium and zinc were indicated by the sample data in the storm sewer serving Building 3703 (engine test cells). No potential source for these compounds were determined in the report. The storm system discharges to Soldier Creek.

Ordnance Disposal

Ordnance disposal was conducted on base between the early 1960's and 1972 by a detachment of the 2701 EOD Squadron. The ordnance disposal area was located at the southeast end of the North-South Runway (Figure 4.10) and comprised a burn pit with an adjacent igloo-shaped protective bunker. Ordnance burned during this period consisted of outdated small arms munitions, blasting caps, flares, pyrotechnics and

egress items. The frequency of burning operations was less than once per month. Since 1972, all ordnance disposal required by Tinker AFB has been performed at nearby military installations.

Defense Property Disposal Office

The Defense Property Disposal Office (DPDO) has handled the contracting for collection and transportation of resalable waste petroleum products. These products include: waste jet fuel, waste oils, waste synthetic oils and chlorinated hydrocarbon solvents. The contracts are granted by DPDO on a bid basis. DPDO is presently finalizing an agreement with CES concerning collection, transportation and disposal of all chemical waste and nonresalable petroleum product waste materials for the base. Eleven transformers believed to contain PCB materials are currently in storage within the DPDO area (Building 3770).

EVALUATION OF PAST DISPOSAL ACTIVITIES AND FACILITIES

The review of past operation and maintenance functions and past waste management practices at Tinker AFB has resulted in the identification of 14 sites containing hazardous waste materials and having the potential for migration of contamination. Other sites were reviewed and eliminated from further evaluation based on the logic presented in the decision tree shown in Figure 4.1.

The 14 sites have been assessed using a hazardous assessment rating methodology (HARM), which takes into account characteristics of potential receptors, waste characteristics, pathways for migration, and specific characteristics of the site related to waste management practices. The details of the rating procedures are presented in Appendix G and the results of the assessment are summarized in Table 4.7. The HARM system is designed to indicate the relative need for follow-on action. The information presented in Table 4.7 is intended as a guide for assigning priorities for further evaluation of the Tinker AFB disposal areas (Chapter 5, Conclusions and Chapter 6, Recommendations). The rating forms for the individual waste disposal sites on Tinker AFB are presented in Appendix H. Photographs of some of the key disposal sites are contained in Appendix E.

TABLE 4.7

SUMMARY OF HARM SCORES FOR POTENTIAL CONTAMINATION SOURCES

Rank	Site Name	Receptor Subscore	Waste Characteristic Subscore	Pathways Subscore	Waste Management Factor	Overall Total Score
1	Landfill No. 4	57	53	100	1.0	70
2	Industrial Waste Pit No. 2	57	100	66	1.0	68
3	Landfill No. 2	56	40	100	1.0	65
4	Industrial Waste Pit No. 1	54	100	28	1.0	61
5	Landfill No. 3	54	60	65	1.0	60
6	RWDS 1030W	56	20	100	1.0	59
7	Landfill No. 6	59	45	65	1.0	56
8	Fire Training Area No. 1	54	70	42	1.0	55
9	Landfill No. 5	57	40	57	1.0	51
10	RWDS 1022E	54	50	42	1.0	49
11	Fire Training Area No. 2	54	36	50	1.0	47
12	Landfill No. 1	54	40	42	1.0	45
13	RWDS 6259B	54	15	42	1.0	37
14	RWDS 2018	53	25	28	1.0	35

CHAPTER 5

CONCLUSIONS

CHAPTER 5

CONCLUSIONS

The goal of the IRP Phase I study is to identify sites where there is the potential for environmental contamination resulting from past waste disposal practices and to assess the probability of contaminant migration from these sites. The conclusions given below are based on the assessment of the information collected from the project team's field inspection, review of records and files, review of the environmental setting, and interviews with base personnel, past employees and state and local government employees. Table 5.1 contains a list of the potential contamination sources identified at Tinker AFB and a summary of HARM scores for those sites.

1) Landfill No. 4 has a high potential for migation of contaminants. This landfill was utilized from 1961 to 1968 and is now a closed site. Leachate has been observed along the west and north banks of Landfill No. 4 despite top soil cover. Results of a leachate sample analysis has indicated the presence of mercury, phenols, and oil and grease. Landfill No. 4 is located 1,500 feet from a drinking water well and 1,300 feet from the base boundary. The distance to ground water is approximately 250 feet and the regional geology information indicates moderately permeable material between the bottom of the landfill and the water level in the aquifer. The landfill received a HARM score of 70.

2) Industrial waste pit No. 2 has a high potential for migration of contaminants due to the types and estimated quantities of hazardous wastes disposed at this location. Waste pit No. 2 is 1,500 feet from the nearest drinking water well and is 1,500 feet from the base boundary. The estimated depth to ground water is 250 feet. The pit was operated from 1958 to 1965 and did not have an impermeable liner. Waste pit No. 2 received a HARM score of 68.

3) Landfill No. 2 has a high potential for contaminant migration. This landfill was operated from 1945 through 1952 and received general refuse from the base and small quantities of industrial waste.

TABLE 5.1

PRIORITY RANKING OF POTENTIAL CONTAMINATION SOURCES

TINKER AFB

Rank	Site Name	Date of Operation or Occurrence	Overall Total Score
1	Landfill No. 4	1961-1968	70
2	Industrial Waste Pit No. 2	1958-1965	68
3	Landfill No. 2	1945-1952	65
4	Industrial Waste Pit No. 1	1947-1958	61
5	Landfill No. 3	1952-1961	60
6	RWDS 1030W	Prior to 1955	59
7	Landfill No. 6	1970-1979	56
8	Fire Training Area No. 1	1950-1962	55
9	Landfill No. 5	1968-1970	51
10	RWDS 1022E	Mid 1950's	49
11	Fire Training Area No. 2	1962-1966	47
12	Landfill No. 1	1942-1945	45
13	RWDS 62598	Early 1950's	37
14	RWDS 201S	Unknown	35

Note: This ranking was performed according to the Hazardous Assessment Rating Methodology (HARM) described in Appendix G. Individual site rating forms are in Appendix H.

The site is closed and has a soil cover with vegetation. The trench areas have settled leaving small depressions in the surface. The southeast section of the site is now a park and recreation area with a small pond built over landfill material. The pond may be acting as a source of infiltration into the landfill. The HARM score for this site was 65.

4) Industrial waste pit No. 1 has a moderate potential for contaminant migration. This pit was used for disposal of industrial waste between 1947 and 1958. Waste pit No. 1 is 1,100 feet from the nearest drinking water well and 2,250 feet from the base boundary. The estimated depth to ground water is 250 feet. Waste pit No. 1 received a HARM score of 61.

5) Landfill No. 3 received general refuse and small amounts of industrial wastes from 1952 through 1961 and poses a moderate potential for contaminant migration. It is believed that some low level radioactive waste was buried by the northwest corner of this landfill. The site is closed with a soil cover and is being used to stockpile surplus fill dirt and rubble (hardfill). Crutcho Creek runs on the north edge of the landfill. The HARM score for Landfill No. 3 was 60.

6) Radioactive waste disposal site (RWDS) 1030W has a moderate potential for contaminant migration primarily because a pond has been constructed over the burial site. The waste is not very toxic (low level radioactive contaminated material) and there may only be a small quantity present. Base reports indicate the waste may have been removed in 1955 during construction of the landfill. The site received a HARM score of 59.

7) Landfill No. 6 poses a moderate potential for migration of contaminants. Landfill No. 6 was operated from 1970 though 1979 and received general refuse and small quantities of miscellaneous industrial wastes and dewatered sludge from the industrial waste treatment plant. The landfill is now closed and has a soil cover and vegetation over most of the surface. No significant erosion was observed at this landfill. The HARM score for Landfill No. 6 was 56.

8) Fire training area No. 1 has a moderate potential for migration of contaminants. Training exercises at area No. 1 may have utilized waste solvents, as well as waste oils and fuels. This pit was unlined during the period of operation (1950 till 1962). Fire training area

No. 1 is 700 feet from the nearest drinking water well and 2,100 feet from the base boundary. This area is about 100 feet from Crutcho Creek. Fire training area No. 1 received a HARM score of 55.

9) Landfill No. 5 has a moderate potential for contaminant migration. This landfill was operated from 1968 through 1970 and received primarily general refuse from the base. Small quantities of chemical and miscellaneous industrial wastes are believed to have been disposed of in this landfill. The site is closed and has a soil cover with vegetation; however, settling in the trench areas has created depressions which retain rainwater runoff. Some seepage streams were observed coming from the base of the landfill on the northeast side. This landfill is adjacent to a drinking water well, a surface stream, and close to the base boundary. The HARM score for Landfill No. 5 was 51.

10) RWDS 1022E has a low potential for contaminant migration. The site was used during the mid-1950's to dispose several containers of low-level radioactive material. Recent radiological surveys by base personnel indicated no radioactivity levels which are hazardous to human health. RWDS 1022E received a HARM score of 49.

11) Fire training area No. 2 has a low potential for contaminant migration. This site was used infrequently as a temporary fire training site from 1962 to 1966. This site received a HARM score of 47.

12) Landfill No. 1 poses a low potential for migration of contaminants and received a HARM score of 45. This landfill is closed and covered. The general refuse disposed in this landfill was burned to reduce volume. Only small amounts of chemicals and industrial wastes were suspected of being disposed in this landfill.

13) RWDS 62598 has a low potential for contaminant migration. The site contains low-level radioactive materials. An Air Force document indicate that the material may have been removed. Recent radiological monitoring has identified no area of increased radioactivity near the site. RWDS 62598 received a HARM score of 37.

14) RWDS 201S also has a low potential for contaminant migration. The site was used for the burial of low-level radioactive contaminated material. Recent radiological monitoring has identified no area of increased radioactivity near the site. RWDS 201S received a HARM score of 35.

15) The surface drainage systems on-base have been sources of contaminant migration since 1942 when the base operation began. This is confirmed by surface water quality data from the U.S. Geological Survey, R.H. Frank, Jr. (1969), and the base Bioenvironmental Engineering monitoring program. The quantity of contaminants discharged from the base was reduced significantly in the 1960's and again in the 1970's when industrial waste treatment facilities were constructed. A sediment sample collected in East Soldier Creek and a soil sample collected from Crutcho Creek were analyzed in July 1981, by the Oklahoma Water Resources Board and indicated high concentrations of chromium and nickel (East Soldier Creek) and COD, oil and grease and total organic carbon (Crutcho Creek). Contaminants may migrate through sediment leaching into the local surface waters and into the ground-water system.

APPENDIX C
SUPPLEMENTAL ENVIRONMENTAL SETTING INFORMATION

BIOLOGICAL RESOURCES

The following information regarding the Tinker AFB biological resources was obtained from Tinker AFB records.

The site of Tinker AFB is situated on a relatively flat expanse of grassland. Prior to the development of the base, the area was characterized by large expanses of agricultural land. At the present time, the base has approximately 1,630 acres of semi-improved and unimproved grounds which are used for the airfield, golf course, housing area, offices and shops. Naturally occurring ecosystems are, therefore, limited on base. The only wooded areas on base are situated along Crutcho Creek and Soldier Creek. No endangered or threatened plants are located within the base. The following list indicates the endangered and threatened animals which, due to their migratory habits, may occasionally visit the area.

Endangered Species:

- Southern Bald Eagle
- Prairie Falcon
- Artic Peregrine Falcon

Threatened Species:

- American Peregrine Falcon
- American Ivory-Billed Woodpecker

SUMMARY OF SURFACE WATER QUALITY DATA

Surface water quality data available from base records, State agencies and private studies are shown in Tables C.1, C.2, C.3, and C.4.

MONITORING DATA COLLECTED BY TINKER AFB BIOENVIRONMENTAL ENGINEERING

Station Number and Location	Date	COD mg/l	O & G mg/l	NO_3-N mg/l	NO_2-N mg/l	Ortho-Phosphate mg/l	Cd mg/l	Phenol µg/l	Cd µg/l	Cr (Tot) µg/l	Cu µg/l	Fe µg/l	Pb µg/l	Mn µg/l	Hg µg/l	Ni µg/l	Zn mg/l	Cl^- mg/l	TDS mg/l	$SO_4^=$ mg/l	Surfactants[1] mg/l
Soldier Creek 275 Ft. S. Bldg. 62510	5/30/80	2	<0.3	2.3	1.1	0.0	0.04	<10	10	193	<20	100	<50	91	<5	92	<50	20	12	200	0.3
	6/11/80	20	<0.3	3.4	1.6	1.7	0.04	<10	<10	200	22	332	<50	193	<5	200	<50	24	12	15	0.3
	7/15/80	20	1.0	1.5	2.5	2.6	0.02	12	30	1119	30	664	<50	360	<5	602	<50	22	31	25	0.3
	7/25/80	95	1.0	3.0	1.0	0.0	0.03	30	<10	23000	177	7100	303	1343	<5	2099	231	20	170	14	0.34
	7/31/80	20	0.0	0.0	2.3	12.5	<0.01	10	<10	274	44	137	<50	166	<5	255	<50	22	13	16	0.16
	8/14/80	10	1.72	4.0	1.4	5.2	<0.01	10	10	107	50	106	<50	213	<5	220	<50	22	6	275	0.26
	9/23/80	60	1.1	5.0	0.0	1.6	0.02	<10	10	125	40	101	<50	197	<5	250	<50	20	9	16	0.2
	10/14/80	25	0.0	3.0	1.1	0.7	<0.01	<10	<10	101	103	143	<50	175	<2	195	<50	24	<1	220	0.01
West Soldier Ch. (80 Ft. S. Bldg. 3110)	1/10/79	-	-	3.7	0.4	<0.2	<0.01	<10	20	<50	54	170	<50	<50	<5	<50	<50	16	3	6	0.2
	2/13/79	10	<0.3	6.0	1.3	<0.2	<0.01	<10	<10	<50	33	<100	<50	<50	<5	83	60	8	5	9	0.1
	2/27/79	10	<0.3	3.0	0.5	<0.2	<0.01	<10	<10	<50	<20	<100	<50	<50	<5	62	84	10	5	7	<0.1
	3/8/79	80	0.4	<0.2	<0.1	<0.2	<0.01	22	<10	100	52	150	<50	61	<5	<50	160	16	6	17	<0.1
	3/26/79	90	13.3	<0.3	<0.3	<0.2	<0.01	24	<10	<50	130	360	<50	<50	9.2	60	110	16	9	8.0	0.1
	4/6/79	120	0.6	<0.3	0.3	<0.7	<0.01	10	<10	<50	53	260	<50	<50	<5	<50	120	12	25	11	0.2
	4/12/79	120	0.4	<0.2	1.5	<0.2	<0.01	15	<10	<50	50	790	<50	<50	<5	<50	<50	20	<1	9	0.1
	4/30/79	300	50	9.0	<0.1	1.5	24	25	110	<50	110	70	<50	<5	<5	<50	75	20	54	7	0.1
	5/25/79	<10	<0.3	<0.3	0.7	<0.2	<0.01	<10	10	87	<20	100	<50	<50	<5	<50	<50	22	4	16	<0.1
	7/2/79	90	<0.3	<0.2	<0.1	<0.2	<0.01	<10	<10	226	40	104	<50	<50	<5	<50	<50	16	3	20	<0.1
	7/13/79	20	1	0.3	0.4	0.2	<0.01	10	<10	1200	100	530	<50	220	<5	<50	<50	20	8	10	<0.1
	7/31/79	<10	<0.3	<0.2	0.4	<0.2	<0.01	10	10	<50	77	<100	<50	<50	<50	<50	<50	8	3	7	0.1
Shelton Ch. (Central) (320 Ft. S. Bldg. 00001)	5/6/80	<10	<0.3	0.5	1.3	<0.2	<0.01	<10	<10	<50	<20	140	<50	62	<5	<50	<50	80	10	22	<0.1
	5/21/80	20	<0.3	<0.2	1.2	<0.2	<0.01	<10	<10	<50	<20	297	<50	63	<5	<50	<50	56	8	19	<0.1
	6/11/80	20	<0.3	<0.2	1.4	<0.2	<0.01	<10	<10	<50	<20	154	<50	77	<5	<50	<50	92	<1	25	<0.1
	6/21/80	<10	<0.3	<0.2	1.1	<0.2	<0.01	<10	<10	<50	<20	240	<50	77	<5	<50	<50	80	13	30	<0.1
	5/22/80	25	<0.3	0.4	1.0	<0.2	<0.01	<10	<10	<50	<20	164	<50	106	<5	<50	50	40	3	22	<0.1
	5/30/80	22	1.2	<0.2	1.3	<0.2	<0.01	<10	<10	<50	<20	249	<50	229	<5	220	<50	40	9	26	<0.1
	6/11/80	12	1.2	0.3	0.3	<0.2	<0.01	<10	<10	<50	<20	1065	52	1341	<5	<50	<50	84	20	10	<0.1
	7/15/80	<10	0.6	<0.2	1.2	<0.2	<0.01	<10	<10	<50	<20	610	<50	111	<5	<50	<50	80	17	26	<0.1
	7/25/80	20	<0.3	0.3	1.2	<0.2	<0.01	<10	<10	<50	<20	273	<50	90	<5	<50	<50	64	9	22	<0.1
	7/31/80	25	0.92	0.3	1.0	<0.2	<0.01	<10	<10	<50	20	1061	122	319	<5	<50	57	80	25	22	<0.1
	8/14/80	10	0.00	0.2	0.7	<0.2	<0.01	<10	<10	<50	30	323	<50	349	<5	<50	1040	16	1	13	<0.1
	9/23/80	<10	<0.3	<0.2	0.0	<0.2	<0.01	<10	<10	<50	<20	120	<50	<50	<5	<50	820	80	4	590	<0.1
	10/14/80	10	0.7	<0.2	0.5	<0.2	<0.01	<10	<10	<50	27	151	<50	57	<2	<50	304	24	9	9	<0.1
Shelton Ch. (North) (150 Ft. S. Bldg. 0619)	5/6/80	20	<0.3	2.1	0.5	<0.2	<0.01	<10	<10	<50	<20	394	<50	256	<5	<50	<50	60	8	21	0.2
	5/21/80	70	<0.3	1.0	1.1	<0.2	<0.01	12	<10	<50	<20	523	<50	511	<5	<50	<50	216	27	20	0.2
	6/15/80	70	<0.3	1.1	0.2	0.3	<0.01	<10	<10	<50	<20	1061	<50	1317	<5	<50	<50	176	20	23	<0.1
	6/21/80	20	<0.3	0.3	0.1	<0.2	<0.01	10	10	<50	<20	719	<50	1711	<5	<50	<50	152	23	12	0.1
	5/22/80	30	<0.3	0.3	0.7	<0.2	<0.01	<10	<10	<50	<20	879	<50	253	<5	<50	<50	92	67	20	<0.1
	5/30/80	22	<0.3	0.4	0.3	<0.2	<0.01	<10	<10	<50	<20	3056	<50	502	<5	690	<50	64	193	25	<0.1
	6/11/80	20	<0.3	0.2	<0.1	<0.2	<0.01	<10	<10	<50	<20	545	<50	300	<5	<50	<50	300	82	26	<0.1
	7/15/80	25	<0.3	0.3	<0.1	<0.2	<0.01	<10	<10	<50	<20	1635	<50	1010	<5	<50	<50	100	53.9	16	0.13
	7/25/80	30	<0.3	0.3	<0.1	<0.2	<0.01	12	<10	<50	<20	694	<50	1337	<5	<50	<50	140	19	30	0.13
	7/31/80	22	2.04	0.3	<0.1	0.2	<0.01	14	<10	<50	<20	965	<50	6464	<5	<50	<50	160	14	65	1
	8/23/80	<10	1.0	<0.2	<0.1	<0.2	<0.01	<10	<10	<50	30	265	<50	155	<5	<50	57	20	6	24	0.2
	10/14/80	10	0.7	<0.2	0.2	<0.2	<0.01	<10	<10	<50	110	173	<50	<50	<2	<50	30	20	7	11	<0.1
Crooks Ch. (Picnic) (400 Ft. S. Bldg. 0600)	5/30/80	20	<0.3	0.6	0.3	<0.2	<0.01	<10	<10	<50	<20	1611	<50	239	<5	220	<50	72	145	29	<0.1
	6/11/80	20	0.4	0.6	<0.1	<0.2	<0.01	<10	<10	<50	<20	351	<50	362	<5	<50	<50	200	10	25	0.1
	7/15/80	20	-	<0.6	<0.1	<0.2	<0.01	<10	<10	<50	<20	1620	<50	1276	<5	<50	<50				
	7/25/80	60	<0.3	0.6	<0.1	<0.2	<0.01	14	<10	<50	<20	670	<50	1619	<5	<50	<50	176	26	10	0.19
	7/31/80	65	0.00	0.3	<0.1	<0.2	<0.01	10	<10	<50	<20	402	<50	1631	<5	<50	<50	100	6	20	0.13
	8/23/80	<10	<0.3	0.2	<0.1	<0.2	<0.01	<10	<10	<50	<20	405	<50	710	<5	<50	<50	100	30	16	0.1
	10/14/80	15	0.7	<0.2	<0.1	<0.2	<0.01	<10	<10	54	57	202	<50	194	<2	<50	<50	80	3	14	<0.1

[1] Determined as Methylene Blue Active Substances (MBAS).

TABLE C.2

HISTORICAL WATER QUALITY DATA
U.S. GEOLOGICAL SURVEY

Station No./Location		Date	Parameter			Remarks
USGS 1	NW Stream, near Air Depot Road at SE 29th	6/7/63	Mn	34	µg/l	Surface Water Sample
USGS 2	West Side Creek at Air Depot Blvd.	6/7/63	Cr	129	µg/l	Surface Water Sample
			Mn	26	µg/l	
			Cd	26	µg/l	
USGS 3	Above Sewage O/F at Air Depot & 44th St.	6/7/63	Pb	45	µg/l	Surface Water Sample
			Mn	400	µg/l	
			V	24	µg/l	
USGS 4	Above sewage O/F, 6/7/63 50 yds West Douglas Blvd.	6/7/63	Cd	2,950	µg/l	Surface Water Sample
			Cr	2,180	µg/l	
			Mn	58	µg/l	
			Ni	129	µg/l	
			V	32	µg/l	
USGS 5	TAFB Gate 7 and SE 29th	6/7/63	Al	620	µg/l	Surface Water Sample
			Cd	46,000	µg/l	
			Cr	31,000	µg/l	
			Fe	540	µg/l	
			Mn	1,400	µg/l	
			Ni	242	µg/l	
			Ag	>500	µg/l	Semi-quantitative
*USGS 6	NE 10th, Between Sooner and Air Depot Blvd.	12/12-14/73	Mn (Total)	780	µg/l	Crutcho Creek Surface Water sample
			Mn (Diss.)	730	µg/l	
			Zn (Total)	320	µg/l	
*USGS 7	E. Reno Ave., 1/2 mile E. of Mid-west	12/12-14/73	Mn (Total)	840	µg/l	Soldier Creek Surface Water Sample
			Mn (Diss.)	840	µg/l	
			Zn (Total)	530	µg/l	

*Note: Sampling station located north of Tinker AFB.

TABLE C.3

OKLAHOMA WATER RESOURCES
BOARD DATA

Station No./Location	Date	Parameter			Remarks
E. Soldier Creek at Douglas Boulevard	7/14/81	Cr	20,650	mg/kg	Sediment Sample
		CN	161	mg/kg	
		Ni	6,900	mg/kg	
		Cd	305	mg/kg	
		Rn	153	mg/kg	
		Zn	295	mg/kg	
Crutcho Creek at Fire Training Area	7/14/81	COD	79,530	mg/l	Soil Sample
		Pb	109	mg/kg	
		O & G	106,200	mg/kg	
		TOC	7377	mg/kg	

Source: Thomas H. Maiello
Oklahoma Water REsources Board 16 November, 1981

TABLE C.4

WATER QUALITY DATA COLLECTED FOR THE Ph.D. DISSERTATION
PREPARED BY R. H. FRANK, JR., ENTITLED
"TRACE METAL POLLUTION OF THE NORTH CANADIAN RIVER BASIN,"
1969, UNIVERSITY OF OKLAHOMA

Station # and Location	Date	Parameters (mg/l)						
		Cd	Cr (tot.)	Cu	Fe	Ni	Zn	Ag
Soldier Creek (at Interstate 40, Station III-B)	8/16/67	0.05	0.76	0.15	0.74	22.0	0.13	0.03
	9/15/67	0.07	0.25	0.18	2.80	0.44	0.28	0.01
	10/13/67	0.41	3.50	0.18	5.00	1.10	0.50	0.03
	11/12/67	0.03	0.35	-	2.10	0.15	0.16	0.03
	11/19/67	0.10	3.20	-	0.44	0.22	0.08	0.01
	12/19/67	0.15	0.36	0.15	0.90	0.66	0.05	0.01
	12/24/67	0.30	0.82	0.23	1.95	1.80	0.16	0.01
	12/31/67	0.15	0.70	-	0.90	2.60	0.10	0.03
	1/29/68	0.05	0.88	0.18	0.74	0.22	0.22	0.03
	2/16/68	1.10	0.71	0.34	2.10	0.66	0.28	0.03
	3/27/68	0.15	3.00	0.4	1.95	0.66	0.22	0.07
	3/29/68	0.41	3.40	0.4	14.00	2.0	0.55	2.15
	4/1/68	2.80	1.40	0.5	1.80	0.54	1.10	0.08
	4/2/68	0.12	1.10	0.4	0.90	0.44	0.28	0.02
	4/3/68	0.15	1.90	0.4	0.60	0.44	0.38	0.01
	4/4/68	0.38	1.50	0.34	0.70	0.90	0.35	0.03
	4/5/68	0.90	1.10	0.34	2.25	0.90	0.35	0.17
	4/6/68	0.05	0.98	-	0.60	0.90	0.13	0.01
	5/8/68	1.30	2.50	0.4	5.00	6.50	0.31	0.03
Crutcho Creek (at Interstate 40 Station III-C	9/5/67	0.25	0.90	0.18	4.00	1.10	0.51	0.01
	9/6/67	0.25	0.58	-	2.70	0.22	0.10	-
	12/10/67	0.30	-	0.15	1.20	0.01	0.05	0.01
	2/20/68	0.08	0.05	0.25	0.15	0.10	0.05	-
	3/29/68	0.23	1.80.	0.15	0.60	0.44	1.5	0.01
	4/5/68	0.25	0.05	0.18	0.30	-	0.10	0.01
Industrial Blvd Drainage Ditch to Soldier Creek (at Interstate 40, Station III-D)	4/5/68	2.0	7.2	0.55	3.60	1.80	0.58	0.04
	5/8/68	0.5	1.5	0.25	0.74	0.22	0.45	0.003

APPENDIX D

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Directorate of Distribution				
Petroleum Storage	290	X	X	CES* Contractor
LOX Systems	1050			
Fuel Services Section	240			
Woodworking Support Section	1			
Paint Support Section	1	X	X	CES Contractor
Installation & Repair Section	1	X		
Central Processing Unit	506	X		
Receiving & Processing Section	506	X		
Air Freight Section	260	X		
Packing Section	506	X	X	DPDO
Packaging Services Section	1	X		
Cargo Operations	506			
Rail Operations	24	X	X	
Drum Storage	1121			CES Contractor
Hazardous Storage Unit	16	X	X	DPDO and CES Contractor

* CES - Civil Engineering Squadron

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-si T.S.I
Directorate of Distribution (Con't)				
Directorate of Maintenance				
Aircraft Division				
Cargo Dock Unit	230	X	X	MADE* tracto
Cargo Structural Unit	240	X	X	MADE C tracto
Cargo Systems Unit	240	X		
Cargo Pre & Post Dock Unit	3105			
Cargo Avionics Unit	3105			
Disassembly & Cleaning Unit	2122	X	X	IWTP** MADE Co tractor
Paint Unit	2280	X	X	IWTP an MADE Co: tractor
Servicing Unit	2122	X		
Fighter Aircraft Unit	3001			
Fighter Structural Unit	3001	X		
Fighter Systems Unit	3001			
Sheetmetal Backshop Unit	3001	X	X	MADE Con tractor
Fighter Avionics Unit	3102	X		
Bomber Docks	2121	X	X	MADE Con- tractor

* MADE - Office for Plant Management Division

**IWTP - Industrial Waste Treatment Plant

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Aircraft Division (Con't)				
Bomber Docks	2121	X	X	MADE Contractor
Bomber Ramp	2121	X		
Bomber Landing Gear Shop	2121	X		
Bomber Sealant Shop	2122	X		
Bomber Glass & Rubber Shop	2122	X		
Bomber Structural Unit	2121			
Bomber Systems Unit	2121	X		
Bomber Pre & Post Dock Unit	3102	X	X	MADE Contractor
Bomber Avionics Unit	2121			
Material Control Section	3001	X	X	MADE Contractor
Transient Alert Branch	240/238	X	X	IWTP and DPDO
Plant Management Division				
Mechanical Installation Sect.	3001	X	X	IWTP
Installation Sect.	2129	X	X	IWTP and MADE Contractor
Metal Processing Sect.	2101	X		
AGE Contractor	2101	X		IWTP and MADE Contractor
Area A Equipment Sect.	210	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Plant Management Division (Con't)				
Area B Equipment Sect.	2210			
Area C Equipment Sect.	3001	X		
Elec. & Electrical Repair Unit	3001	X		
Numerical & Computer Control Repair Unit	3001	X		
Mechanical Unit	3001	X	X	MADE Contractor
Pipefitter & Refrig. Unit	3001	X		
B3108 Test Equip Unit	3108	X	X	MADE Contractor
Engine Test Equip Unit	3234	X		
Miscellaneous Services Sect.	101			
Transient & Mat'l Processing Sect.	3001	X	X	DPDO
Propulsion Division				
Parts Inspection Unit	3001	X	X	IWTP and MADE Contractor
Parts Processing Unit	3001	X	X	MADE Contractor
Cleaning Subunit	3001	X	X	MADE Contractor
Blasting Subunit	3001	X	X	IWTP and MADE Contractor
Disassembly Unit	3001			

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Propulsion Division (Con't)				
TF30 Rotor Unit	3001	X	X	MADE Contractor
TF30 Assembly Unit	3001	X	X	MADE Contractor
J57 Rotor Unit	3001	X	X	DPDO
J57 Assembly Unit	3001	X	X	DPDO
J75 Assembly Unit	3001	X	X	MADE Contractor
TF41 Assembly Unit	3001	X	X	MADE Contractor
TF33 Assembly Subunit	3001	X	X	DPDO
TF33 Rotor Subunit	3001	X	X	MADE Contractor
TDR* & EACI** Section	3001	X		
Fan Jet Machining Subunit	3001	X	X	DPDO
Jet Machining Subunit	3001	X	X	DPDO
Lapping & Rework Subunit	3001	X	X	MADE Contractor
Heavy Grinding Subunit	3001	X		
Light Grinding Subunit	3001	X	X	DPDO
Hour Glass Case Subunit	3001	X	X	MADE Contractor
Specialized Machining Subunit	3001	X	X	MADE Contractor

* Tear-down Deficiency Report

** Engine Analysis Condition Report

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Propulsion Division (Con't)				
Heavy Case Subunit	3001	X	X	MADE Contractor
Heavy Grinding Subunit	3001	X	X	MADE Contractor
Component Machining Subunit	3001	X	X	MADE Contractor
Rotor Component Mach. Unit	3001	X	X	MADE Contractor
Turbine Blade Unit	3001	X	X	MADE Contractor
Gear Box Unit	3001	X	X	MADE Contractor
pressor Blade Unit	3001	X		
Chrome Plating Subunit	3001	X	X	IWTP and MADE Contractor
Nickel Plating Subunit	3001	X	X	IWTP and MADE Contractor
Misc. Plating Subunit	3001	X	X	IWTP and MADE Contractor
Solution Maintenance Subunit	3001	X	X	IWTP and MADE Contractor
Heat Treat Subunit	3001	X	X	MADE Contractor
Plasma Spray Subunit	3001	X	X	MADE Contractor
asting Subunit	3001	X	X	IWTP and MADE Contractor
Sermetal Subunit	3001	X	X	MADE Contractor

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Propulsion Division (Con't)				
Coating Subunit	3001	X	X	MADE Contractor
Vane & Shroud Rework Unit	3001	X		
Electric Welding Subunit	3001	X		
Gas Welding Subunit	3001	X		
Resistance Welding Subunit	3001	X		
Material Control Section	3001	X	X	DPDO
Test Section	3234	X	X	IWTP and MADE Contractor
ıtegorization Unit	3703			
Final Preparation Unit	3703	X	X	IWTP and MADE Contractor
Test Section	3703	x	X	IWTP
Reclamation Unit	2101	X	X	MADE Contractor and DPDO
Stripping Unit	2101	X	X	IWTP and MADE Contractor
Quality Division				
Cargo Quality Section	230			
Bomber Quality Section	2121			
ghter Quality Section	3001			

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Quality Division (Con't)				
Chemical Laboratory Section	3001	X	X	IWTP AND MADE Contractor
Non-Destructive Insp. Section	3001	X	X	IWTP and MADE Contractor
Metallurgical Section	3001	X	X	MADE Contractor
Material Testing Section	3001			
Jet Engine Quality Section	3001			
Machining and Special Processes Quality Section	3001			
Flight Control and Accys. Quality Section	230			
Engine Accys & Trans. Qlty. Sect.	3001			
Accessories Division				
Area A Precision Measurement (PME) Section	201	X		
Special Measurement Supt. Sect.	3113	X		
Area C PME Section	3113	X		
Cabin Pressure Regulator and Valve Unit	210	X	X	IWTP
Turbine Powered Accys. and Missile Maintenance Unit	210	X	X	MADE Contractor

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Accessories Division (Con't)				
Oxygen & Assoc. Equipment Unit	1055	X	X	MADE Contractor
Air Accys. Testing Unit	210	X	X	MADE Contractor
Electrical Accys. Unit	3001	X	X	IWTP and MADE Contractor
Electro-Mechanical Accys. Unit	3001	X	X	IWTP
Governor, Misc Engine Accys. Overhaul & Test Unit	3001	X	X	MADE Contractor
Fuel Control Overhaul Unit	3001	X	X	MADE Contractor
Accessories Unit	3001	X	X	IWTP
Machine Unit	3001	X	X	MADE Contractor
Accessories Test Unit	3108	X	X	MADE Contractor
Automatic Pilot Unit	230	X	X	IWTP and MADE Contractor
Engine Instrument Unit	230	X		
Flight Control Unit	230	X	X	IWTP and MADE Contractor
Gen. Trans. Overhaul Unit	2210	X	X	IWTP and MADE Contractor
Specialized Transmission Overhaul Unit	2210	X	X	DPDO
Bearing Unit	3001	X	X	MADE Contractor

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Accessories Division (Con't)				
Machine Shop Unit	2210	X	X	IWTP and MADE Contractor
Manufacture Subunit	3001	X	X	MADE Contractor
Tubing & Cable Mfg. Subunit	3001	X	X	DPDO
Tubing & Cable Repair Subunit	3001	X	X	DPDO
Foundry	2101			
Tank & Cooler Unit	3001	X	X	IWTP and MADE Contractor
General Machine Shop Unit	3001	X	X	MADE Contractor
Numerical Control Unit	3001	X	X	DPDO
Woodmill Subunit	2121	X		
Manufacture and Radome Subunit	230	X	X	IWTP and MADE Contractor
Mfg. & Repair Glass Subunit	230	X		
Parachute Subunit	229	X	X	MADE Contractor
Rubber Subunit	229	X	X	MADE Contractor
Tooling/Tool & Die Subunits	3001	X	X	MADE Contractor
Grinding Subunit	3001	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Accessories Division (Con't)				
Pattern Shop	3001	X	X	DPDO
Gas and Electron Beam Subunit	3001			
General Welding Subunit	3001	X		
Accessories Welding Subunit	3001	X		
Air Accys. Material Control Sect	230			
ALC Miscellaneous Shops				
Specialized Eng. Branch	3220	X		
Vocational Technical Training Center	675	X	X	MADE Contractor
2953 Combat Logistic Supp. Sqdn	3001	X	X	MADE Contractor
2854 Air Base Group				
Printing & Duplicating Sect	1	X	X	IWTP
Small Arms Marksmanship Br.	1023			
Photo Lab.	4026	X	X	Silver recov. then IWTP
Aircrew Life Support Branch	3102	X		
Restaurant Equip. Maintenance	203	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
2854 Air Base Group (Con't)				
Restaurant Vehicle Maint.	769	X		
Bowling Lanes	5703			
Auto Hobby Shop	6002	X	X	CES Contractor
Ceramics Hobby Shop	6002			
Wood Hobby Shop	6002			
General Purpose Maintenance	2101	X	X	CES Contractor
Special Purpose Vehicle Maintenance	2101	X	X	CES Contractor
Refueling Maintenance	2110	X	X	CES Contractor
2854 Civil Engineering Squadron				
Fire Protection Branch	461	X		
Protective Coating Unit	414	X	X	CES Contractor
Metal Working Unit	414			
Plumbing Unit	414	X		
Structural Unit	414			
Exterior Electrical Unit	414	X	X	CES Contractor
Interior Electrical Unit	414	X	X	CES Contractor
Grounds/Pavements Section	773	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
2854 Civil Engineering Squadron (Con't)				
Golf Course Maintenance	6601	X		
Liquid Fuels System Maint.	246	X	X	CES Contractor
Heating Systems Unit	414	X	X	CES Contractor
Refrigeration/Air Conditioning	414	X	X	CES Contractor
Electrical Power Production	414	X	X	CES Contractor
Entomology Unit	773	X	X	CES Contractor
Water/Waste Unit	62516	X	X	CES Contractor
USAF Hospital				
Dental Clinic	5801	X	X	CES Contractor
Clinical Lab	5801	X		
Radiology	5801	X		
Medical Maintenance	5801	X		
Surgery	5801			
Veterinary Services	702	X		
3 Combat Communications Group				
Electrical Power Production	1010	X	X	CES contractor

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
3 Combat Communications Group (Con't)				
Refrig./Air Conditioning Maint.	1010	X		
Navigational Aids Maintenance	900			
Radar Maintenance	7001	X		
Radio Maintenance	7003			
Longhaul Maintenance	7003			
Ground/Air Maintenance	7003			
Wideband Maintenance	904	X		
DSTE Maintenance	7003	X		
Teletype Maintenance	7003	X		
Cryptographic Maintenance	7003			
Inside Plant	7003	X		
Outside Plant	7003			
Vehicle Maintenance	1001	X	X	CES Contractor
6 Weather Squadron				
Vehicle Maintenance	2101	X	X	CES Contractor, oil/water separator and IWTP
507 Tactical Flighter Group				
Flight Line Maintenance	1070	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
507 Tactical Flighter Group (Con't)				
Jet Engine Shop	1070	X	X	CES Contractor
Communications/Navigation Shop	1030	X		
Auto Pilot/Instruments	1030			
Inertial Navigation Shop	1030			
Electronic Countermeasures	1072			
Weapons Control System	1030			
Welding	1030			
Structural Repair	1030			
Machine Shop	1030			
Survival Equipment	1030			
Pneudraulics	1030	X	X	CES Contractor
Mechanical Accys.	1041	X	X	CES Contractor
Electric Shop	1030	X		
Non-Destruct. Inspect.	1030	X		
Powered Aircraft Ground Equip. (AGE)	1041	X	X	CES Contractor
Inspection	1030			
Corrosion Control	1030	X	X	CES Contractor

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
507 Tactical Flighter Group (Con't)				
Fuel System Repair	1030	X	X	CES Contractor
Repair & Reclamation	1037			
Egress	1030	X		
Loading/LSC		X		
Armament/Gun Shop	1030	X	X	CES Contractor
Life Support	1048	X		
Munitions Storage	1030	X		
552 Aircraft Warning and Control Wing				
Acft. Gen. Sqdn. (AGS) E3A Aircraft Maint. Unit (AMU)	230	X	X	CES Contractor
AGS-C135 AMU	230	X	X	CES Contractor
Component Repair Sqdn. (CRS)-Comm. Shop	230			
CRS-Nav/Instrum Shop	230			
CRS-Computer Shop	230			
CRS-Radar Shop	230	X		
CRS-Corrosion Control	289	X	X	CES Contractor

MASTER LISTS
INDUSTRIAL SHOPS

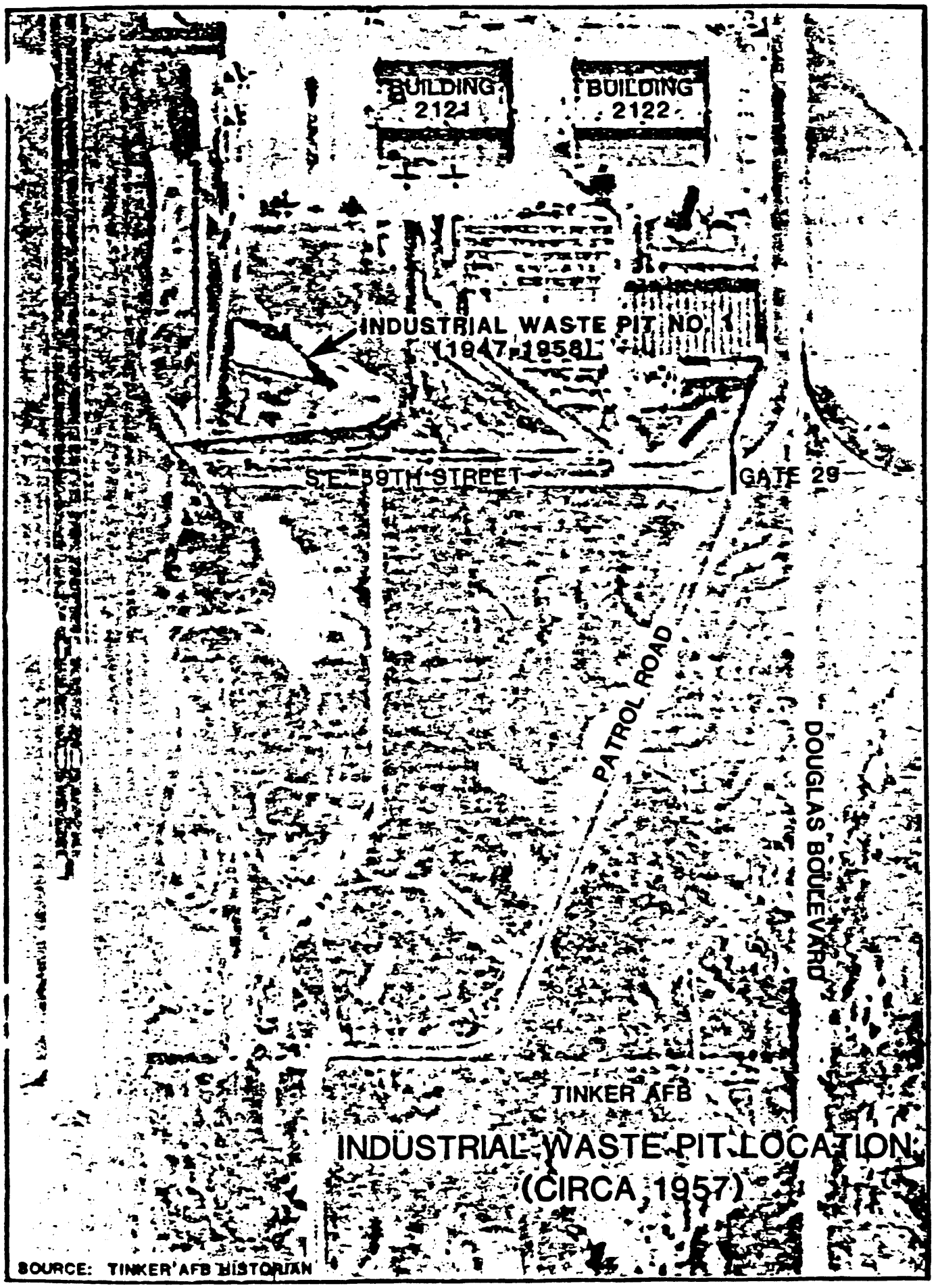
Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-sit. T.S.D
552 Aircraft Warning and Control Wing (Con't)				
CRS-Fuel Cell Section	230	X	X	CES Contractor
CRS-Maintenance Inspection	230	X	X	CES Contractor
CRS-Repair & Reclamation	230			
CRS-Flight Simulator	283	X		
CRS-AGE Branch	228	X	X	CES Contractor
CRS-Electric Shop	230	X		
CRS-Environ. Control Systems Shop	230	X	X	CES Contractor
CRS-Hydraulic Shop	230	X	X	CES Contractor
CRS-Jet Engine Shop	228	X	X	CES Contractor
CRS-Sheet Metal/Machine Shop	230	X		
CRS-Welding Shop	228			
Wing Life Support	221			
1985 Communications Squadron				
Power Production	3001	X	X	DPDO
Navigational Aids Maintenance	18			

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
1985 Communications Squadron (Con't)				
Radar Maintenance	249			
Weather Maintenance	219			
Radio Maintenance	18			
TV Maintenance	18			
Centralized Repair Activity	2101			
Teletype Maintenance	18			
Crypto Maintenance	3001			
Defense Property Disposal Office	3767	X	X	DPDO Contractor Disposal

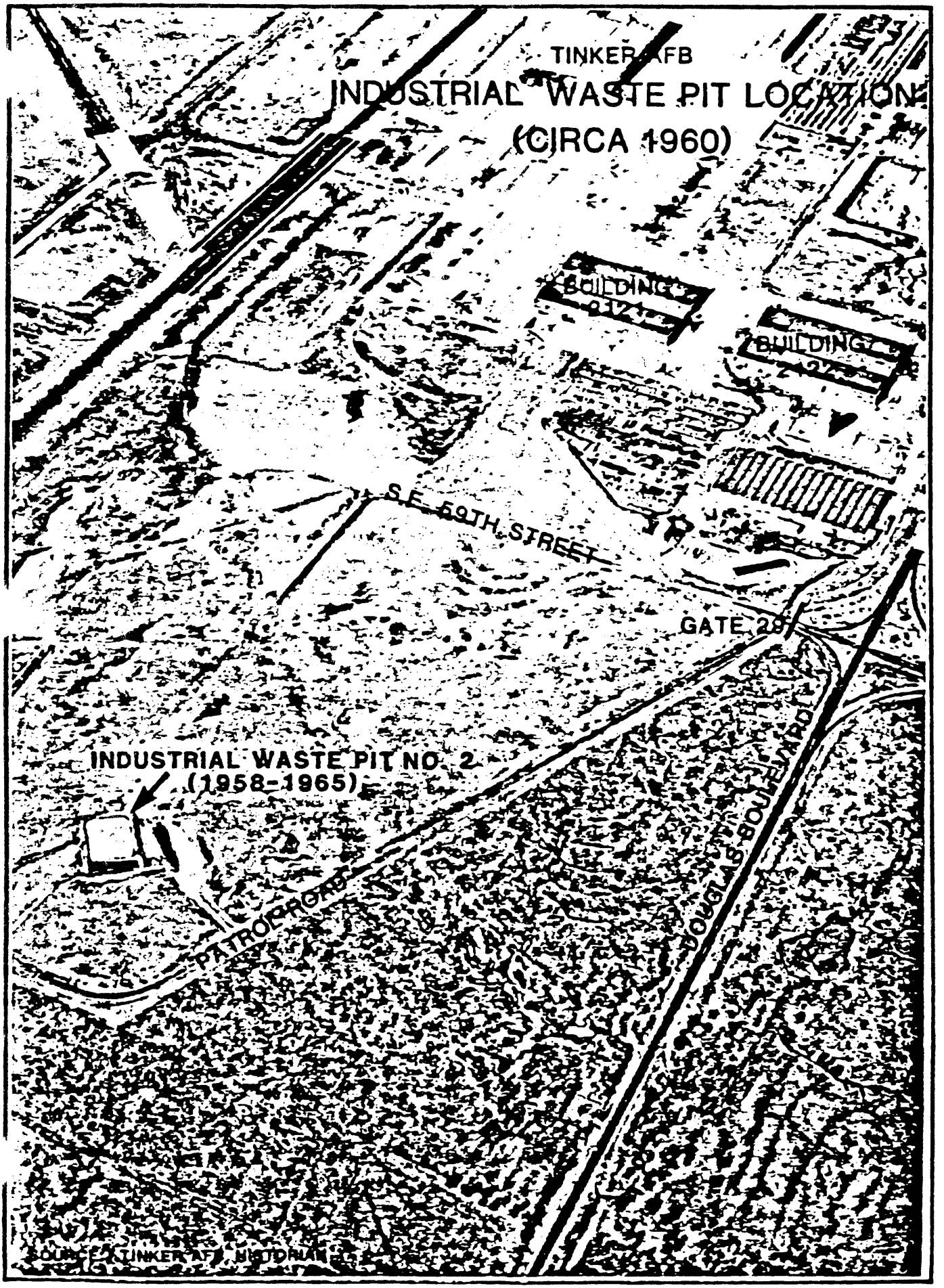
APPENDIX E

PHOTOGRAPHS



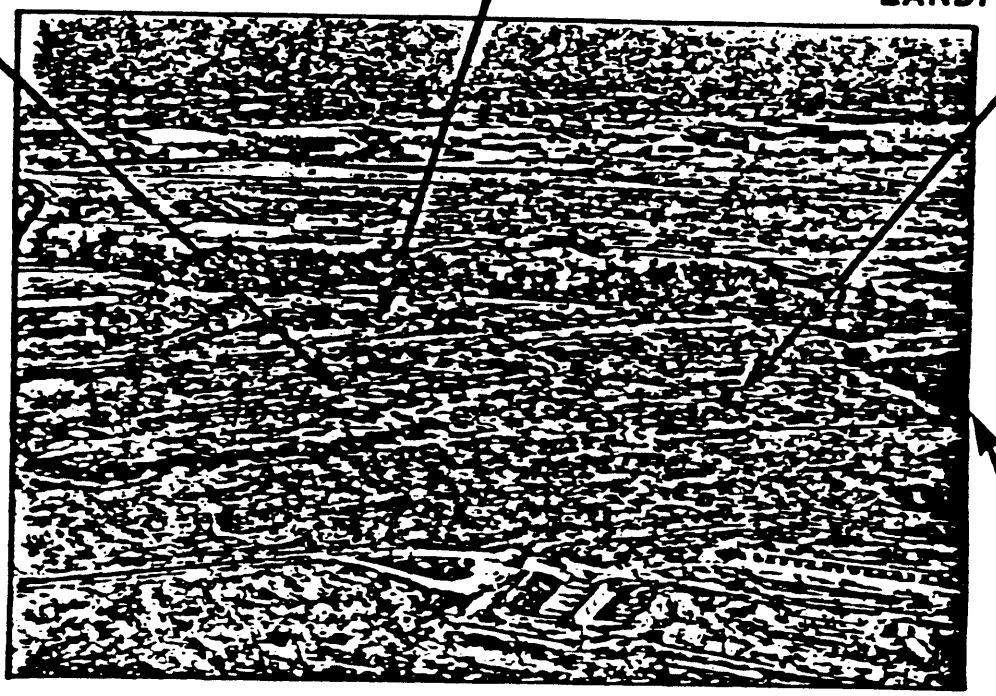
INDUSTRIAL WASTE PIT LOCATION (CIRCA 1957)

SOURCE: TINKER AFB HISTORIAN

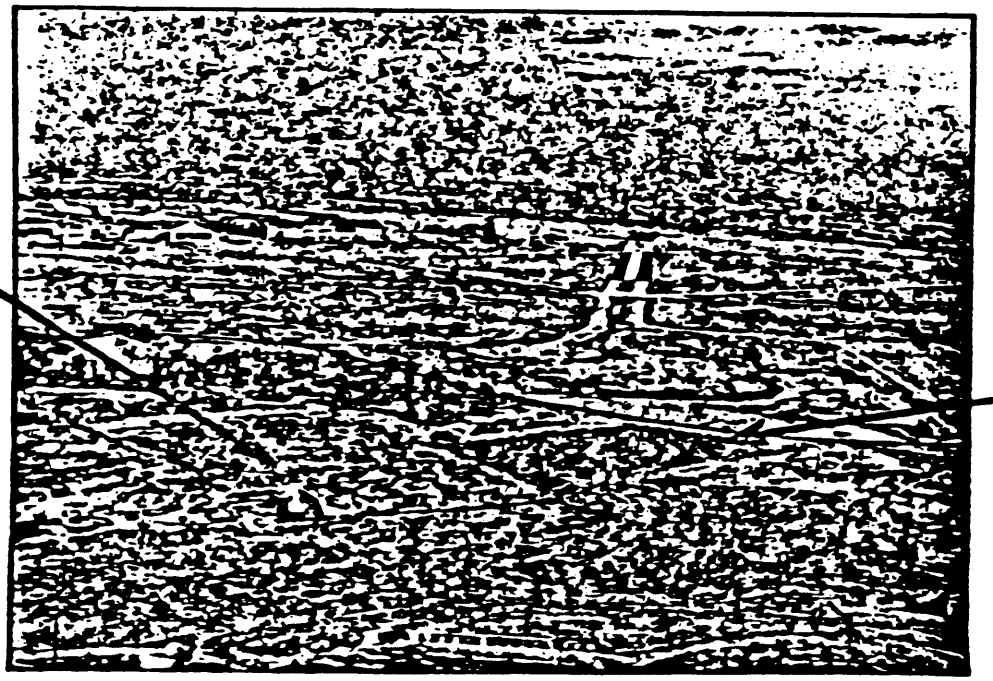

TINKER AFB
INDUSTRIAL WASTE PIT LOCATION
(CIRCA 1960)
BUILDING
BUILDING
S.E. 59TH STREET
GATE 28
INDUSTRIAL WASTE PIT NO. 2
(1958-1965)
PATROL ROAD
DOUGLAS BOULEVARD
SOURCE: TINKER AFB, HISTORIAN

LANDFILL NO. 1

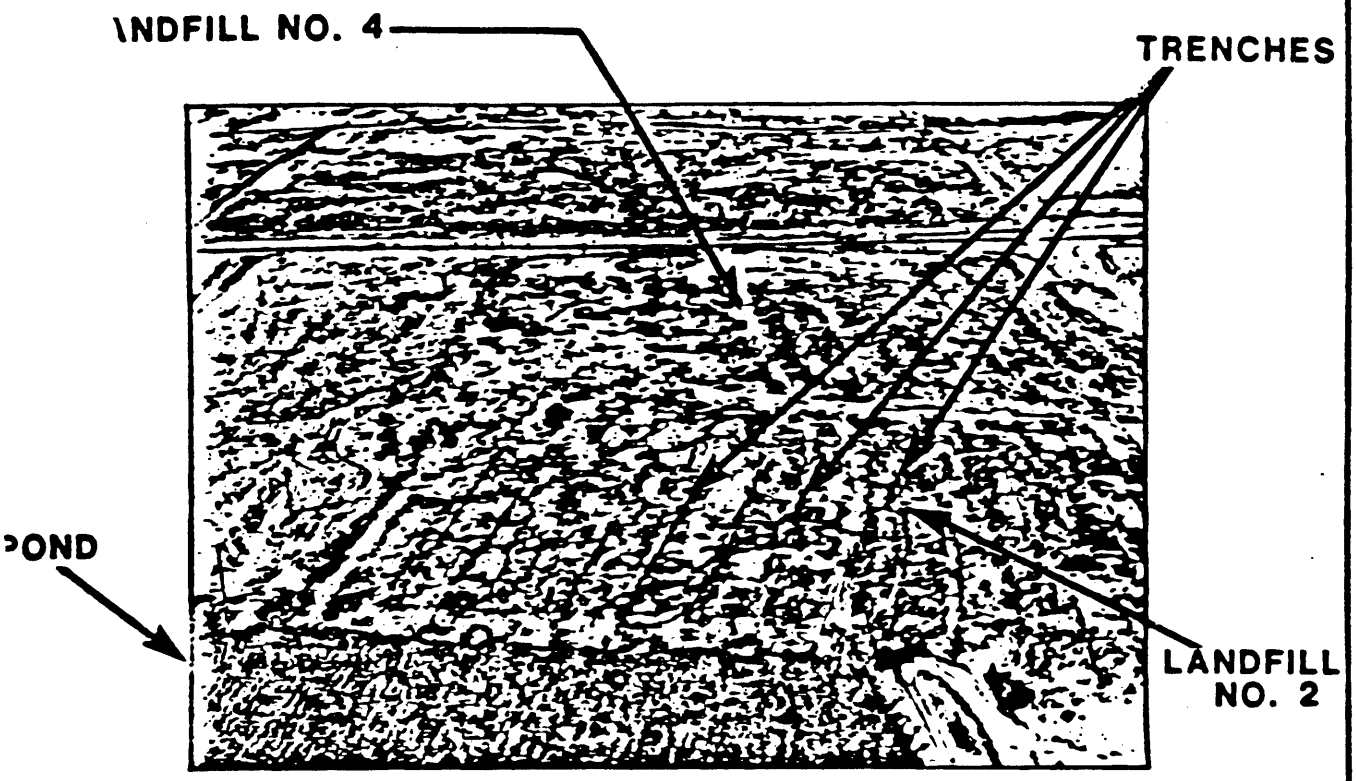
LANDFILL NO. 1



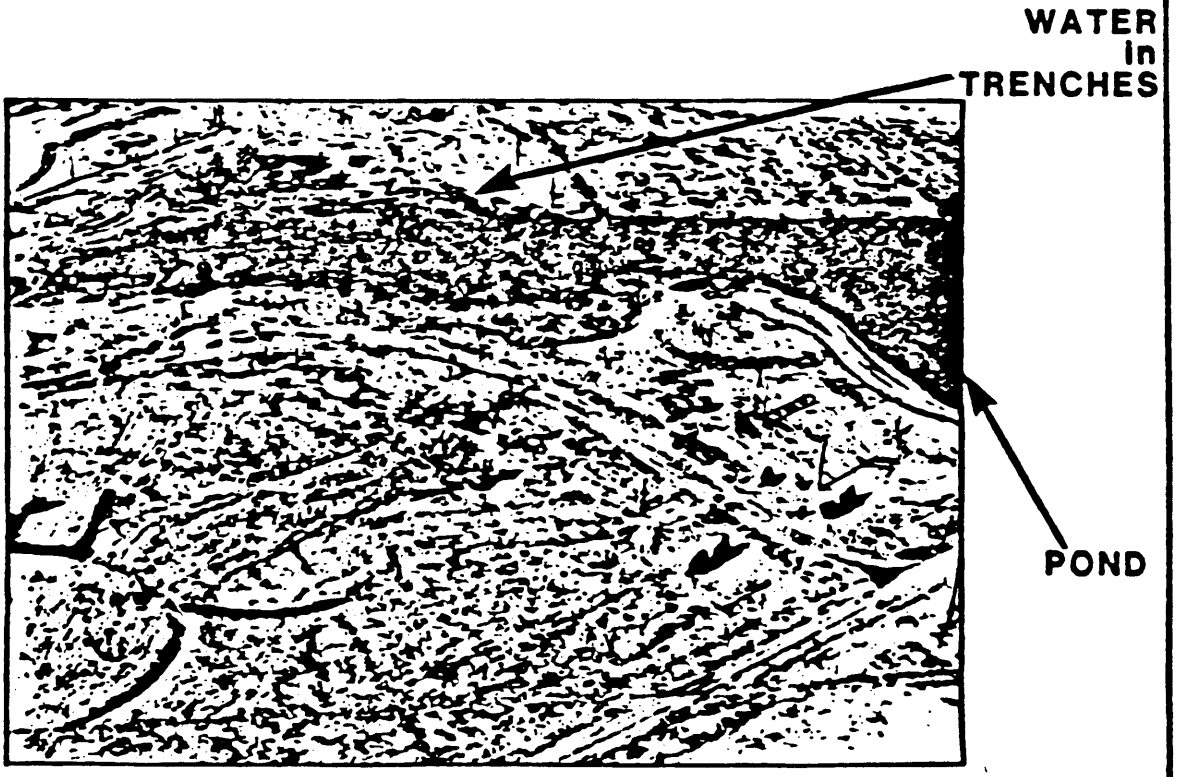
LANDFILLS NO. 2, NO. 3 & NO.4



LANDFILL NO. 2 & RECREATIONAL POND



LANDFILLS NO. 2 & NO. 4



POND at LANDFILL NO. 2

APPENDIX F

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RADIAN CORPORATION

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Volume I

INSTALLATION RESTORATION PROGRAM
PHASE II - FIELD EVALUATION
STAGE 1

DRAFT FINAL REPORT

FOR

TINKER AFB, OKLAHOMA

AIR FORCE SYSTEMS COMMAND
HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION

NOVEMBER, 1984

PREPARED BY

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SUMMARY

Background and Purpose

The Department of Defense (DOD) is conducting a nation-wide program to evaluate waste disposal practices on DOD property, control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Initial Assessment/Record Search; Phase II, Problem Confirmation; Phase III, Technology Base Development; and Phase IV, Remedial. The United States Air Force (USAF) has initiated an IRP investigation at Tinker Air Force Base near Oklahoma City, Oklahoma.

Phase I studies for the Tinker AFB Installation Restoration Program were completed in April 1982. The purpose of the Phase I study was to conduct a records search for the identification of past waste disposal activities which may have caused ground-water contamination and the migration of contaminants off-base.

Fourteen individual sites at Tinker AFB were identified as possibly containing hazardous waste. The potential for adverse environmental consequences of each site was evaluated with a rating or scoring system. This system took into account such factors as the site environmental setting, the nature of the wastes present, past waste disposal practices and the potential for contaminant migration.

Of the fourteen individual sites identified, eight sites, comprising four zones, were selected for Phase II studies. Two additional problem areas, not addressed in Phase I, were added to the list of sites for Phase II studies. These are the Base water supply wells and the wells in Building 3001. Radian Corporation performed the Phase II (Stage 1) Field Evaluation under USAF Contract No. F33615-83-D-4001, Delivery Order 0004.

waste, and covering with soil. The depth of the trenches has not been accurately recorded; it is probable that the depth is largely related to the ease of excavation of the shallow soil above shale bedrock, generally 10 to 15 feet below land surface. The landfills are visible today as features slightly elevated above the surrounding topography, with a hummocky surface corresponding to the former trenches that have undergone differential compaction. Most waste deposited in the landfill consisted of general base refuse, paper, trash, construction debris, and garbage. Table 1 identifies the features of each landfill and lists the probable contents at each site.

Liquid wastes and sludges generated during the period 1947-1965 were directed to industrial waste pits located in the southeast portion of the Base. These sites, Industrial Waste Pits 1 and 2, were used for the disposal of waste streams originating from the various aircraft maintenance shops at Tinker AFB. The streams were thought to contain high levels of heavy metals, and a variety of organic compounds (solvents and cleaners). The pits were probably unlined, with the materials in the pits periodically burned (Engineering Science, 1982).

Site Descriptions

The Phase II (Stage 1) Field Evaluation was organized by zones; each zone consisting of one or more waste disposal sites grouped together geographically or functionally. Zone 1 consists of four landfills, Landfills 1, 2, 3 and 4, located on the southwest part of the Base. Zone 2 consists of two landfills (Landfills 5 and 6) on the south side of the Base on opposite sides of the N-S runway. Zones 3 and 4 are the sites of Industrial Waste Pits Nos. 2 and 1, respectively, on the southeast part of the Base. Zone 5 consisted of the activity involved in the sampling of all water-supply wells at Tinker; and Zone 6 consisted of the evaluation of trichloroethylene in water-supply wells 18 and 19 located in Building 3001. The locations of the zones of investigation are shown on Figure 1.

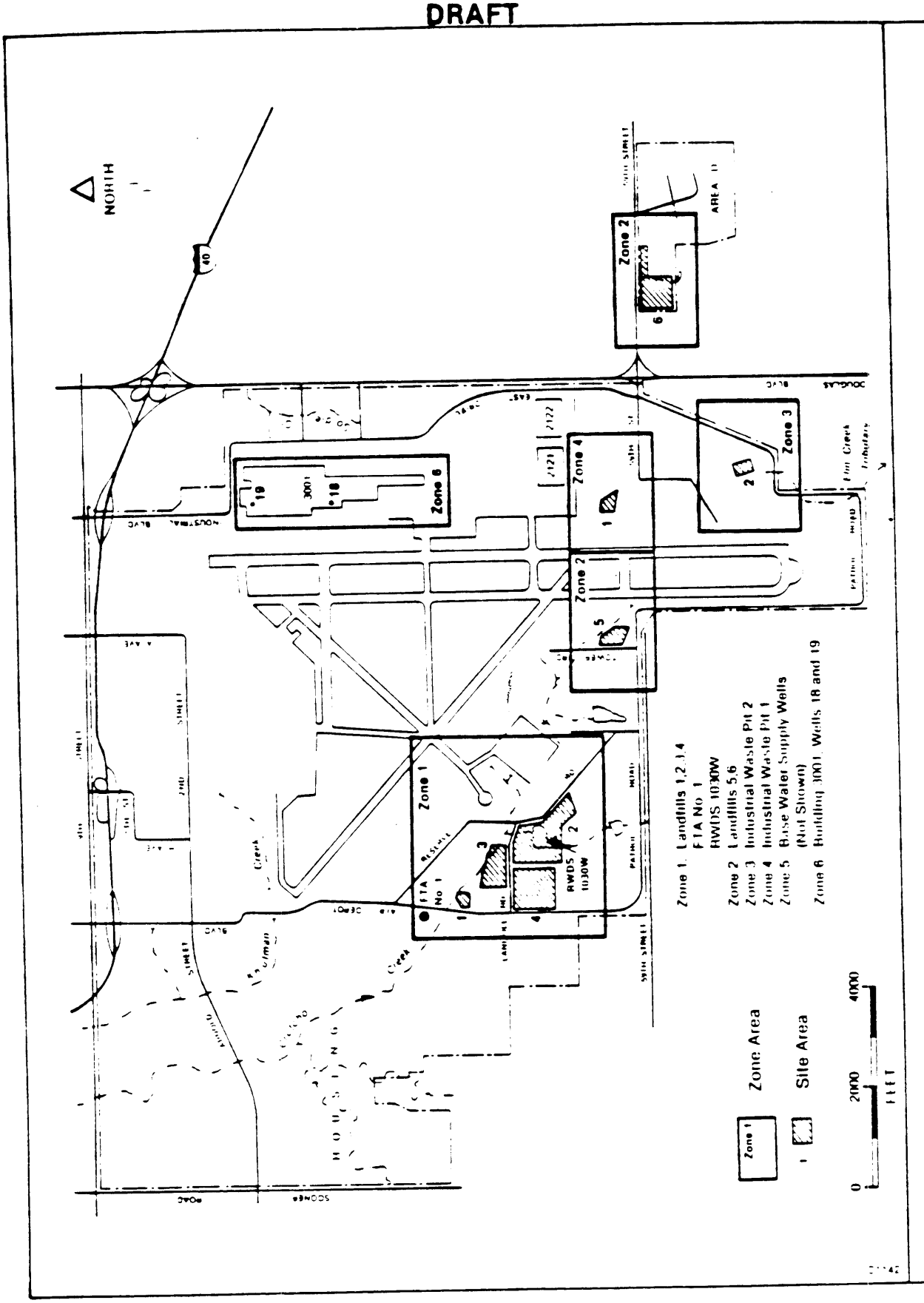

Figure 1. Zones of Investigation, Tinker, AFB.

Zone 3

Zone 3 is the former site of a surface impoundment located north of Patrol Road (betwen the main N-S runway and Douglas Boulevard) on the south side of the Base. The impoundment, Industrial Waste Pit 2, was in operation from 1958 to 1965. The pit received large quantities (i.e., more than 85 55-gallon drums) of waste oils, cyanides, chromates, phenols, solvents and waste acids and alkalies. No data are available concerning construction of the pit. It has been closed and the land surface regraded to approximate original contours. Grass now covers the site, obscuring the original limits of the pit.

Zone 4

Zone 4 encompasses Industrial Waste Pit 1 at Tinker AFB. The site is located in the south-cental portion of the Base. This pit, in operation from 1947 to 1958, received industrial wastes similar to those in Industrial Waste Pit No. 2 (Zone 3).

Zone 5

Activities in Zone 5 consisted of sampling all Base water supply wells. Tinker AFB presently obtains water supplies from a system of 27 water wells constructed along the east and west Base boundaries. All Base wells are completed in the Garber-Wellington Aquifer. Base wells range from 700 to 900 feet in depth, with yields ranging from 205 to 250 gallons per minute. The wells incorporate multiple screens, deriving water supplies from sand zones that vary in thickness from 103 to 184 feet (Wickersham, 1979).

Zone 6

Activities in Zone 6 consisted of evaluating the occurrence of trichloroethylene in Tinker AFB water supply wells 18 and 19 located in Building 3001.

TABLE 2. ANALYTICAL SCHEDULE FOR SOIL AND WATER SAMPLES, TINKER AFB

Parameter	Zones
Barium	2
Iron	1, 2
Manganese	1
Total Organic Halogen (TOX)	1, 2, 3, 4
Oil and Grease	1, 2, 3, 4
Total Organic Carbon (TOC)	1, 2, 3, 4
Cyanide	1, 2, 3, 4
Metals (Cd, Cr, Ni, Cu, Zn, Pb, Hg)	1, 2, 3, 4
Volatile Hydrocarbons (EPA 601)	5
Phenol	1, 2, 3, 4
Pesticides and Herbicides	1, 2
Trichloroethylene and tetrachloroethylene (EPA 601)	6
Acid Neutral Extractable Organic Priority Pollutants (modified EPA 625)	
- selected wells	1, 2, 3, 4, 5
- selected soils	3, 4
Volatile Organic Priority Pollutants (EPA 624)	
- selected wells	5

Other Sampling: In addition to the monitor well sampling, selected surface water samples were also collected. Leachate seeps were sampled by excavating a small trench at the site of the seep and allowing water to accumulate. The surface impoundment at Landfill 2 was sampled by compositing grab samples from four randomly selected locations within the pond. Samples were submitted for the same chemical analyses as were the ground-water samples. An aliquot of the composited pond sample was also provided to the Base Bioenvironmental Engineering staff for radiochemical analysis.

Results of Analysis

In general, the Phase II (Stage 1) investigation documented only limited contaminant movement from the waste sites investigated. However, analytical data supplied by the State of Oklahoma suggest that volatile organic priority pollutants may be important species at all waste disposal sites. A summary of the analytical data for Zones 1 through 4 is provided in Table 3.

With the exception of wells in the vicinity of Building 3001, all Base water supply wells appear to be unaffected by contaminant migration from Base waste disposal sites.

Based on the results of the Phase II (Stage 1) investigation, conditions at Zone 6 consist of a zone of contamination, dominantly trichloroethylene, of unknown source and extent, in the vicinity of Building 3001. The occurrence of contamination is limited to relatively shallow zones.

Recommendations

Based on the findings of this study, Radian recommends certain follow-up investigations to resolve remaining issues. These recommendations and issues addressed are listed in Table 4, in order of priority. The selection and prioritization criterion is the verification of impacts on possible receptors.

TABLE 4. RECOMMENDATIONS

Problem Area or Site No.	Recommended Action	Rationale
Zone 6	Investigate hydrogeologic conditions and contaminant occurrence in the vicinity of Building 3001, as provided in Delivery Order 21.	Occurrence of TCE in Well 18 suggests shallow source/occurrence. Need to document area of contamination and movement.
Zone 2 (Landfill 6)	Investigate hydrogeologic conditions and contaminant occurrence in the vicinity of Landfill 6, as provided in Delivery Order 21.	Hydrocarbon contamination reported by Oklahoma State Department of Health in a private well, immediately northeast of Landfill 6. Possible source is Landfill 6.
All Zones	Investigate the occurrence of volatile halocarbons and aromatics in all monitor wells by resampling and analysis by EPA Methods 601 and 602 (double column).	Oklahoma State Department of Health data suggest existence of volatile contaminants in ground water.
Zone 1	Investigate the seasonal variations in water quality in the existing monitor wells along Crutcho Creek by conducting a quarterly sampling program for a period of one year. Analyses should be for total organic carbon, total organic halogen, and the metals on the parameter list in the current Statement of Work, Fe, Mn, Cd, Cr, Ni, Cu, Zn, Pb and Hg.	Data from original investigation do not agree with Phase II (Stage 1) data.

1.0 INTRODUCTION

The Department of Defense (DOD) is conducting a nation-wide program to evaluate waste disposal practices on DOD property, control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Initial Assessment/Record Search; Phase II, Problem Confirmation; Phase III, Technology Base Development; and Phase IV, Operations. The United States Air Force (USAF) has initiated an IRP investigation at Tinker Air Force Base near Oklahoma City, Oklahoma; Radian Corporation has performed the Phase II (Stage 1) Field Evaluation under USAF Contract No. F33615-83-D-4001, Delivery Order 0004.

1.1 Purpose of the Investigation

The purpose of the Phase II (Stage 1) investigation was to determine if environmental contamination has resulted from waste disposal practices at Tinker AFB. In addition, the purpose of the investigation included an estimate of the magnitude and extent of contamination, the identification of environmental consequences of migrating pollutants, and the recommendation of additional investigations to identify the magnitude, extent and direction of movement of discovered contaminants.

1.2 Duration of the Program

Authorization to proceed on the Tinker AFB Phase II (Stage 1) program was given on 12 September 1983. Following the initial site visit conducted on 29 September 1983, field activities were initiated during November 1983. A second field season was completed during February-March, 1984. The field work consisted of the installation and sampling of ground-water monitoring wells, electromagnetic surveys of two waste disposal sites, coring and sampling of shallow soils at suspected waste disposal sites, sampling and analysis of ground water from Tinker AFB water supply wells, and the investigation of trichloroethylene contamination in two water supply wells.

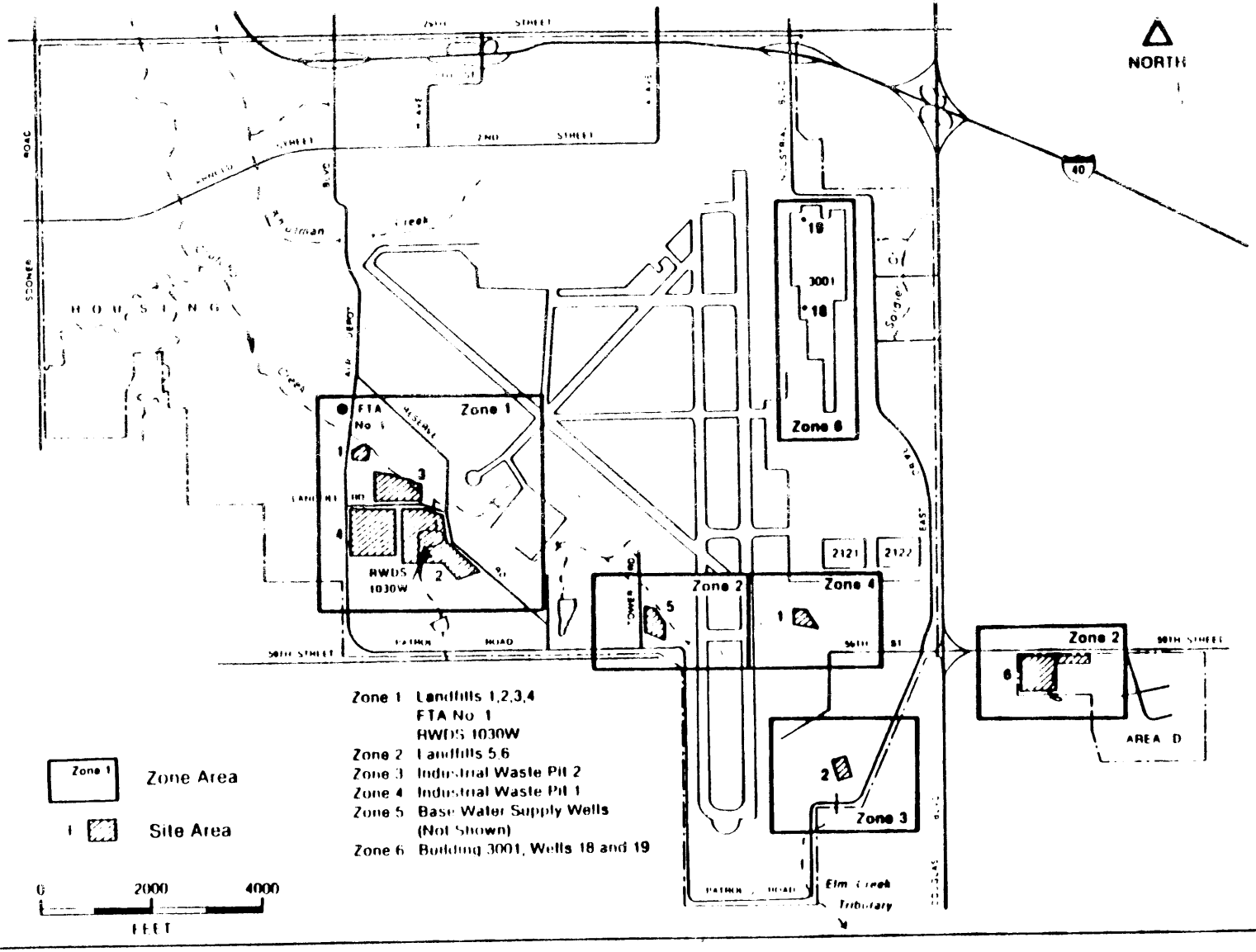

Figure 1-1. Locations of Waste Disposal Areas, Tinker AFB.

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1.4 Site Descriptions

The Phase II (Stage 1) Field Evaluation was organized by zones; each zone consisting of one or more waste disposal sites grouped together geographically or functionally. Zone 1 consists of four landfills, Landfills 1, 2, 3 and 4, located on the southwest part of the Base as well as Fire Training Area No. 1 and Radiological Waste Disposal Site (RWDS) 1030W. Zone 2 consists of two landfills (Landfills 5 and 6) on the south side of the Base on opposite sides of the N-S runway. Zones 3 and 4 are the sites of industrial waste pits Nos. 2 and 1, respectively, on the southeast part of the Base. Zone 5 consisted of the activity involved in the sampling of all water-supply wells at Tinker; and Zone 6 consisted of the evaluation of trichloroethylene in water-supply wells 18 and 19 located in Building 3001. The locations of the zones of investigation are shown on Figure 1-2.

Zone 1

Zone 1 consists of four individual landfills on the southwest side of the Base. The landfills, numbered from 1 to 4, were active from 1942 to 1968; all are closed, covered with soil, and vegetated. The landfills are clearly visible from the ground and are characterized by elevated (3-8 feet above the surrounding land), irregular surfaces with elongate depressions corresponding to former trenches, areas of patchy vegetation, and isolated zones of leachate emergence at the surface margins of the fills. Also included within Zone 1 are Fire Training Area No. 1 and Radiological Waste Disposal Site 1030W.

Prior to the Phase II (Stage 1) work, a series of ground water monitoring wells had been installed near Zone 1, primarily on the northeast side of the zone along Crutcho Creek. These wells are shallow, averaging approximately 25 feet in depth and are completed in deposits influenced by conditions in the creek. Conditions along the creek are adequately monitored by these wells.

Zone 2

Zone 2 consists of Landfills 5 and 6 at Tinker; these widely-separated sites are located at the southern end of the Base. Landfill 5 is near the intersection of Patrol Road and Tower Road; it is bordered on the northeast by Crutcho Creek, on the west by Tower Road, and on the south by Building 1141. Three ground-water monitoring wells completed in the shallow alluvium exist along Crutcho Creek; these wells provide ample coverage of ground-water conditions on the northeast side of the landfill.

Landfill 6 is approximately one-half mile east of the main Base (on AF leased property), south of 59th Street. Shallow ground-water monitoring wells have been installed at two locations along 59th Street, north of the landfill. Additional ground-water data are available from several wells located north of 59th Street and south of Interstate 40.

Zone 3

Zone 3 is the former site of a surface impoundment located north of Patrol Road (between the main N-S runway and Douglas Boulevard) on the south side of the Base. The impoundment, Industrial Waste Pit 2 (IWP2) was in operation from 1958 to 1965. The pit received large quantities of waste oils, cyanides, chromates, phenols, solvents and waste acids and alkalies. No data are available concerning construction of the pit. It has been closed and the land surface regraded to approximate original contours. Grass now covers the site, obscuring the original limits of the pit.

Zone 4

Zone 4 encompasses Industrial Waste Pit 1 at Tinker AFB. The site is located in the south-central portion of the Base. This pit, in operation from 1947 to 1958, received industrial wastes similar to those in Industrial Waste Pit No. 2 (Zone 3).

TABLE 1-2. ANALYTICAL SCHEDULE FOR SOIL AND WATER SAMPLES, TINKER AFB.

Parameter	Zones
Barium	2
Iron	1, 2
Manganese	1
Total Organic Halogen (TOX)	1, 2, 3, 4
Cyanide	1, 2, 3, 4
Metals (Cd, Cr, Ni, Cu, Zn, Pb, Hg)	1, 2, 3, 4
Volatile Hydrocarbons (EPA 601)	5
Phenol	1, 2, 3, 4
Pesticides and Herbicides	1, 2
Trichloroethylene and tetrachloroethylene (EPA 601)	6
Acid Neutral Extractable Organic Priority Pollutants (Modified EPA 625)	
- Selected wells	1, 2, 3, 4, 5
- Selected soils	3, 4
Volatile Organic Priority Pollutants (EPA 624)	
- Selected wells	5

2.0 ENVIRONMENTAL SETTING

This discussion of the Tinker AFB environmental setting was principally derived from the Installation Restoration Program Phase I Records Search report (Engineering-Science, 1982). Information developed from that report is supplemented by the literature and the general findings of this study. The following sections describe the environmental setting of Tinker AFB. Basic features and history of the sites investigated in this study are also discussed here.

2.1 General Geographic Setting and Land Use

Tinker AFB is located in central Oklahoma, within the corporate limits of Oklahoma City and adjacent to the suburbs of Midwest City and Del City (Figure 2-1). Tinker AFB is bordered by Interstate 40 to the north, Douglas Boulevard to the east, Sooner Road to the west, and industrial and undeveloped land near S.E. 59th Street to the south. The general features of Tinker AFB are illustrated in Figure 2-2.

The Base lies within an area representing a transition from residential and industrial/commercial land use on the west to agricultural land on the east and south. The principal industrial use of the area southwest of the Base is the General Motors installation south of S.E. 59th Street.

2.2 Physiographic and Topographic Features

Tinker AFB is located within the Central Redbed Plains section of the Central Lowland Physiographic Province, an area characterized by nearly level to gently rolling hills, broad flat plains and well-entrenched main streams. Surface elevations in the Oklahoma City area range from 1,070 to 1,400 feet MSL; at Tinker AFB the elevations range from 1,210 feet MSL (at Crutcho Creek, near the northwest portion of the Base) to about 1,320 feet

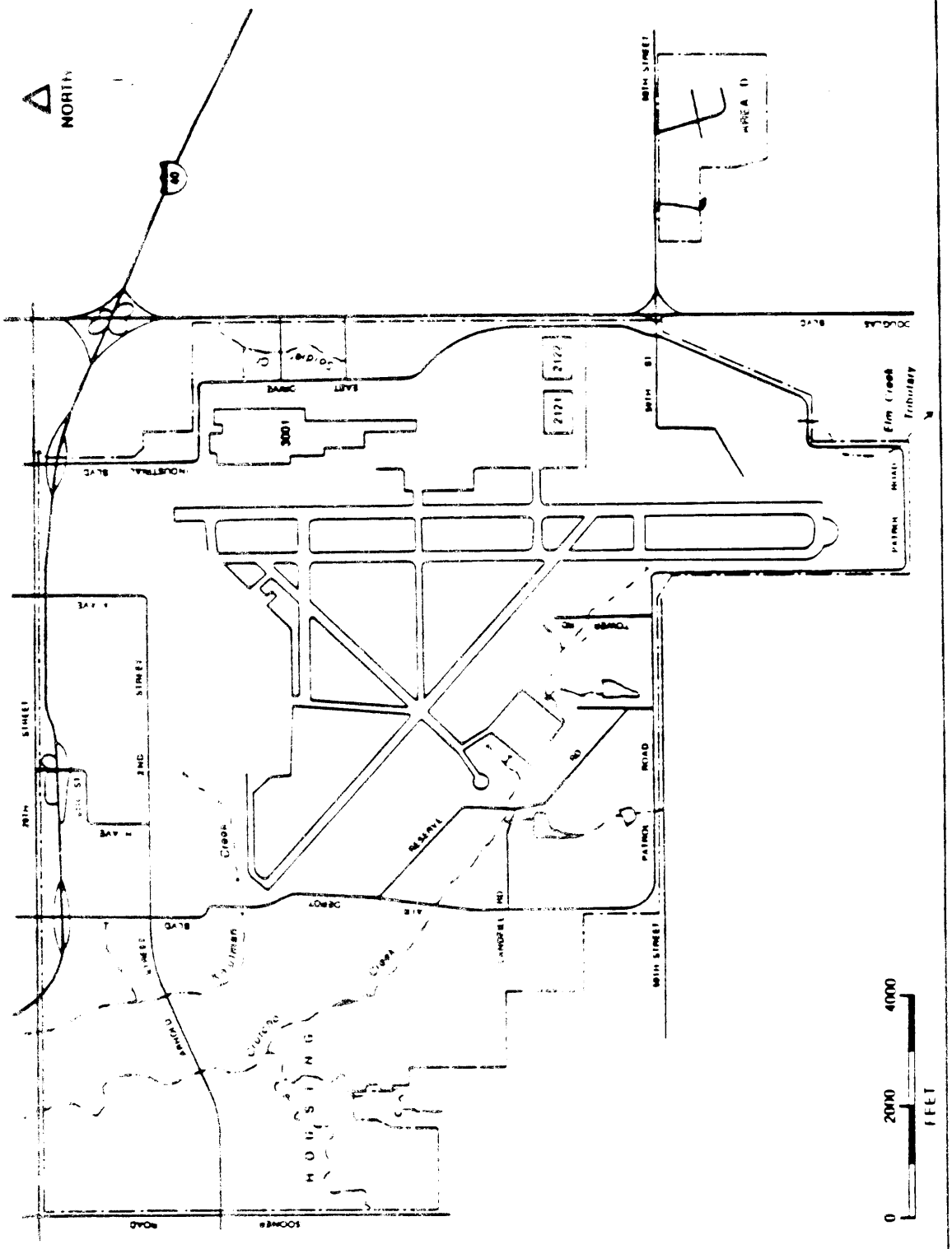

Figure 2-2. General Features of Tinker AFB.

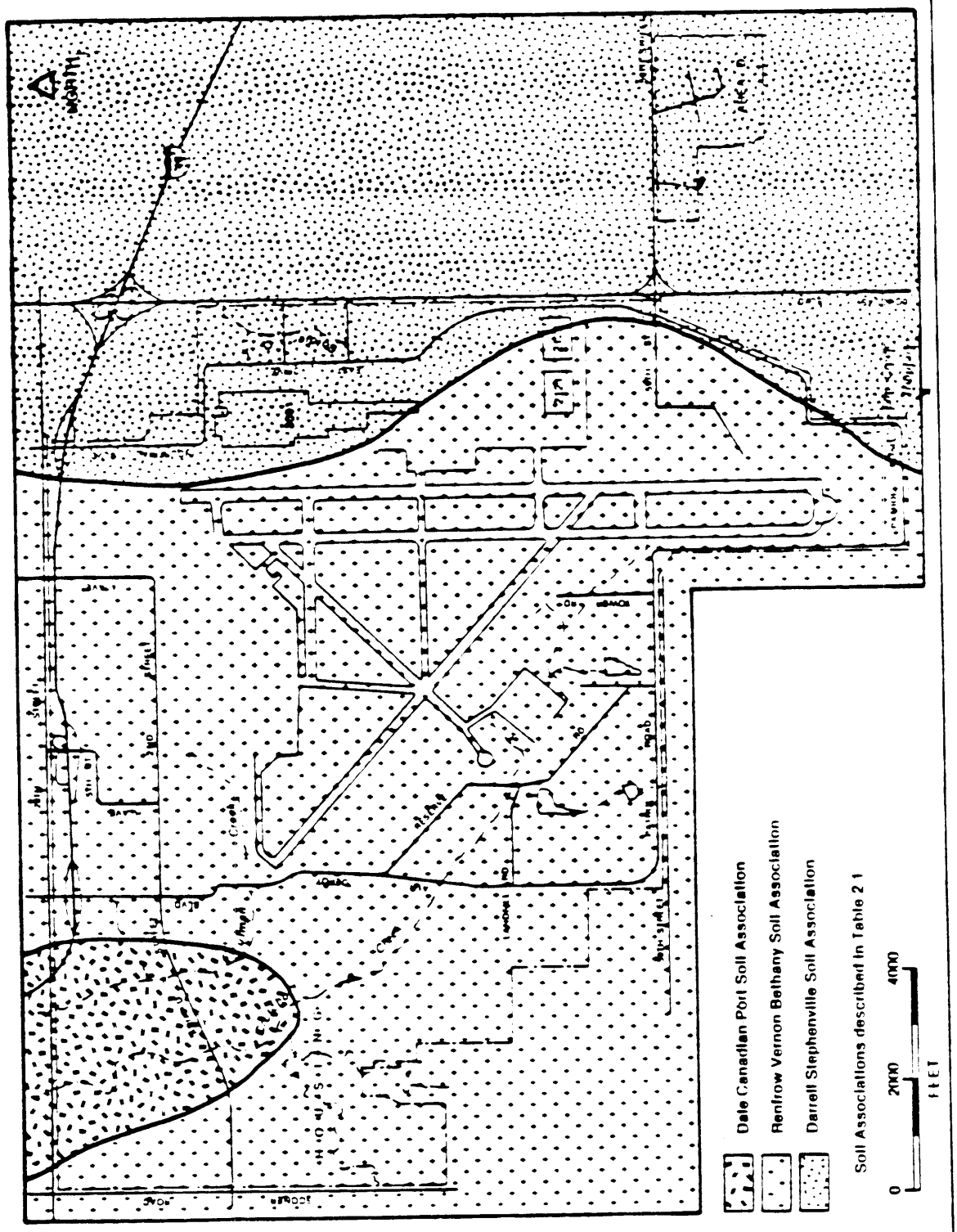

Figure 2-3. Soil Associations, Tinker AFB (USDA, Soil Conservation Service, 1969).

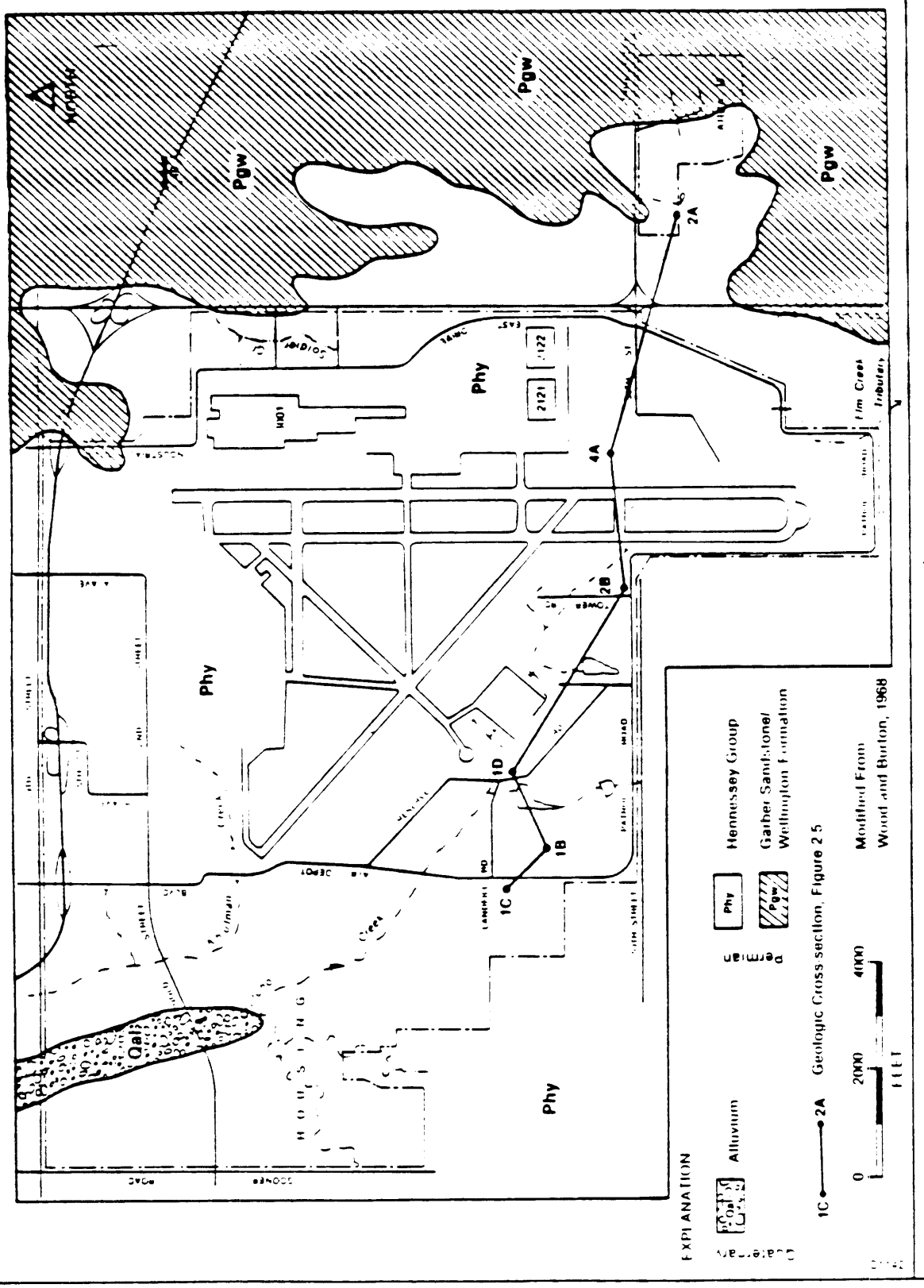

Figure 2-4. Geologic Map of Tinker AFB.

Siltstone and the Fairmont Shale, as indicated on geologic maps by Miser (1959) and Bingham & Moore (1975) and confirmed by drilling in Phase IIB. The Fairmont Shale (Hennessey Group) strata, consisting predominantly of shale, are difficult to distinguish from upper portions of the underlying Garber Sandstone, which is reported to be shaly. The contact between the Fairmont Shale and Garber Sandstone is gradational throughout the Oklahoma City area. Published geologic maps differ in the interpretation of the surface geology at Tinker AFB; Wood and Burton (1968) extend the Fairmont Shale (Hennessey Group) over most of the Base, but Bingham and Moore (1975) map the Garber Sandstone over most of the Base and show the contact with the Fairmont Shale to lie, for the most part, south of S.E. 59th Street. Figure 2-5 is a shallow cross section across the southern portion of Tinker AFB, based on Phase IIB drilling. This cross section is supportive of the Wood and Burton (1968) map, in that it shows the Fairmont Shale occurring north of S.E. 59th St. However, no geologic mapping, per se, was done to support or refute either interpretation. In either event, the significant observations are the occurrence of shale and sandstone beds, whether they be Fairmont or Garber. Results of drilling are discussed further in Section 4.0.

Structure

Tinker AFB lies within a tectonically stable area. No major faults or fracture zones have been mapped near the base. Most of the consolidated rock units of the Oklahoma City area are nearly flat-lying. The reported regional dip is forty feet per mile in a generally westward direction (Bingham and Moore, 1975).

Ground Water

Shallow Aquifer - Shallow, ephemeral aquifers exist temporarily within the study area where zones of alluvium border streams or where shallow sandy residual soils collect precipitation. At Tinker AFB, sandy residual soils overlying bedrock at shallow depths form such an ephemeral aquifer. Soil aquifers are typically recharged directly by precipitation, gradually

running dry seasonally as base flow to local streams and recharging of underlying rock aquifers deplete limited supplies. The significance of the shallow aquifer is that it may facilitate the contamination of important lower aquifers or surface waters by leachate generation and mobilization of wastes. It is not useable from a water-supply standpoint.

Garber-Wellington Aquifer - Tinker AFB lies within the limits of the Garber-Wellington Ground-Water Basin. The Garber Sandstone and the Wellington Formation are considered to be a single aquifer and provide the most significant source of ground-water supplies in the Oklahoma City area. At the present time, Tinker AFB derives most of its water supplies from this aquifer and supplements the supply by purchasing from the Oklahoma City Water Department. The nearby communities of Midwest City and Del City derive water supplies from both surface sources and wells tapping the aquifer. Industrial operations, individual homes, farm irrigation, and small communities not served by a municipal distribution systems also depend on the Garber-Wellington Aquifer. Communities presently depending upon surface supplies such as Oklahoma City also maintain a well system drilled into the Garber-Wellington as a standby source of water in the event of drought. The aquifer area is depicted in Figure 2-6.

The Garber Sandstone and the Wellington Formation are considered to be a single aquifer. They were deposited under similar conditions and consist of lenticular beds of sandstone, siltstone and shale that tend to vary in thickness over relatively short horizontal distances (Wood and Burton, 1968). The sediments constituting the aquifer tend to be loosely cemented and have a maximum thickness of some 1,000 feet. In the area of outcrop, ground water occurs under water table (unconfined) conditions and may occur at relatively shallow depths below ground surface (100 to 150 feet). In areas overlain by younger geologic units, ground water occurs in the aquifer under artesian (confined) conditions and wells must be drilled deeper (200-250 feet) in order to encounter it (Wickersham, 1979). Ground water can occur under either water table or artesian conditions in the vicinity of Tinker AFB.

The Garber-Wellington aquifer is exposed at ground surface or mantled by a thin soil over the northern two-thirds of Tinker AFB. As noted above, the aquifer is probably overlain by a thin, discontinuous sequence of Hennessey Group sediments (Kingman Siltstone and Fairmont Shale) over the southern portion of the base. Water in useable quantities from productive zones in the Garber-Wellington is encountered at depths of approximately 100 feet at Tinker AFB, although the top of the saturated, but poorly productive, zone delineated by Phase II (Stage 1) drilling was usually less than 50 feet. A geologic cross-section of base wells developed by Wickersham (1979) is presented as Figure 2-7. This figure graphically depicts the lenticular nature of the sandy zones. Although most of the aquifer is believed to be saturated, multiple screened wells are usually constructed in order to obtain water from the more productive zones.

Recharge of the Garber-Wellington Aquifer is accomplished principally by rainfall infiltration and by percolation of surface waters crossing the area of outcrop. Because most of Tinker AFB is located in an aquifer outcrop area, it is therefore assumed that the base is situated in a recharge zone (Havens, 1981). The aquifer is therefore susceptible to contamination in the study area. Ground-water levels and flow directions (1976 data) are presented as Figure 2-8. It is important to note that Figure 2-8, a verbatim transcript from Wickersham (1979), is based on generalized data from throughout the area shown. It is "true" in only a regional sense. Results of detailed investigations in any one small portion of the area are likely to be at variance with the regional data. The maps show Tinker AFB to be within a roughly 10-mile long zone, trending northeast-southwest which makes up a regional ground-water "high" - i.e., a recharge zone. Superimposed on this is a local "low" or saddle surface, perhaps reflective of the ground-water withdrawals by the Base wells. According to the indicated hydraulic gradients, ground-water flow at Tinker AFB is presently directed to the west and northwest over most of the Base and to the south in the southeast part of the Base.

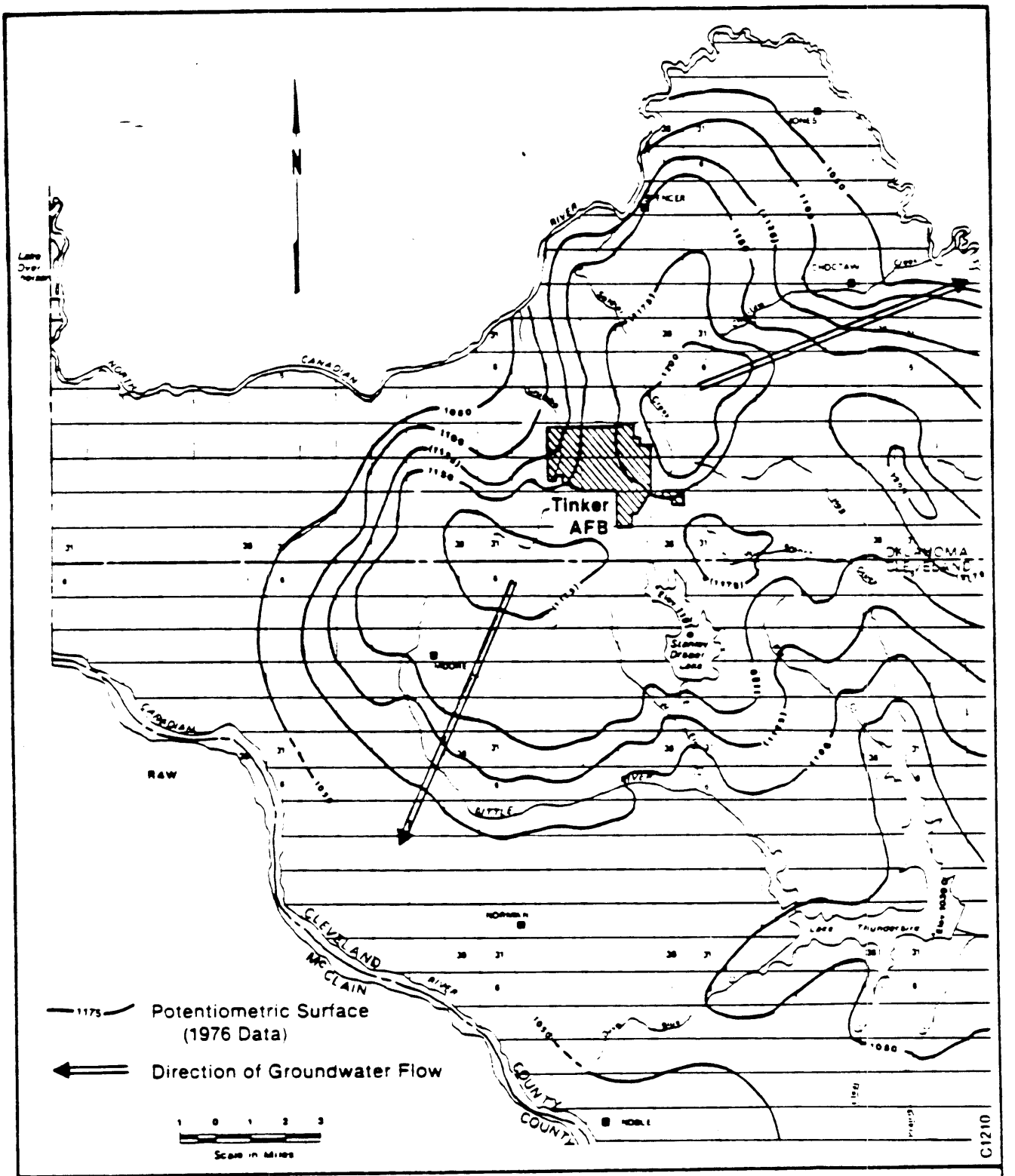

Figure 2-8. Ground-Water Levels and Flow Directions in the Garber-Wellington Aquifer (from Wickersham, 1979).

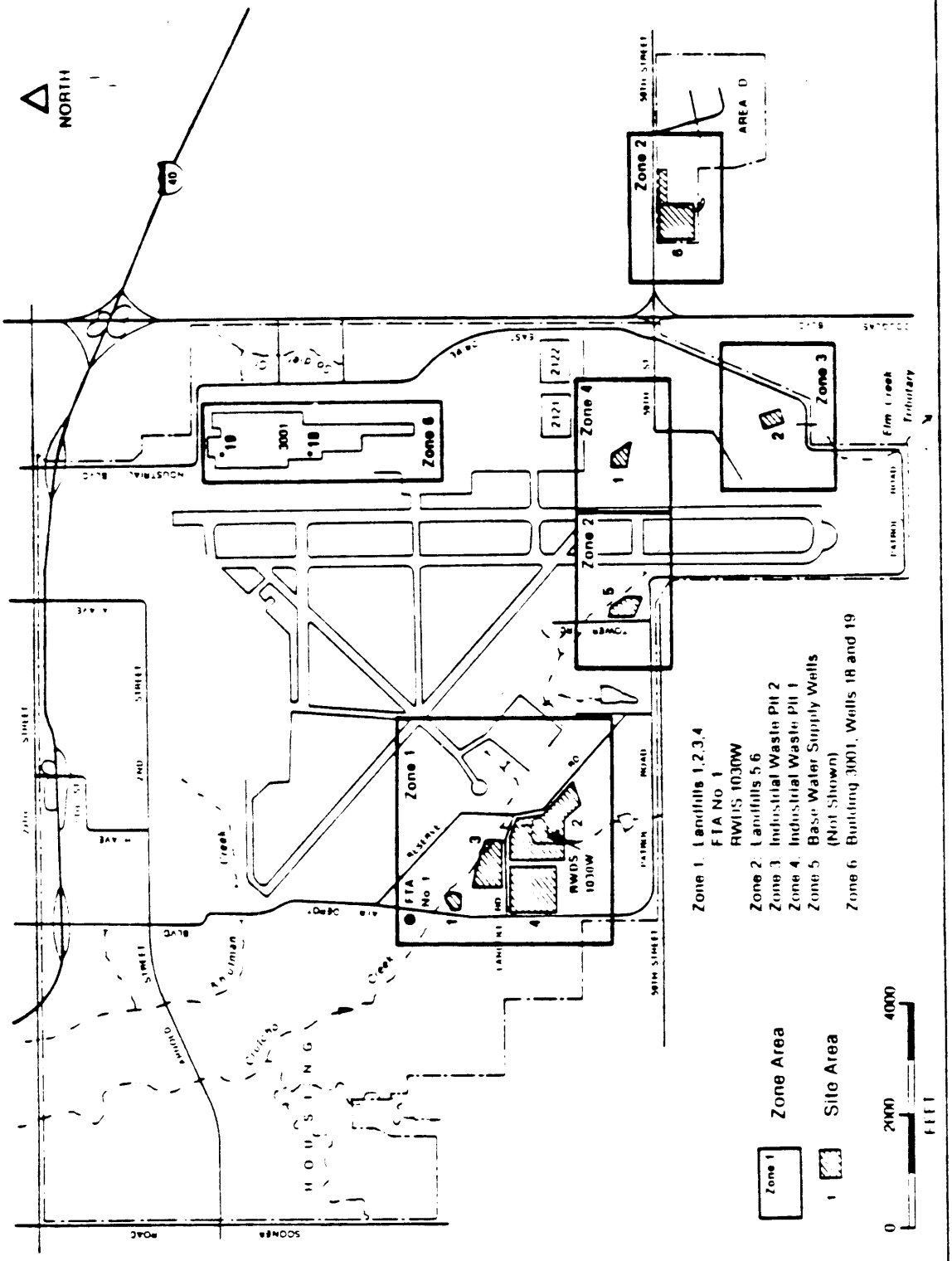

Figure 2-9. Zones of Investigation, Tinker AFB.

No. 2. The pond was constructed in the mid-1960s either partly on top or adjacent to the landfill area. From the air, the outlines of trenches can be seen along the boundary of the pond where the water level is high enough to inundate portions of the trenches. Overflow from the pond enters the upper reaches of Crutcho Creek. It is presently unknown to what extent the pond waters percolate through the landfilled material.

During the time period 1952-1961, wastes were disposed of in an eight acre area designated as Landfill No. 3. This area is located adjacent to Landfill No. 2 north of Landfill Road and south of Crutcho Creek. Crutcho Creek crosses the northeast corner of Landfill No. 3. The type of waste disposed of and disposal methods were similar to previous landfills. The landfilled material consisted primarily of general refuse, but did include paint buckets, insecticide cans, and empty barrels. A number of vacuum tubes which contained low levels of radioactivity were also disposed of at this site. Landfill materials were disposed of in trenches running the length of the landfill. Trenches were approximately 25 feet deep, and extended through a surface clay layer into a sand/rock layer. The refuse was covered daily, and a final cover of 3 to 4 feet of excavated material was placed on completed trenches.

Additional radioactive material was reported to have been disposed of in a deep pit adjacent to the northwest corner of landfill No. 3. The area was formerly posted with radioactivity warning signs, which have been destroyed.

Landfill No. 3 shows no evidence of erosion along the creek or elsewhere around the landfill. At present, additional dirt and hardfill are being stored on top of the landfill. This practice has been in effect for approximately 5 years.

After closure of the Landfill No. 3, a 16-acre site south of Landfill Road between Landfill No. 2 and Air Depot Boulevard was utilized for

the trenches has resulted in surface depressions which collect and hold rain water. A small area of seepage is noticeable on the northeastern edge of the landfill adjacent to West Crutcho Creek. Recent (1984) construction activities have disrupted a portion of the landfill surface.

Landfill No. 6 was used for the disposal of refuse from 1970 to 1979. This landfill is located in Area "D" approximately 1/2 mile east of Tinker AFB along S.E. 59th Street on land leased from Oklahoma City. Although 40 acres are available at the site, only about 20 acres on the western half of the landfill were used prior to the closing of the site during 1979. Base refuse since that time has been disposed of off-site by private contractor.

Materials disposed in Landfill No. 6 consisted primarily of general refuse with small quantities of industrial waste materials such as paint buckets, insecticide cans, etc. Industrial wastewater treatment plant sludge was also intermittently disposed of in this landfill. The refuse was covered daily with 6 to 8 inches of compacted soil, and several feet of compacted cover was used as a final trench covering. Highly permeable river sand was used for daily cover for several years, although other areas had a cover of excavated clay and sand/rock. After closure, the site was revegetated with grasses. Field reconnaissance of the site indicated moderate surface erosion and no observed leachate.

2.4.2 Waste Disposal Pits

Prior to the establishment in 1963 of an industrial wastewater collection and treatment system, some of the industrial wastes were disposed of in large, open pits. Two waste disposal pit areas were located on the east side of the base south of the aircraft maintenance area. The pits were used for the disposal of industrial wastes between 1947 and 1965.

Industrial Waste Pit No. 1 (Zone Four of the Phase II (Stage 1) study) was located southwest of Building 2121. Waste disposal occurred during the period 1947-1958. During the Base records search, no written information

Zone 5 (Base Water Supply Wells)

Zone 5 consists of the 27 Base Water Supply Wells, a system of wells located along the east and west Base boundaries. All wells are completed in the Garber-Wellington Aquifer. Base Wells range from 700 to 900 feet in depth, with yields ranging from 205 to 250 gallons per minute. The wells incorporate multiple screens, deriving water supplies from sand zones that vary in thickness from 103 to 184 feet (Wickersham, 1979).

Zone 6 (Building 3001 Wells)

Zone six consists of two Base water supply wells (Wells 18 and 19) located within Building 3001 (The Oklahoma City Air Logistics Center manufacturing complex) in the northeast portion of the Base (Figure 2-9). An Air Force monitoring program had discovered both trichloroethylene (TCE) and tetrachloroethylene in these wells, so both were taken out of service. Radian was tasked with a preliminary assessment of the contamination in these wells.

Both Wells 18 and 19 are deep (>1,000 feet), high capacity water supply wells, pumping directly into the distribution system, which supplies both industrial and potable uses. The wells were drilled in 1942 and incomplete construction records remain. No driller's or geophysical logs were available, but partial casing and perforation records were found.

3.0 FIELD PROGRAM

Various field activities were performed at Tinker Air Force Base in support of the IRP Phase II (Stage 1) investigation. The activities consisted of the completion of eleven deep and four shallow ground-water monitor wells, performance of two ground conductivity (electromagnetic) surveys, and soil coring of two waste sites. The periods of performance of the field activities were November 1983 and February-March 1984.

3.1 Field Techniques

The following paragraphs contain descriptions of the various field techniques used in the Tinker AFB Phase II investigation. These techniques included geophysical surveying, hollow-stem augering and air rotary drilling, monitor well installation, and soil and ground-water sampling.

3.1.1 Geophysical Surveying

Geophysical surveying was performed in order to accurately define the area of investigation at two buried industrial waste pits (Zone 3 - Industrial Waste Pit No. 2 and Zone 4 - Industrial Waste Pit No. 1). The two sites are currently vacant land; no surface remnants of the waste disposal facilities are visible. The geophysical technique selected for the investigation consisted of an electromagnetic survey using two devices: the Geonics EM31 and the EM34-3 ground conductivity sensors. Both ground conductivity sensors are designed for rapidly obtaining data over large areas. The meters employ magnetic dipoles or magnetic induction loops for transmission and reception of low-frequency electromagnetic waves. The effective depth sampled by the EM31 is 6 meters; the depth sampled by the EM34-3 depends on the coil separation and orientation, applied frequency, and to some extent on the conductivity profile of the subsurface (McNeill, 1980). Geophysicon, Inc., of Lakewood, Colorado, performed the ground conductivity surveys at Zones 3 and 4. Operating procedures and specifications of the EM31 and EM34-3 are provided in Appendix L.

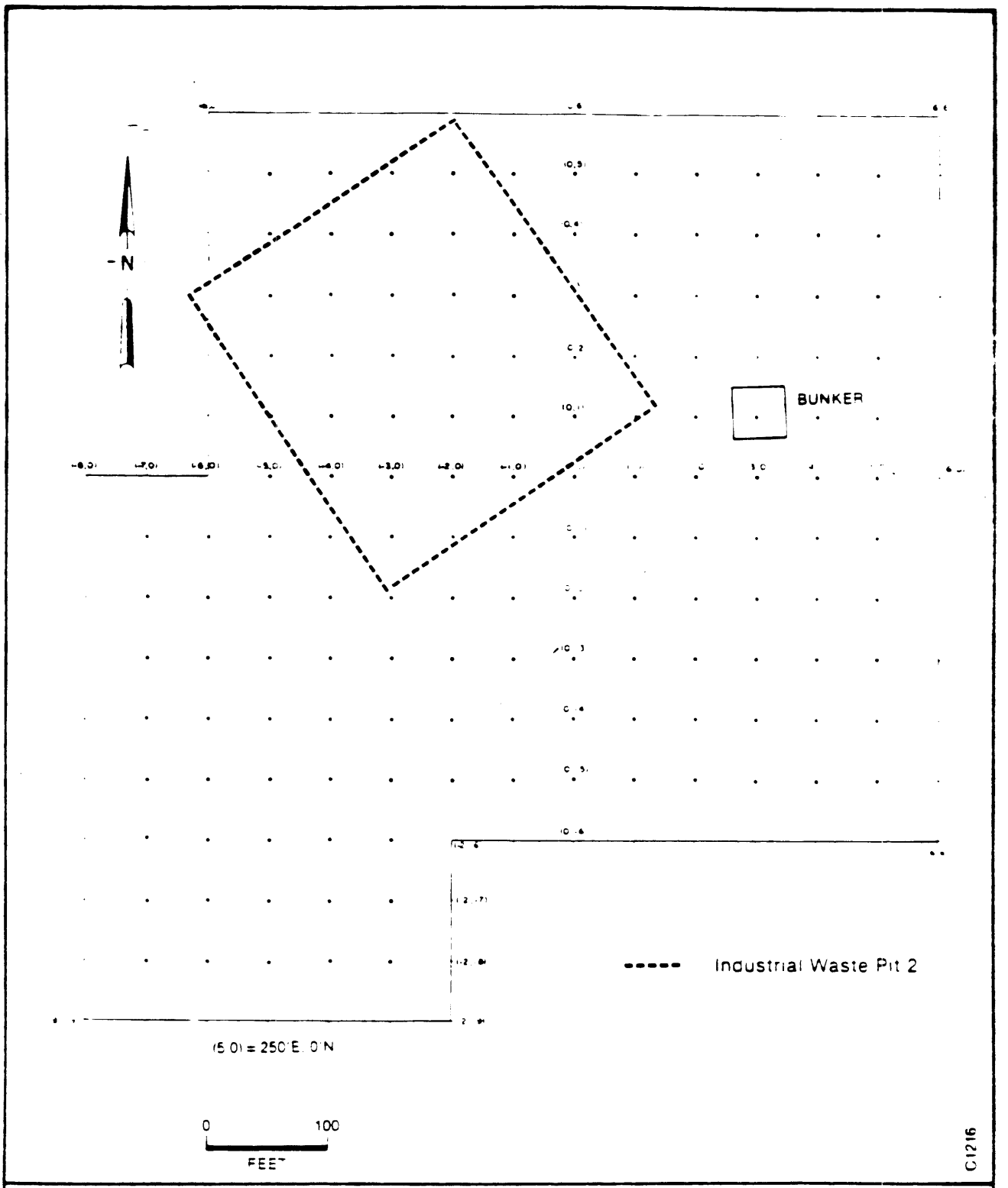

Figure 3-1. Data Point Grid for Geophysical Survey - Zone 3.

depth of 10 feet below the first ground water encountered. No drilling fluids or additives were used in the drilling program. As the bore hole was advanced, the cuttings discharged at the surface were examined for lithology, moisture, and other features to describe the geologic section. Drilling conditions, such as relative rate and ease of penetration, were noted by the driller. Water encountered during drilling was noted with respect to depth of occurrence and rate of production; if needed, drilling was suspended temporarily to allow for recovery of water in the borehole. The decision to complete the borehole and install the screen and casing for the monitor well was made on the basis of relative water level (with respect to the approximate predicted regional water level), the likelihood of perched water above a regional water table, and the representativeness of the water table in terms of evaluating the impact of the waste disposal site on the quality of ground water.

The method of introduction of contaminants is by dissolved constituents moving with downward migrating infiltration. Once these contaminants reach the ground-water body they are entrained in the flow and move with it. So long as no density effects operate, there will be no tendency for contaminants to plunge or sink in the ground-water system. Common causative agents of density effects, concentrated brines or nearly pure streams of dense industrial chemicals (such as TCE) do not exist at Tinker AFB, so this phenomena may safely be ignored. As was discussed in Section 2, there is a downward component of flow, so some contaminants would be expected to move down in the aquifer. However, they would also be diluted, so detection is less likely. Contaminants of interest are expected to be at their highest concentrations at the water table, so all wells were completed as near the water table as practicable.

Hollow-Stem Augering

A hollow-stem auger drilling rig, the Mobile B-50, was used at Zones 3 (Industrial Waste Pit 2) and 4 (Industrial Waste Pit 1) to perform shallow coring in the vicinity of the pits. The hollow-stem method allowed for an

TABLE 3-1. MONITOR WELL CONSTRUCTION SPECIFICATIONS

- Casing: 2-inch or 4-inch diameter, flush joint, Schedule 80 PVC.
- Screen: 2-inch or 4-inch diameter, flush joint, Schedule 80 PVC, 0.010-inch mill slot. Normal screen length was 10 feet, reduced to 5 feet at the discretion of the supervising geologist.
- Gravel pack: 8-12 mesh silica, emplaced from bottom of hole to 2 feet above top of screen.
- Bentonite seal: 2 feet above top of sand pack.
- Grout: neat cement (Type I Portland cement) grout from the top of the bentonite seal to the land surface.
- Surface completion: the PVC casing was cut off to provide a 2 to 3 foot stickup and solid cap placed on the casing. A 6-inch diameter guard pipe, 4 feet in length, was placed over the exposed casing, and seated in the cement. A locking cap lid was installed on the guard pipe.
- Guard pipes or posts: 3-inch diameter steel posts, 6 feet in length, with a minimum of 2 feet below ground, 3 each installed radially 4 feet from the wellhead.
- After each well was installed, it was developed by air lifting or bailing until a clear stream was produced, or until the supervising geologist determined that development was complete.
- The split-spoon sampler was washed between samples (water, acetone, water) and the drill pipe, bit, and augers cleaned (pressure water wash) between corings.

Water Level Determination

As the first step of ground-water sampling operations at each monitor well, water level measurements were taken using a Soiltest Model 762A electrical probe. The probe and associated electrical line were washed with laboratory deionized water between each well to preclude the possibility of cross-contamination. Measurements were taken to the nearest 0.01 foot with respect to the top of the protective steel well casing. The elevation point was surveyed as discussed in Section 3.1.9. Water level measurements taken prior to each sampling operation are listed in Appendix E.

Water level measurements were not taken at the base supply wells since the readings would reflect levels influenced by pumping.

Well Purging

Following the completion of well construction activities, each monitor well was purged using a 1.75-inch diameter submersible gas-driven pump. The pump, manufactured by ISCO, Inc. (Model 2600) delivered water to the surface by means of the rapid inflation and deflation of the pump's silicone rubber bladder. Gas (compressed air from a cylinder) did not contact the sample; water comes into contact with stainless steel, polycarbonate, medical-grade silicone rubber, Teflon, polypropylene, Delrin acetal, polyethylene, and the PVC well casing. The pump was operated in the following way: after the pump was set at the appropriate position in the well, the gas supply and pump gas lines were attached to the control box, controls were adjusted to compensate for the bladder inflation rate at varying lifts and gas supply pressure, and the gas valves were opened to begin operation of the pump. Some of the eight existing monitor wells were purged and sampled with a 1.1 liter bottom-discharge Teflon bailer due to low water or poor yields.

Each well was purged either immediately prior to sample collection or within 1 day of sample collection (for low-yield wells) to ensure that fresh formation water was collected as the sample. Purging operations were conducted using a 1.1 liter bottom-discharge Teflon bailer. Purging operations were considered complete when 3 wetted well volumes had been evacuated.

TABLE 3-2. ANALYTICAL SCHEDULE, TINKER AFB

Parameter	Zones
Barium	2
Iron	1, 2
Manganese	1
Total Organic Halogen (TOX)	1, 2, 3, 4
Oil and Grease	1, 2, 3, 4
Total Organic Carbon (TOC)	1, 2, 3, 4
Cyanide	1, 2, 3, 4
Metals (Cd, Cr, Ni, Cu, Zn, Pb, Hg)	1, 2, 3, 4
Volatile Hydrocarbons (EPA 601)	5
Total Phenol	1, 2, 3, 4
Pesticides and Herbicides	1, 2
Trichloroethylene and tetrachloroethylene (EPA 601)	6

A representative of the Oklahoma State Department of Health accompanied the Radian team during most of the sampling effort and split samples from selected monitor wells. A report of all available State data is provided in Appendix H. Analytical results are discussed in Section 4.0.

3.1.5 Geologic Sampling

Geologic sampling consisted of two distinct activities. The first consisted of the routine collection of samples from the air rotary discharge during well drilling. Geologic samples were collected at variable intervals during monitor drilling or where significant changes in lithology occurred. At coring operations (Zones 3 and 4), samples were collected through hollow-stem augers with the use of split-spoon sampler in accordance with ASTM Method D-1586. Grab samples from shallow depths were collected from the auger flights where conditions warranted. All split-spoon samples collected were described, logged, and placed in glass jars with screw-on lids. These samples were labeled and retained by Radian for future reference. Selected samples (ten each from Zones 3 and 4) were frozen and submitted for chemical analysis.

3.1.6 Sampling Schedule

A total of 38 wells were sampled for ground water during Phase II (Stage 1) field activities (February-March 1984). Generally, sufficient sample was obtained during a single sampling round to satisfy the volume requirements for all analytical tests to be performed. However, in some cases, well recovery or leachate production was very slow and sample sets from the same sampling point were collected on more than one occasion. Details of the sampling schedule, including well identification, sample type, date collected, date delivered to the laboratory, and sampler are provided in Appendices E and G.

3.2 Zone Activities

The field program at Tinker AFB consisted primarily of the installation and sampling of ground-water monitor wells. Other activities, such as geophysical surveying, soil coring and sampling, and leachate and pond sampling, were also conducted. The conduct of the field program is presented in narrative form in the following subsections. For each of the zones of investigation, a similar sequence of events was followed, as described in Section 3.1. Each zone of investigation (Figure 3-3) is discussed separately, below.

3.2.1 Zone 1 (Landfills 1 through 4)

This section contains a description of the field activities that occurred at Zone 1, consisting of Landfills 1 through 4. Zone 1 is located at the southwest corner of Tinker AFB; bordered by Patrol Road on the west, Crutcho Creek on the northeast, and Storage Road area on the south. The activities that took place at Zone 1 included; completion of 4 boreholes, installation of 3 ground-water monitor wells, sampling of a series of existing ground-water monitor wells near Crutcho Creek, sampling of the newly-installed monitor wells, and sampling of the leachate from Landfill 4 and water from the recreational pond.

Monitor Well Installation

The locations of the drilling sites are illustrated on Figure 3-4. These locations were selected in order to provide complete coverage of the hydrogeologic conditions at Zone 1. The anticipated ground-water flow direction was to the west and southwest. Well 1A, located on the northwest portion of the zone, is the shallowest boring; borehole 1D, located east of the zone, was intentionally drilled as the deepest boring for the purpose of investigating the subsurface to at least 150 feet below the land surface. Wells 1B and 1C, south and west of the zone, respectively, were drilled to intermediate depths. Each boring encountered a weathered zone of residual soil, underlain

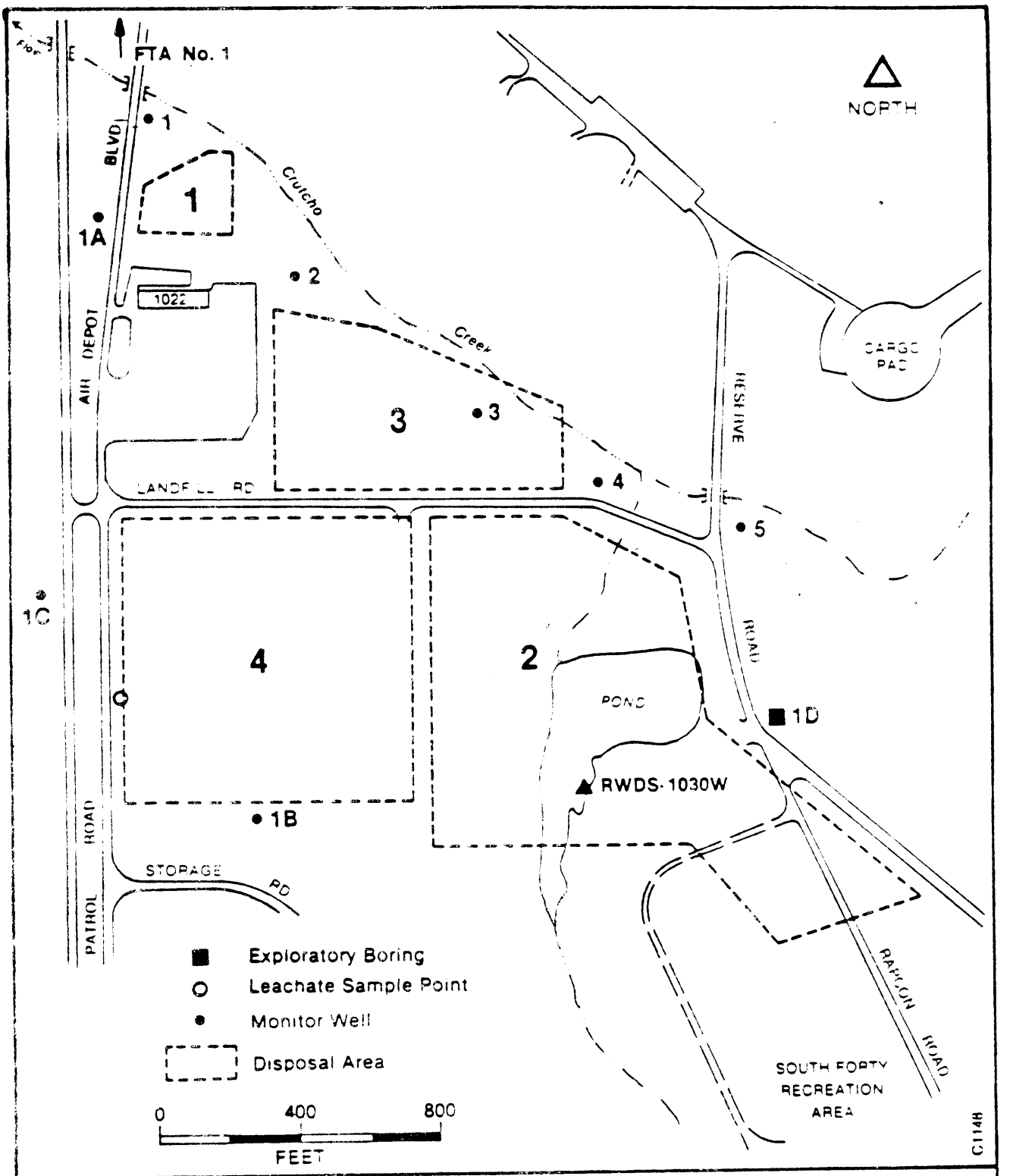

Figure 3-4 Drilling Locations - Zone 1.

TABLE 3-4. GENERAL SPECIFICATIONS FOR ZONE 1 MONITOR WELLS AND CORES

Monitor Well or Core	Measuring Point Elevation[1]	Measuring Point Height	Ground Level Elevation[2]	Screened Interval[3]	Screen Elevations[4]	Total Depth[5]
1A	1223.09	3.00	1220.09	25-35	1195-1185	35
1B	1256.03	2.58	1253.44	65-75	1191-1181	75
1C	1242.49	2.91	1239.59	45-55	1197-1187	55
1D	1238[7]	0	1238[7]	grouted	N/A	150
1[6]	1219.16	2.90	1216.26	37.8-41.8	1178-1174	42.8
2	1222.09	2.95	1219.14	35.8-39.8	1183-1179	42.6
3	1223.37	2.58	1220.79	28.0-32.0	1193-1189	34.3
4	1225.10	3.25	1221.85	29.0-32.5	1193-1189	41.9
5	1227.78	2.95	1224.83	24.0-29.0	1201-1196	32.2
6	1243.63	2.95	1240.68	24.4-28.4	1216-1212	32.2
7	1247.63	2.66	1244.97	18.5-22.5	1226-1222	25.8
8	1254[7]	2.54	1251[7]	16.2-20.2	1235-1231	22.9

[1] Top of PVC casing for monitor wells; ground level for cores; surveyed, except as noted.
[2] Feet, msl to nearest 0.1 foot.
[3] Feet below ground level.
[4] Feet, msl.
[5] Feet below ground level.
[6] Wells 1-8, pre-existing monitor wells.
[7] Ground level elevations taken from Base topographic map.

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3.2.2 Zone 2 (Landfills 5 and 6)

Zone 2 consisted of two widely-separated landfills: Landfill 5 west of the main runway and southwest of Crutcho Creek, and Landfill 6 east of Tinker AFB and south of S.E. 59th Street near Area "D". These landfills represent the most recent on-base landfilling operations, with the period of activity ranging from 1970 to 1979. Earlier ground-water investigations at these sites have resulted in the placement of monitor wells near Crutcho Creek at Landfill 5 and near an unnamed tributary of Soldier Creek near Landfill 6 along S.E. 59th Street.

Monitor Well Installation

Drilling for the emplacement of monitor wells at Zone 2 was conducted from 17 to 20 November 1983. Two wells were installed; 2A at Landfill 6, and 2B at Landfill 5. Both wells were installed in boreholes drilled using the air rotary method. Locations of the wells are shown on Figures 3-5 and 3-6. Prevailing ground-water flow was determined to be generally south on the basis of published information (Figure 2-8) (Wichersham, 1979). Therefore, well 2A was located on the south margin of Landfill 6 in order to monitor conditions hydraulically downgradient from the landfill. Regional ground-water flow in the vicinity of Landfill 5 is believed to be to the south or southwest; well 2B was therefore placed on the south side of Landfill 5 to monitor downgradient conditions and provide complementary coverage to the existing 3 monitor wells located to the north and east of the landfill. Appendix D contains detailed descriptions of the log of borings and well completion data. Table 3-6 provides a summary of monitor well data.

Monitor Well Sampling

After the completion and initial development of the monitor wells each one was purged and sampled. Field sampling was conducted by Radian personnel during the period 12-18 February 1984. Details of the field sampling procedures are presented in Section 3.1.4. The ground-water samples were analyzed for the parameters specified in the Statement of Work as shown on Table 3-7. Results of all analyses are discussed in Section 4.2.2.

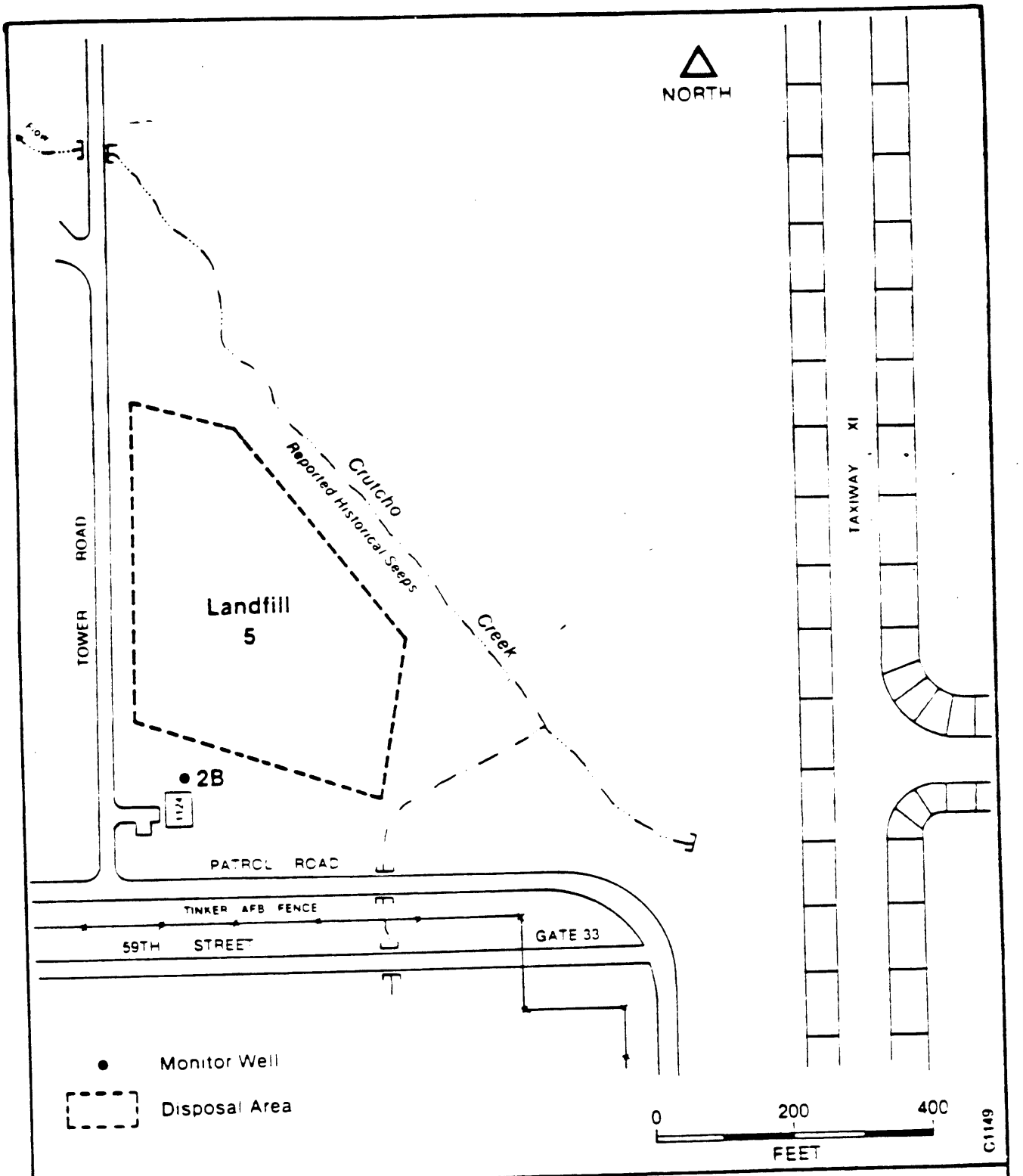

Figure 3-6. Location of Well 2B - Zone 2, Landfill 5.

TABLE 3-7. ANALYTICAL SCHEDULE, ZONE 2

Barium
Cadmium
Cyanide, total
Chromium
Copper
Iron
Herbicides
2,4-D
2,4-5TP (Silvex)
Mercury
Nickel
Oil and Grease (IR)
Lead
Pesticides (EPA Method 608)
DDT Isomers
aldrin
dieldrin
lindane
methoxychlor
heptachlor
heptachlor epoxide
Total Organic Carbon
Total Organic Halogen
Total Phenol
Zinc
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)

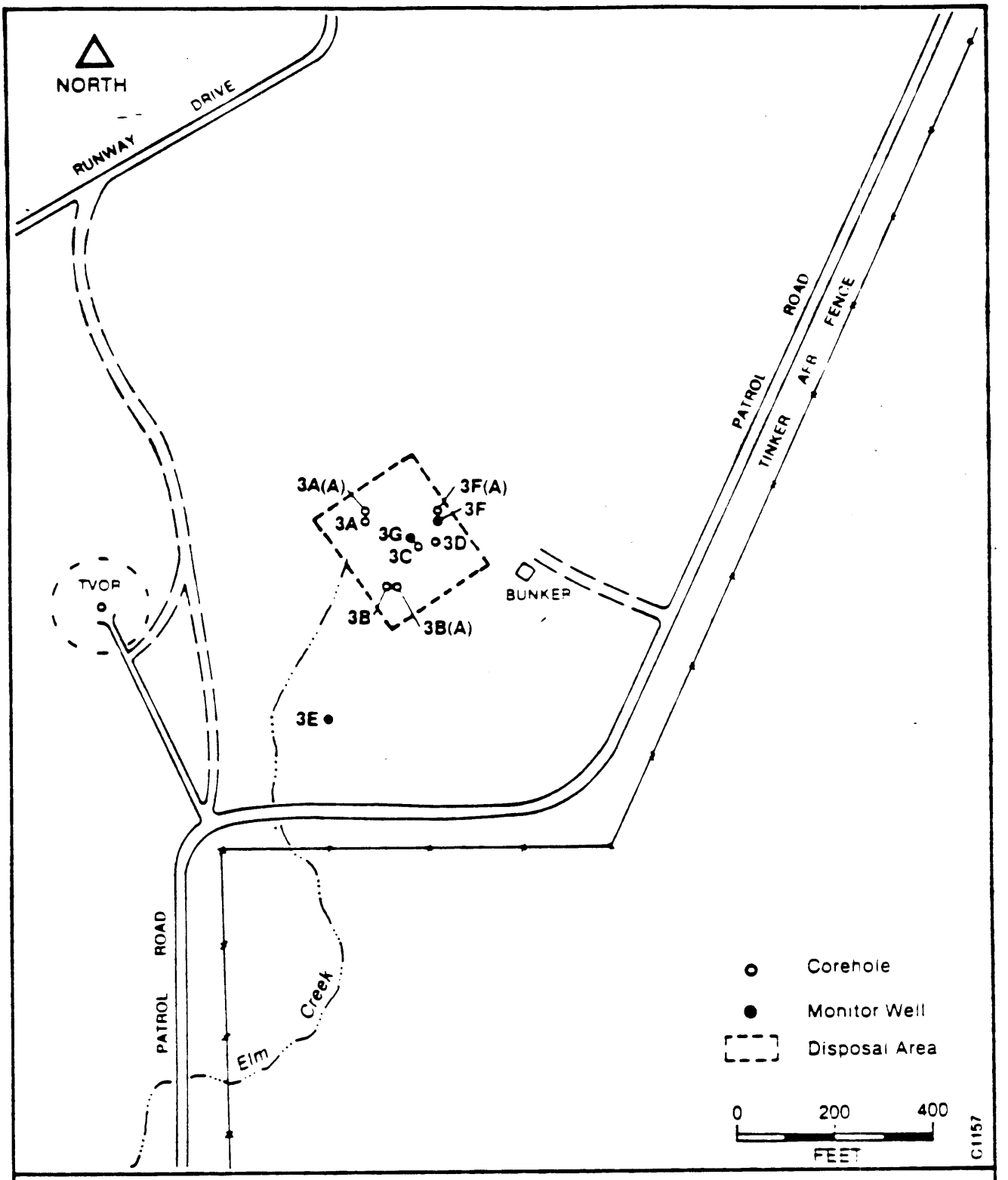

Figure 3-7. Drilling Locations, Zone 3 - Industrial Waste Pit No. 2.

TABLE 3-8. GENERAL SPECIFICATIONS FOR ZONE 3 MONITOR WELLS AND CORES

Monitor Well or Core	Measuring Point Elevation[1,2]	Measuring Point Height	Ground Level Elevation[2]	Screened Interval[3]	Screen Elevations[4]	Total Depth[5]
3A	1305	0.0	1305	grouted	N/A	10
3A(A)[6]	1305	0.0	1305	grouted	N/A	5
3B	1303	0.0	1303	grouted	N/A	11
3B(A)[6]	1303	0.0	1303	grouted	N/A	21
3C	1305	0.0	1305	grouted	N/A	10
3D	1305	0.0	1305	grouted	N/A	10
3E	1297.6	2.6	1295	64.5-74.5	1230.5-2330.5	74.5
3F	1309.9	2.9	1307	15.4-30.3	1291.6-1276.6	30.4
3F(A)	1307	0.0	1307	grouted	N/A	6
3G	1302	2.3	1305	3.0-8.0	1302-1297	8.0

[1]Top of PVC casing for monitor wells; ground level for cores.
[2]Feet, msl taken from Base topographic map.
[3]Feet below ground level.
[4]Feet, msl.
[5]Feet below ground level.
[6](A) = alternate.

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TABLE 3-9. ANALYTICAL SCHEDULE, ZONE 3

Cadmium
Cyanide, total
Chromium
Copper
Mercury
Nickel
Oil and Grease (IR)
Lead
Total Organic Carbon
Total Organic Halogen
Total Phenol
Zinc
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)[1]

[1]Ground-water samples and one selected soil sample only.

at other zones in order to monitor the first significant occurrence of ground water. The shallow wells (Wells 4F and 4G) were installed in boreholes drilled using hollow-stem auger equipment as part of the effort to define subsurface conditions directly over the buried industrial waste pit. In total, six boreholes were drilled using the hollow-stem auger, revealing a wide range of subsurface conditions in a relatively small area. Small diameter wells (consisting of 2-inch PVC as described in Section 3.1) were installed in two adjacent boreholes. The shallow borehole (4G) collected a significant amount of water within a few hours; the deeper borehole (4F) remained dry but was converted to a monitor well in order to observe the possible accumulation of ground water in the shale bedrock. Appendix D contains detailed descriptions of the logs of borings and well completion data. Table 3-10 provides a summary of the cores and monitor well data.

Soil Sampling

During the coring operations, samples were collected through the hollow-stem augers with the use of split-spoon sampler in accordance with ASTM Method D-1586. All split-spoon samples collected were described, logged, and containerized in glass jars with Teflon-lined screw-on lids. These samples were labeled and retained by Radian for future reference. Ten selected samples were frozen and submitted for chemical analysis. Results of chemical analysis are discussed in Section 4.2.4.

Monitor Well Sampling

After the completion and initial development of the monitor wells each one was purged and sampled. Field sampling was conducted by Radian personnel during the period 12-18 February 1984. Details of the field sampling procedures are presented in Section 3.1.4. The ground-water samples were analyzed for the parameters specified in the Statement of Work as shown on Table 3-11. Results of all analyses are discussed in Section 4.2.4.

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After the completion and initial development of the monitor wells each one was purged and sampled. Field sampling was conducted by Radian personnel during the period 12-18 February 1984. Details of the field sampling procedures are presented in Section 3.1.4. The ground-water samples were analyzed for the parameters specified in the Statement of Work as shown on Table 3-11. Results of all analyses are discussed in Section 4.2.4.

TABLE 3-11. PARAMETERS FOR WATER AND SOIL ANALYSES - ZONE 4

Cadmium
Cyanide, total
Chromium
Copper
Mercury
Nickel
Oil and Grease (IR)
Lead
Total Organic Carbon
Total Organic Halogen
Total Phenol
Zinc
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)[1]

[1]Ground-water samples and one selected soil sample only.

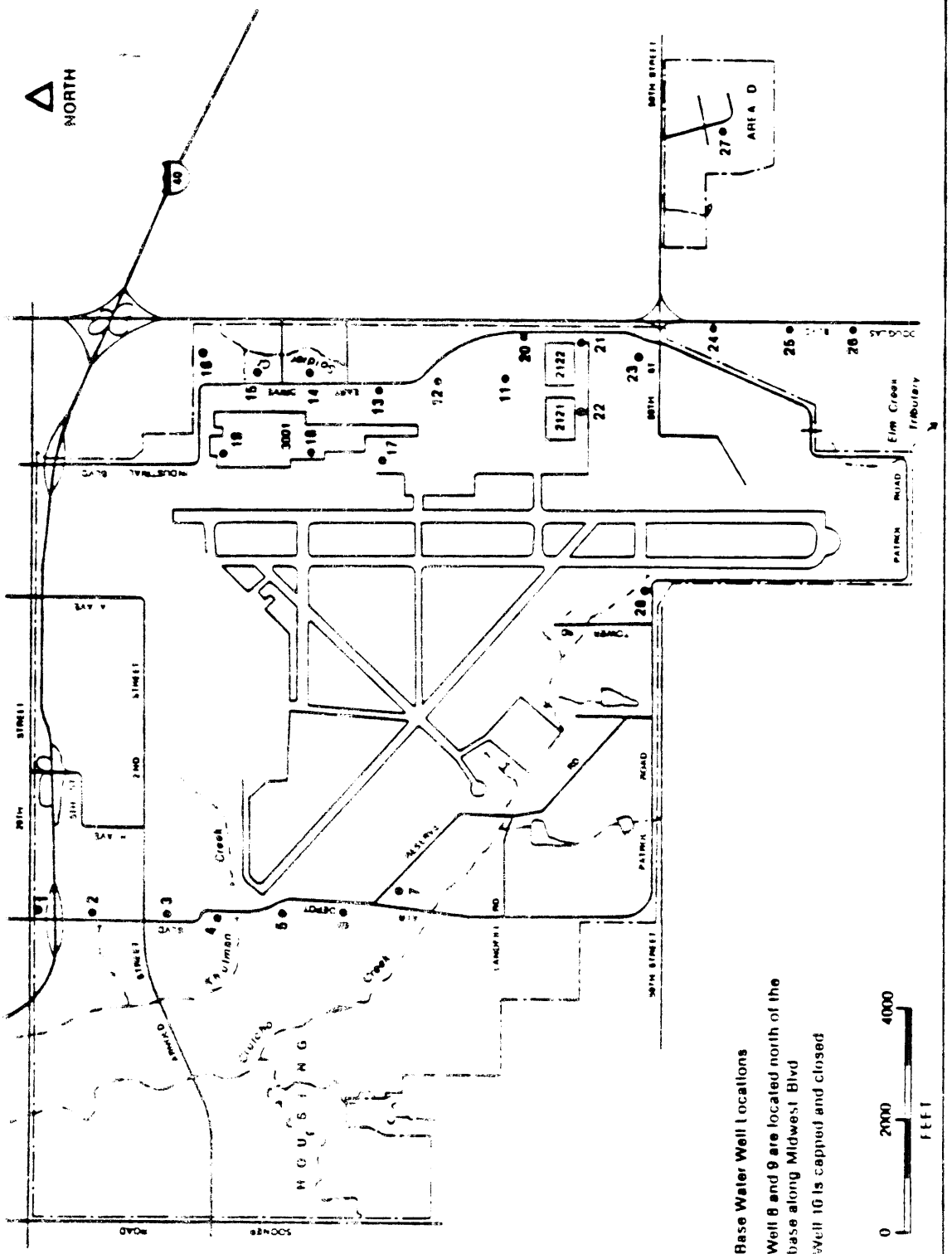

Figure 3-9. Zone 5 - Base Water Supply Wells.

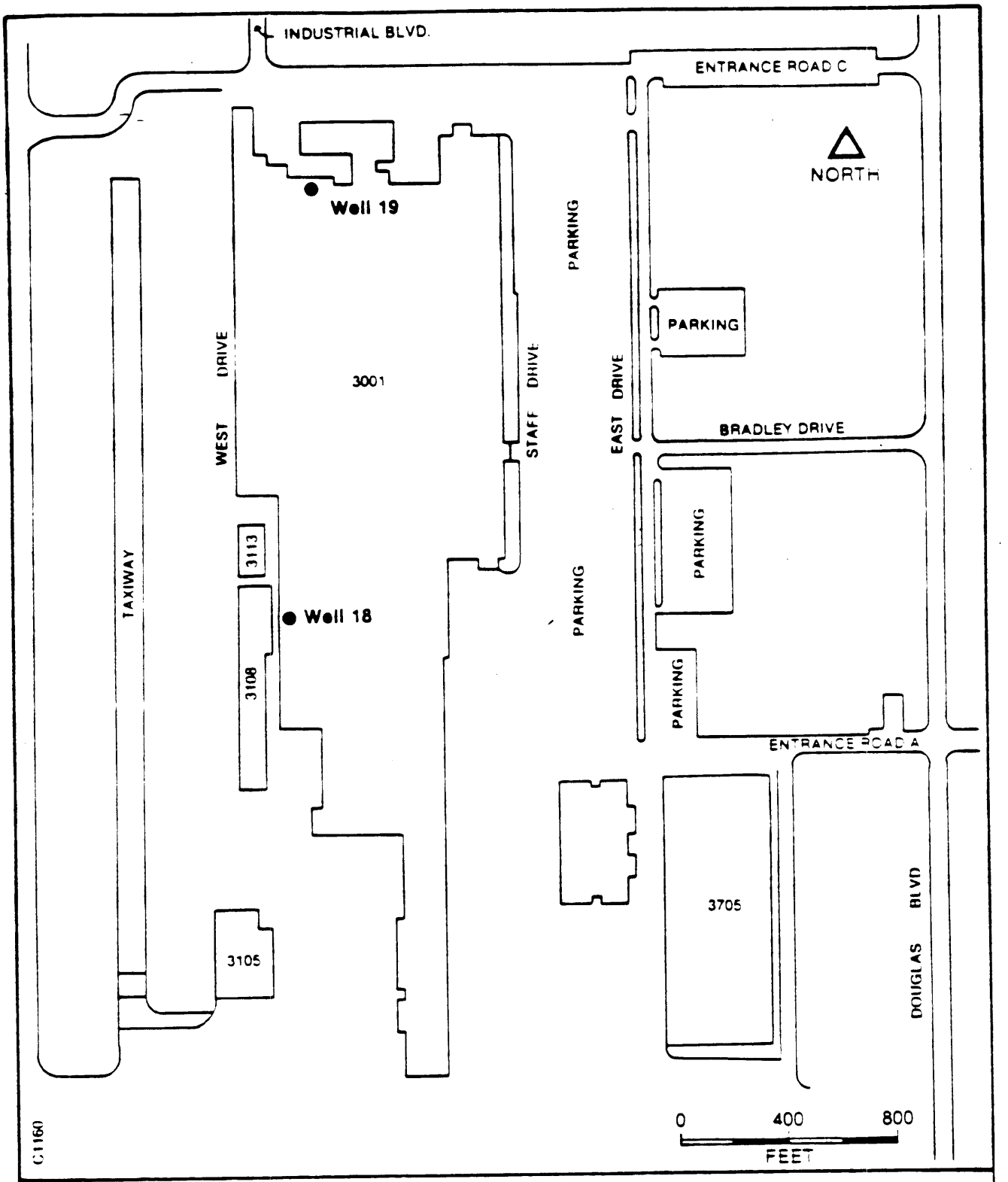

Figure 3-10. Zone 6 (Building 3001 Wells).

- Occurrence (i.e., quantity) of contaminants in the deeper aquifer.
- Mechanism for introduction of contaminants into well bore.
- Occurrence of contaminants in shallow zone.
- Movement of contaminants in shallow zone.
- Source of contaminants.

Radian determinated that the most effective means of addressing the highest priority issues was to conduct a protracted pump test with periodic sampling for contaminants of interest. If contaminants were shown to decline with continued pumping, this could be taken as evidence for limited contamination within the deeper zones of the aquifer. If, on the other hand, contaminant concentrations showed a constant or increasing trend, this would be evidence for widespread contamination. Corrollary issues (occurrence of contaminants in shallow zones, etc.) would be addressed after the results of the preliminary investigation were available.

The original plan, as specified in the modified Statement of Work, was to test-pump wells 18 and 19 for a period of up to eight hours each, collecting samples periodically for analysis by Method 601 for trichloroethylene (TCE) and tetrachloroethylene. However, as long as these wells remain connected to the water distribution system, neither could be pumped for more than approximately five minutes. Since test-pumping remained the method of investigation most likely to yield the required data in a timely and cost-effective manner, the method of investigation was modified. The test-pumping was limited to a single, 16-hour test of Well 18, only, which was disconnected from the distribution system with temporary plumbing installed to allow the well to discharge to the industrial sewer inside Buiding 3001. The test took place on 5 March 1984. Results are discussed in Section 4.2.6.

4.0 DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

In this section, the hydrogeologic observations and chemical analytical data are discussed on a zone-by-zone basis. Hydrogeologic interpretations are made on the basis of the available data. Analytical chemistry data are discussed within the context of available regulatory standards and criteria. After an introduction section dealing with available standards and criteria, the discussion of results and significance of findings are each discussed zone by zone in separate sections.

4.1 Regulatory and Human Health Criteria and Standards

In order to determine possible water quality impacts on the local ground-water systems, the organic and inorganic compounds detected in the ground-water samples were compared to various criteria. These criteria were drawn from federal drinking water regulations, standards and guidelines. Table 4-1 shows parameters detected, along with the corresponding primary or secondary drinking water standard. These standards provide a stringent comparison for human health considerations.

The second column of Table 4-1 lists EPA toxicity values for chemicals detected. These human health criteria are also available for most of the other organic chemicals detected, as summarized on Table 4-2. Although these criteria do not have the force of standards, they do provide a valid means of assessing properties of chemicals of concern. Many of the compounds are proven or suspected animal carcinogens where zero consumption is recommended for the protection of human health. Many are also regulated as hazardous waste under RCRA (40 CFR Parts 262 and 263). For each zone, parameters detected are evaluated in comparison with these standards and criteria.

The use of human health criteria and standards for comparison of ground-water contamination at Tinker AFB provides stringent evaluations of observed concentrations. Since the shallowest zones of the aquifer are not used as water supply sources, contaminants in situ have neither human health

TABLE 4-2. GUIDELINES FOR ORGANIC COMPOUNDS DETECTED IN GROUND WATER

Compound	EPA Toxicity[1,2] ppb unless noted
EPA Method 601 (Purgeable halocarbons)	
Methylene Chloride	0 (1.9)[3]
1,1-Dichloroethene	0 (0.33)
trans-1,2-Dichloroethene	n.c.[4]
1,1-Dichloroethane	0 (9.4)
1,2-Dichloroethane	0 (9.4)
1,1,1-Trichloroethane	18.4 ppm
Trichloroethylene	0 (27)
Chlorobenzene	488
Chloroform	0 (1.9)
Bromodichloromethane	0 (1.9)[3]
Tetrachloroethylene	0 (8)
Modified EPA Method 625 (Acid/Neutrals)	
1,2-Dichlorobenzene	400
1,3-Dichlorobenzene	400
1,4-Dichlorobenzene	400
di-n-butyl phthalate	34 ppm
Isophorone	5.2 ppm
butyl benzyl phthalate	n.c.

[1]Footnote 2, Table 4-1.

[2]EPA has recommended human health effects criteria of zero (0) for carcinogens, but notes that this level may currently be infeasible. The Agency provides criteria for achieving various levels of protection on an interim basis. The levels which may result in a 10^{-5} incremental increase of cancer risk over a lifetime are presented in parentheses in ppb unless noted. These figures would permit one case of cancer per 100,000 people exposed.

[3]Criterion for "halomethanes".

[4]n.c. -- denoted no criteria set for human health due to insufficient data.

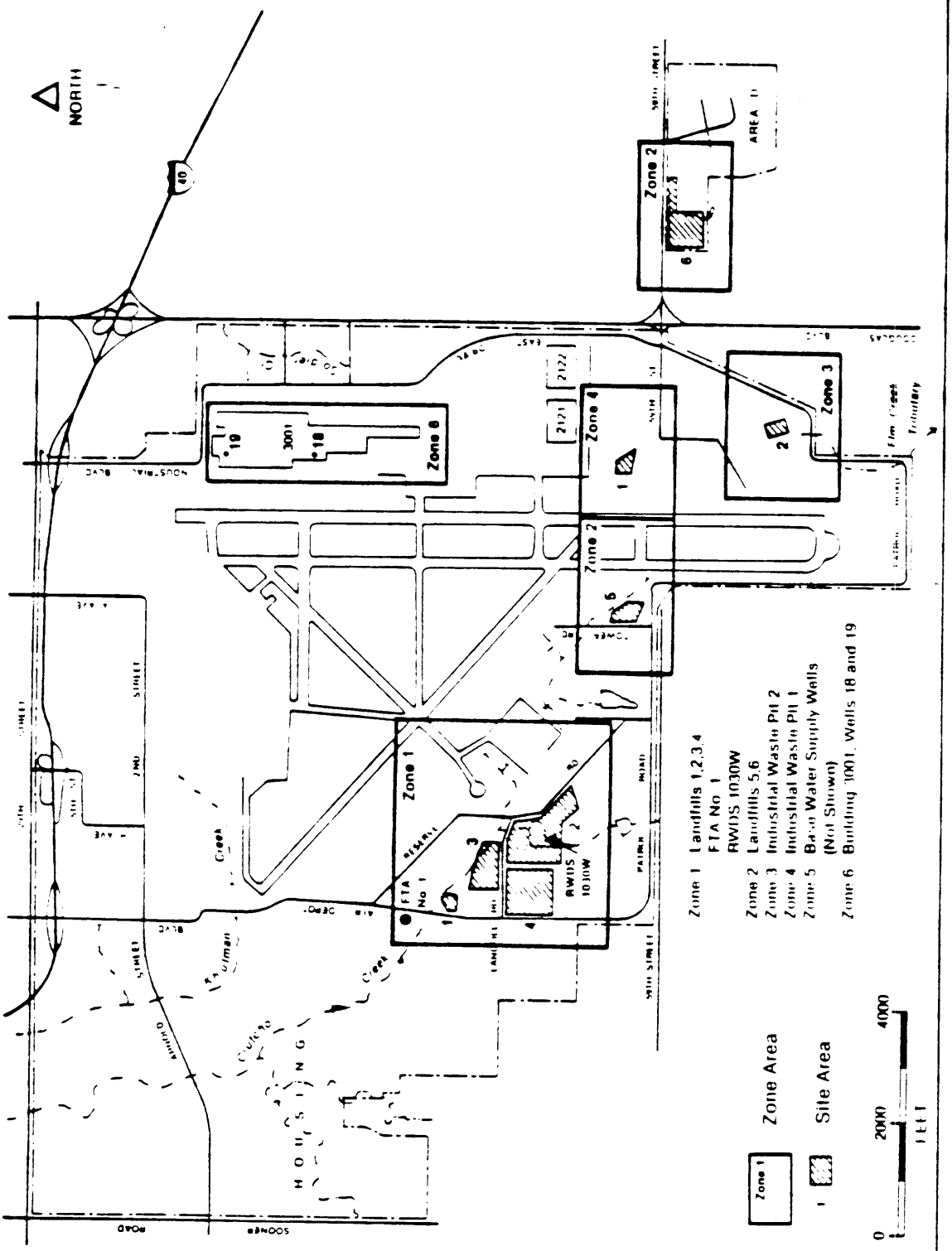

Figure 4-1. Zones of Investigation, Tinker AFB.

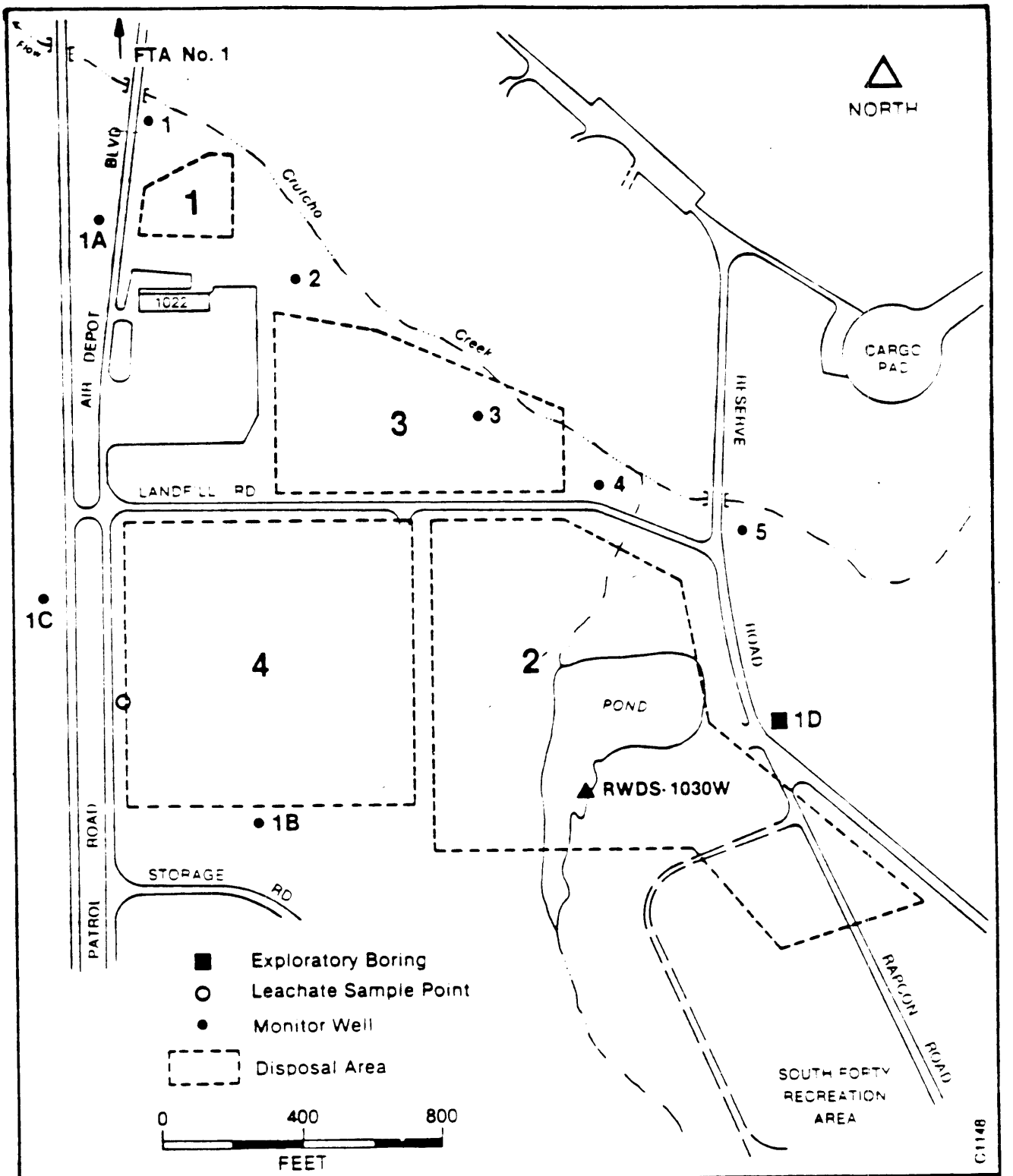

Figure 4-2. Location of Sample Points, Zone 1.

Perched ground water also exists within Landfill 4 (and possibly other landfills), emerging as both discrete seeps and broad zones of seepage along the margins of the landfill. The volume of seepage at the land surface is correlatable with rainfall events; for example, active seeps were observed at the west side of Landfill 4 within several weeks of heavy rainfall that occurred in October 1983, but these seeps were nearly dry in February 1984 following a relatively dry spell. Landfill leachate that emerges at the surface collects in roadside ditches and flows to the north to Crutcho Creek.

Ground-water flow, as inferred from water-level elevations in wells away from the influence of Crutcho Creek, is generally to the west. The results of water level interpretations for Zone 1 are consistent with the results obtained in other zones, indicating a hydrogeologic picture consistent with the regional flow patterns observed in the Oklahoma City area.

Ground-Water Quality

After installation, each of the Phase II (Stage 1) monitor wells was sampled for chemical analysis. The eight existing monitor wells (numbered one through eight) were also sampled at this time. The results of analyses are given on Table 4-3. Samples from monitor wells 1A, 1B, and 1C were analyzed for acid/neutral extractable organic priority pollutants (modified EPA Method 625). Samples from monitor wells 2 and 4 were resubmitted for modified Method 625 analysis, based on the results of total organic carbon analyses performed in the specific parameter schedule. No additional compounds were detected by modified Method 625. Complete reports of all analyses are provided in Appendix H. These data are discussed in Section 4.3.

Other Samples

In addition to the monitor well samples, selected surface water samples were also collected. The recreation pond overlying Landfill 2 was sampled by compositing grabs from randomly selected points. The leachate seep on the west fence of Landfill 4 was sampled, but leachate seeps at other landfills remained dry throughout the period. Results of analyses are also shown on Table 4-3. These data are also discussed in Section 4.3.

4.2.2 Zone 2 (Landfills 5 and 6)

Work performed at Zone 2 consisted of the installation of two groundwater monitor wells (one at Landfill 6 and one at Landfill 5) and the sampling and analysis of water from the monitor wells. The results and significance of the hydrogeologic and chemical data are discussed in the following paragaphs.

Topography

Zone 2 is separated into two distinct areas with over 1 mile of separation (Figure 4-1). It exhibits the same types of topograhic features that occur in other zones. Landfill 5 (Figure 4-3), located just southwest of Crutcho Creek and upstream of Zone 1, is built up on the order of 5 to 10 feet above the surrounding land, which slopes gently to the northeast toward Crutcho Creek. Similarly, Landfill 6 (Figure 4-4) is higher than the surrounding land as it is located on the crest of a low hill just south of S.E. 59th Street and east of Douglas Boulevard. Both landfills are relatively recent features, having been active within the last 5 to 15 years. Accordingly, there is patchy vegetation on both fill surfaces. There is also recent disruption of the surface of Landfill 5 due to nearby construction.

Geologic Features

Results of monitor well installation show that the geologic setting at sites in Zone 2 is essentially the same as the geologic setting at Zone 1. A near-surface zone of soil and weathered shale, normally 3 to 5 feet thick, is underlain by dry, red Fairmont Shale. The shale is in turn underlain by fine-grained sandstone of the Garber Sandstone. Logs of borings (Appendix D) for wells 2A (at Landfill 6) and 2B (at Landfill 5) include detailed descriptions of the geologic section. Figure 2-5, a geologic cross-section of the southern part of the base, illustrates the continuity of geologic strata from zone to zone. The dip of the strata is to the west at a shallow angle, which is consistent with the regional geologic framework of Permian-age strata in central Oklahoma.

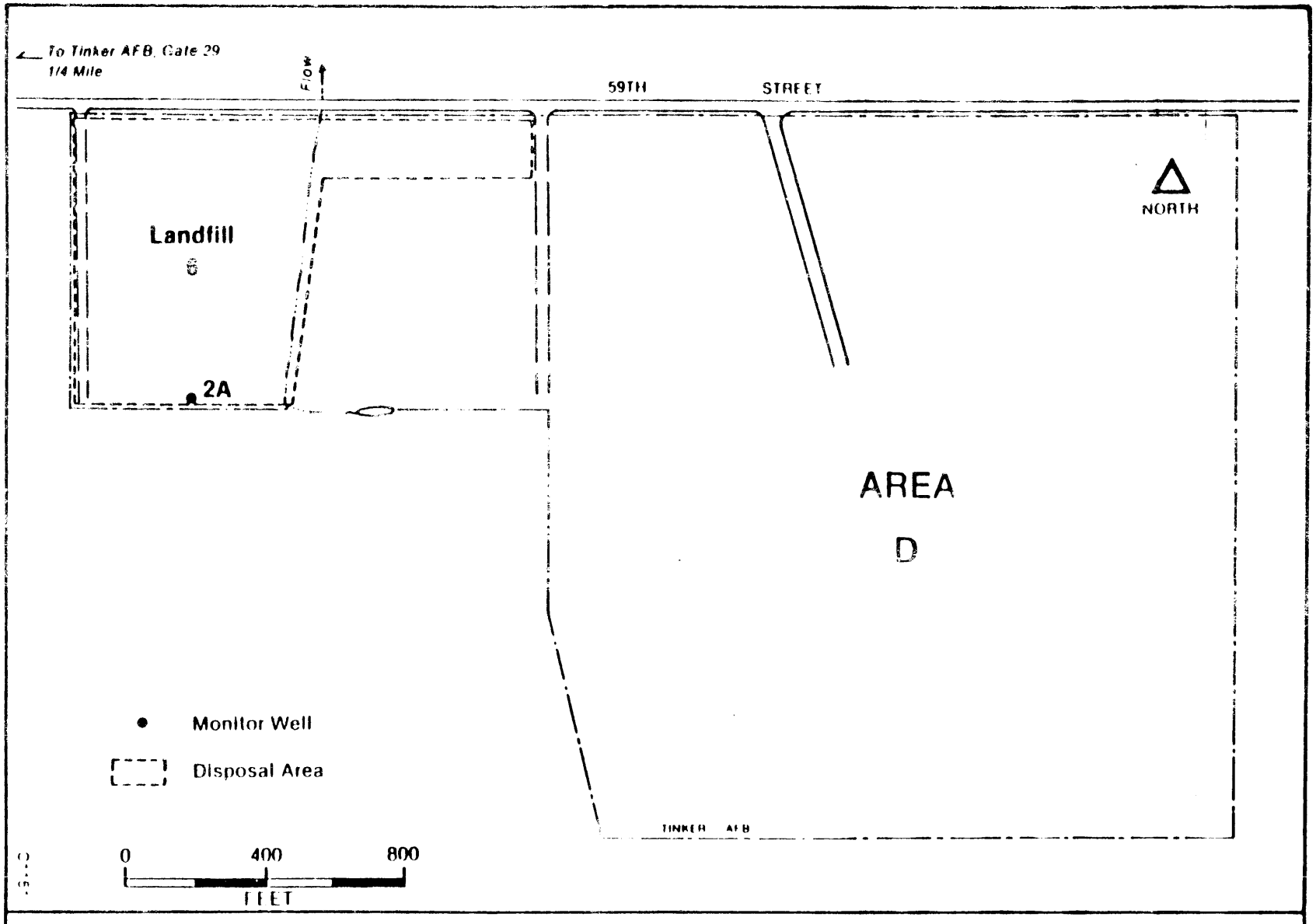

Figure 4-4. Location of Sampling Points, Zone 2 (Landfill 6), Tinker AFB.

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TABLE 4-4. RESULT OF CHEMICAL ANALYSES, ZONE 2, TINKER AFB

Parameter mg/l (except as noted)	Well 2A	Well 2B
Barium	0.21	0.45
Cadmium	0.006	<.002
Cyanide	<.01	<.01
Chromium	<.001	<.001
Copper	<.001	<.001
Iron	0.23	<.008
Mercury	0.0004	<.0005
Nickel	<.003	<.003
Oil & Grease	<0.10	<0.10
Lead	<.002	<.002
Phenol	<.005	<.005
Total Organic Carbon	<1	9
Total Organic Halogen	<.01	<.01
Zinc	0.34	<.003
Herbicides		
2,4-D	ND	ND
2,4,5-TP (silvex)	ND	ND
Pesticides (EPA Method 608)	ND	ND
Acid/Neutral Extractable Organic Priority Pollutants (Modified EPA Method 625)		
butyl benzyl phthalate	ND	2.3 µg/L

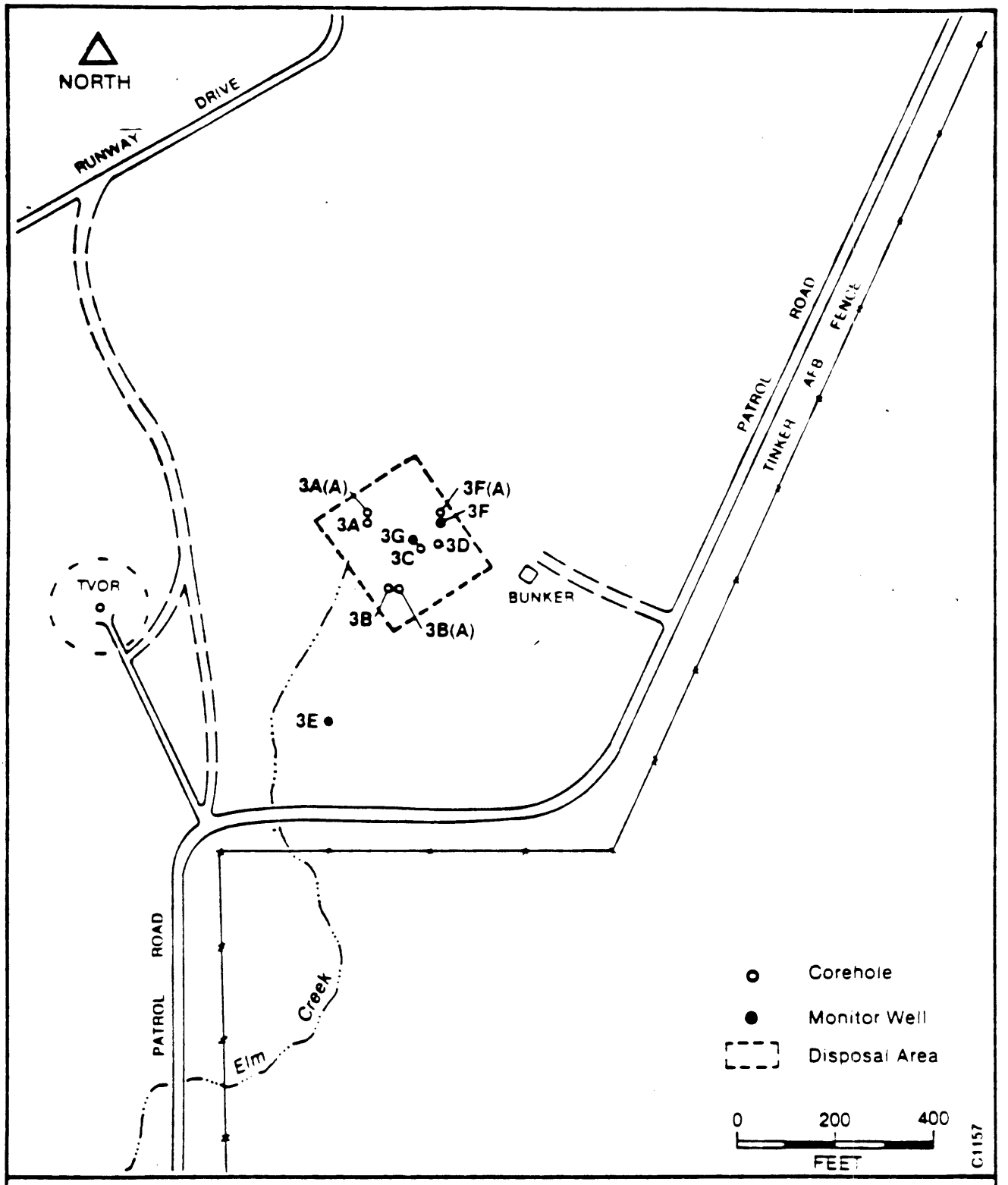

Figure 4-5. Location of Sampling Points, Zone 3, Tinker AFB.

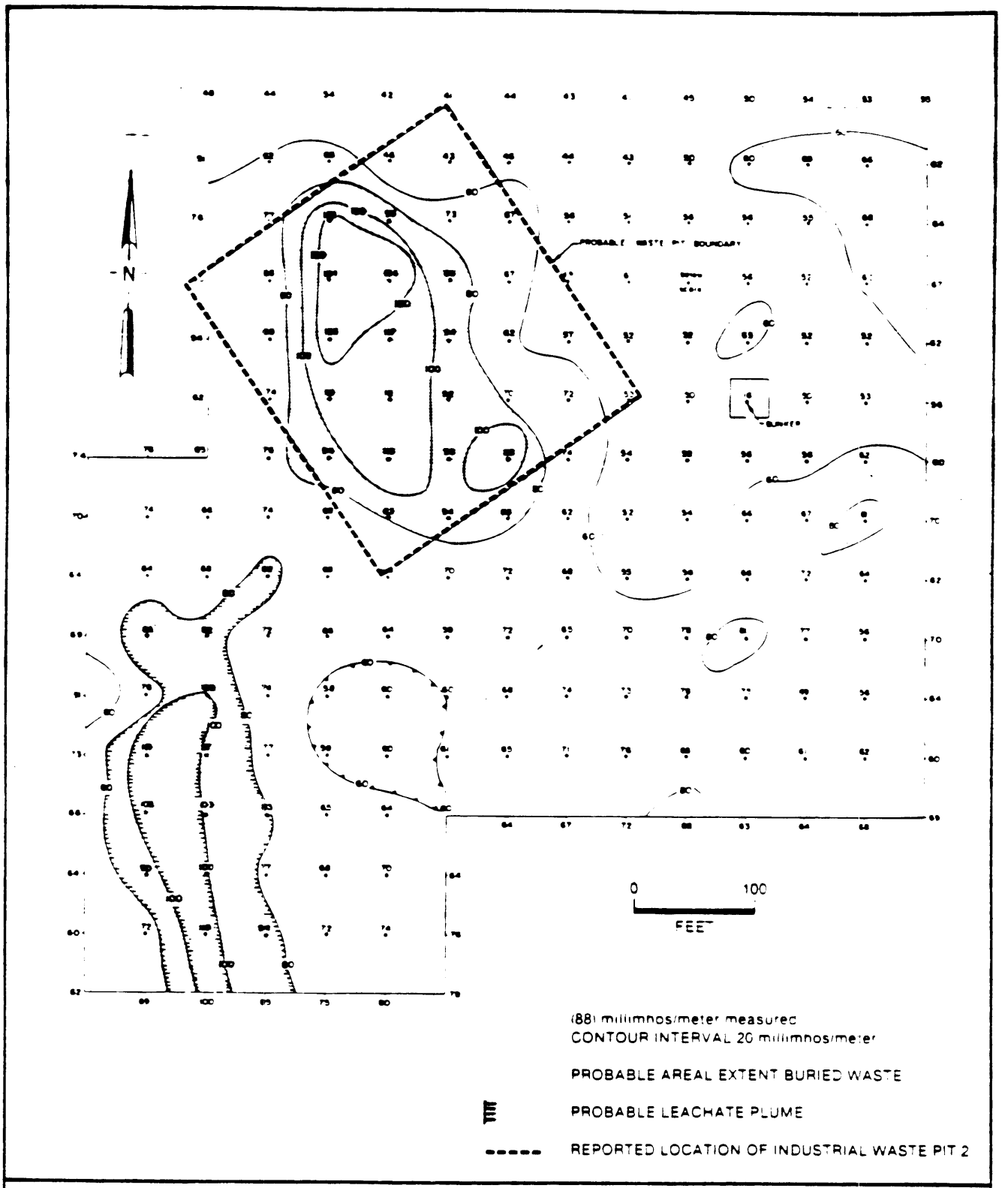

Figure 4-6. Geophysical Survey Results, EM31, Zone 3, Tinker AFB.

Soil Sampling

Shallow soil sampling operations (described in Section 3.1.2) were conducted at the conclusion of the field geophysical survey. Results of the geophysical survey were used as an aid in selecting the locations of the cores so as to investigate the area of the waste pit. Sampling was performed at five locations in order to directly observe soil conditions at the waste pit and to provide for the installation of two shallow ground-water monitor wells.

The geologic materials varied considerably within the area of investigation. For the most part, the subsurface consisted of soil and fill, underlain by weathered and unweathered shale. Augering and sampling were quite difficult in unweathered shale, with refusal typically at or slightly below the weathered shale - unweathered shale contact. Split-spoon samples from directly over the conductivity anomalies generally yielded near-surface samples of soil with a contaminated appearance: dark brown, moist, clayey fill-like material. The logs of borings for Zone 3 (Appendix D) provide additional and specific details. It is believed that the fill-like material simply represents soil that was pushed or placed into or over the waste pit during reclamation in the mid-1960s.

Rotary Drilling

Sampling of deeper stratigraphic horizons (at monitor wells 3E) southwest of the waste pit revealed a sequence essentially identical to the geologic setting at Zones 1 and 2. No evidence of soil or ground-water contamination was observed during the drilling of 3E.

Occurrence of Ground Water

Ground water at Zone 3 was found to occur under three different conditions: in a shallow, saturated interval extending from just below the land surface to the top of the unweathered shale; in a sandstone body isolated in a dominately shale section directly below the waste site; and in the regional water-table aquifer continuous within the base.

of selected metals, total organic carbon, total organic halogen, and phenols. The samples selected for analysis were chosen such that the vertical and horizontal distribution of chemical species in geologic materials within and below the pit could be evaluated, as shown on Table 4-5. Based on the results of these analyses, one sample (the sample with the highest level of total organic carbon) was resubmitted for modified EPA Method 625 analysis. Results of these analyses are provided on Tables 4-6 and 4-7.

After installation, each of the monitor wells was sampled for chemical analysis. The results of analyses are shown on Table 4-8. Samples were analyzed for acid/neutral extractable organic priority pollutants (modified EPA Method 625); only compounds detected are shown. Complete reports of all analyses are provided in Appendix H. These data are discussed in Section 4.3.

4.2.4 Zone 4 (Industrial Waste Pit No. 1)

Work performed at Zone 4 consisted of geopysical (EM) survey, shallow soil coring at six locations, installation of two shallow ground-water monitor wells within the boundary of the disposal area, installation of 1 deep ground-water monitor well away from the disposal area, and sampling and analyses of soil and ground water. The results of the hydrogeologic, geophysical, and chemical data are discussed in the following paragraphs.

Topography

Zone 4 is located in the southeastern portion of Tinker AFB, just east of the main north-south runway and southwest of maintenance buildings 2121 and 2122. The area is nearly flat, with a gentle slope to the southwest toward Crutcho Creek. The topographic relief is about 20 feet, with elevations ranging from 1270 feet to about 1290 feet across the site.

Figure 4-8 illustrates the suspected disposal area, as well as the locations of the cores, monitoring wells, and the limits of the geophysical survey.

TABLE 4-6. RESULTS OF SOILS ANALYSES, ZONE 3, TINKER AFB

Parameter (µg/g, except as noted)	Soil Sample									
	3Aa	3Aa (alt)	3Ab	3Bb	3Bd	3Be	3Ca	3Cb	3Fb	3Fc
Cadmium	3.2	2.0	0.49	0.25	0.20	<.15	23	1.2	0.25	<.020
Cyanide	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Chromium	8.9	6.2	4.5	3.8	2.9	4.0	750	5.7	15	4.0
Copper	7.1	4.1	11	5.6	5.6	5.7	130	13	5.1	2.3
Mercury	4.0	4.5	4.1	3.5	3.4	4.0	3.5	3.5	3.8	3.8
Nickel	38	13	13	7.2	5.4	6.0	40	11	7.9	5.7
Oil & Grease (mg/g)	2	5	2	0.5	1.5	0.5	6	1	1.5	1
Lead	5.2	2.5	2.9	2.5	1.8	1.9	41	3.3	9.2	1.6
Phenol	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Total Organic Carbon (%)	0.11	0.32	0.02	0.02	0.02	0.04	0.52	0.03	0.19	0.02
Total Organic Halogen	<1	12	<1	<1	<1	<1	14	<1	<1	<1
Zinc	9.2	3.0	12	5.9	5.0	8.2	36	7.6	16	5.7

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TABLE 4-8. RESULTS OF GROUND-WATER SAMPLE ANALYSES, ZONE 3, TINKER AFB

Parameter (mg/L, except as noted)	Well 3E	Well 3F	Well 3G
Cadmium	<.002	<.002	2.2
Cyanide	<.01	<.01	<.01
Chromium	<.001	<.001	12
Copper	<.001	<.001	0.15
Mercury	0.0004	0.0006	<.0005
Nickel	<.003	<.003	82
Oil & Grease	<0.10	<0.10	70
Lead	<.002	<.002	3.3
Phenol	<.005	<.005	80
Total Organic Carbon	<1	3	4000
Total Organic Halogen	<.01	<.01	3.4
Zinc	0.016	0.024	29
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)			
1,2-dichlorobenzene	ND	ND	20
phenol	ND	ND	220

[1]Probable low bias due to interferences with colorimetric procedure, large dilution required for analysis.

Topography

Zone 4 is located in the southeastern portion of Tinker AFB, just east of the main north-south runway and southwest of maintenance buildings 2121 and 2122. The area is nearly flat, with a gentle slope to the southwest toward Crutcho Creek. The topographic relief is about 20 feet, with elevations ranging from 1270 feet to about 1290 feet across the site.

Figure 4-8 illustrates the suspected disposal area, as well as the locations of the cores, monitoring wells, and the limits of the geophysical survey.

Geologic Features

Geologic data developed for Zone 4 resulted from three primary activities: geophysical (EM) surveying, geologic sampling during coring and drilling operations, and observations of water levels during and after coring and monitor well installation.

The geologic picture at Zone 4 is virtually the same as at other zones. The major geologic units are a thin soil cover, underlain by dry, red Fairmont Shale, in turn underlain by sandstone of the Garber Sandstone. Logs of boring and drilling operations (Appendix D) provide additional details of the geologic section. The major geologic feature of interest in the investigation of Zone 4 are the near-surface phenomena (conductivity anomalies and disturbed earth materials) associated with the former Industrial Waste Pit No. 1. The purpose of the geophysical survey and shallow coring efforts was to investigate in detail the near-surface geologic conditions in view of the potential for ground-water contamination.

Geophysical Survey

Ground conductivity was read directly using the Geonics EM31 and EM34-3. By using both the EM31 and EM34-3 (10m and 20m of separation) the

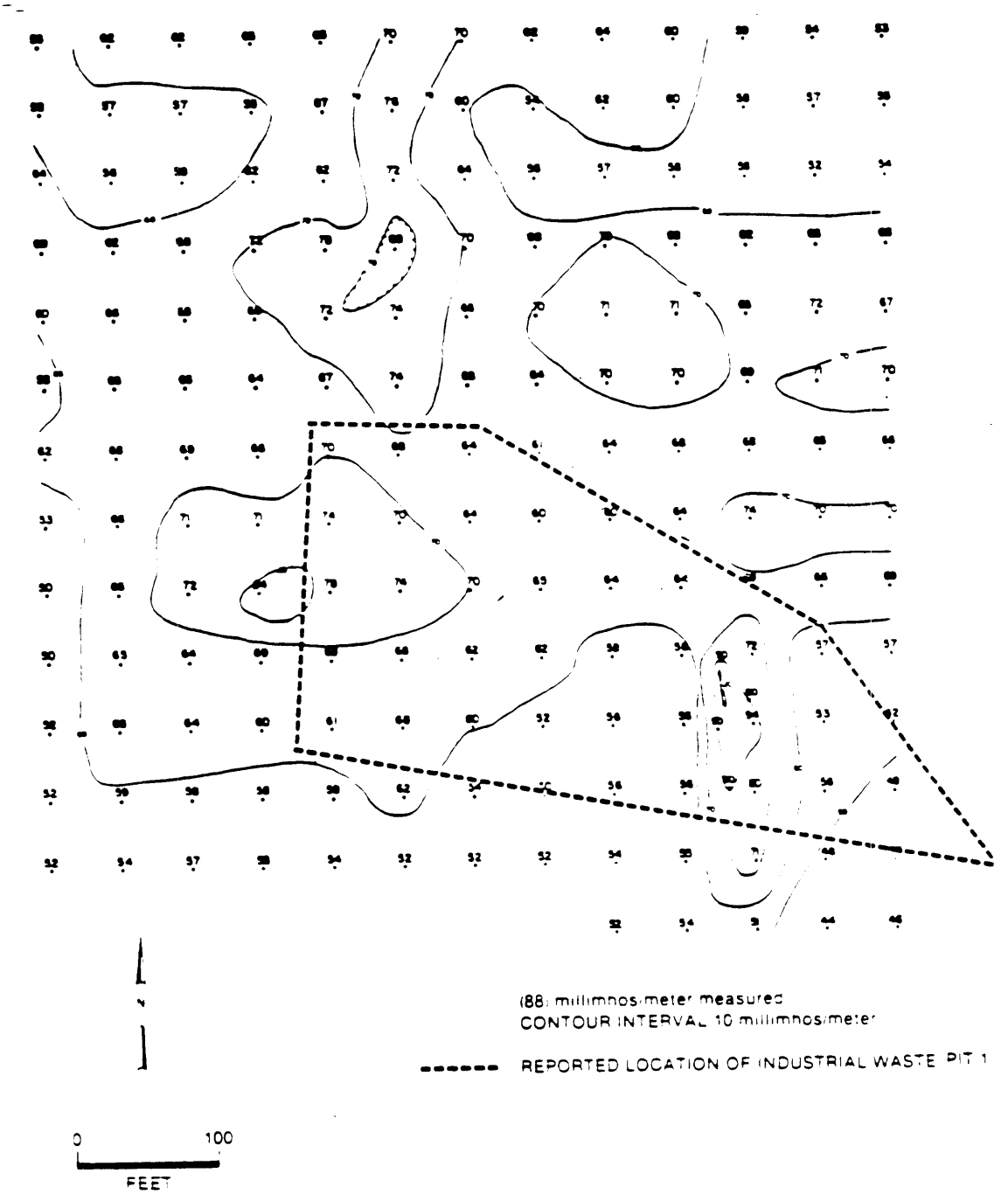

Figure 4-9. Geophysical Survey Results, EM31, Zone 4, Tinker AFB.

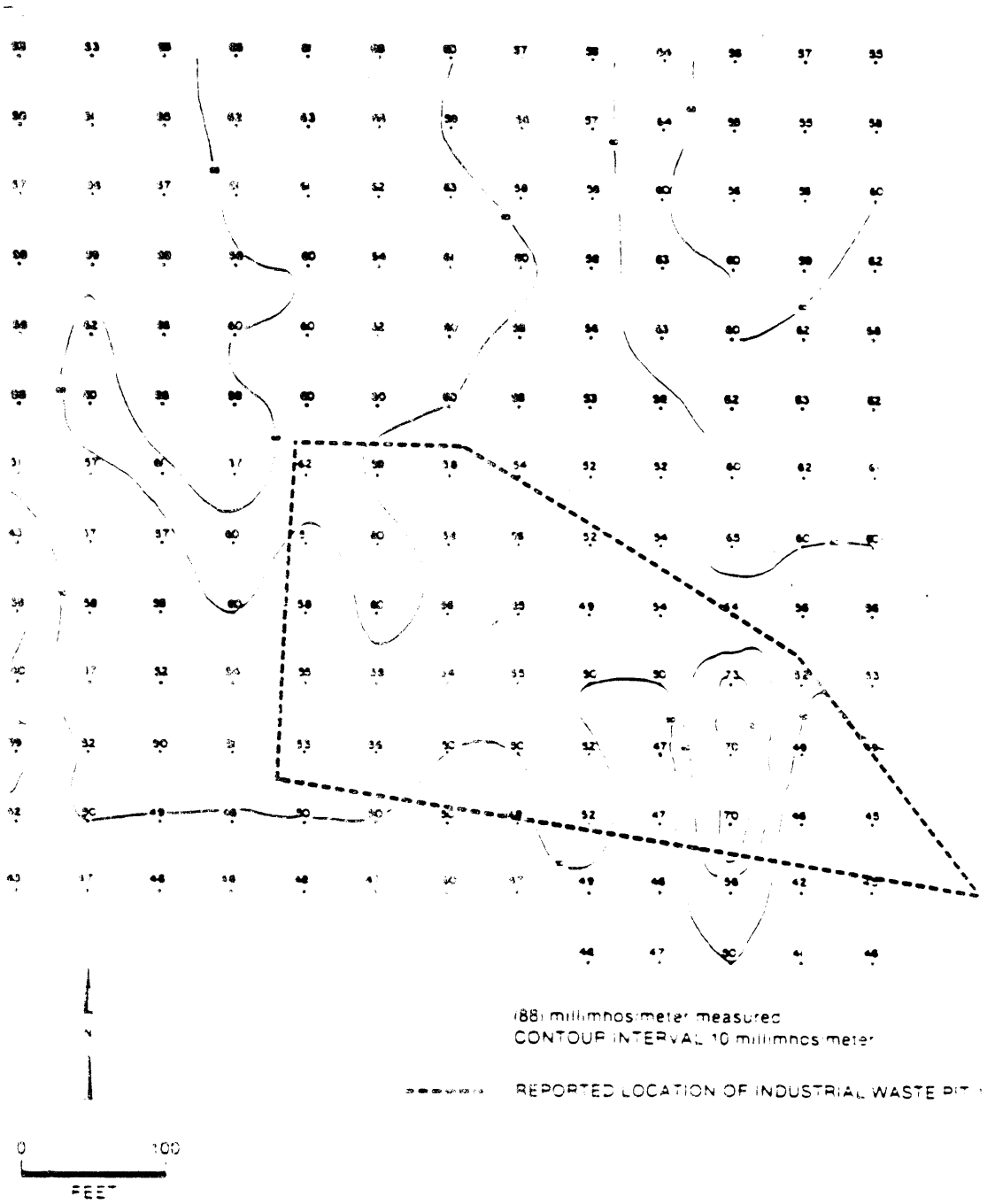

Figure 4-11. Geophysical Survey Results, EM34-3 (20m spacing), Zone 4, Tinker AFB.

Soil Chemistry and Ground-Water Quality

Split-spoon samples collected in the coring operations were retained and examined for evidence of contamination. Based on the apparent geometry of the pit, ten samples of soil were selected for detailed analysis, consisting of selected metals, total organic carbon, total organic halogen, and phenols. The samples selected for analysis were chosen such that the vertical and horizontal distribution of chemical species in geologic materials within and below the pit could be evaluated, as shown on Table 4-9. Based on the results of these analyses, one sample (chosen to be the sample with the highest level of total organic carbon) was resubmitted for modified EPA Method 625 analysis. Results of these analyses are provided on Table 4-10.

After installation, each of the monitor wells was sampled for chemical analysis. The results of the analyses are shown on Table 4-11. Samples were analyzed for acid/neutral extractable organic priority pollutants (modified EPA Method 625); only compounds detected are shown. Complete reports of all analyses are provided in Appendix H. These data are discussed in Section 4.3.

4.2.5 Zone 5 (Base Water Supply Wells)

Zone 5 consists of 27 Base Water Supply wells, as shown on Figure 4-12. Each of the 20 operational wells was sampled during 7-17 February 1984. Samples were submitted to the laboratory for screening analyses (Total Organic Carbon and EPA Method 601). Sampling results are shown on Tables 4-12 and 4-13. Based on the results of these tests, five samples were resubmitted for analysis by EPA Methods 624 (Volatile Organic Priority Pollutants by GC-MS) and modified 625 (Acid/Neutral Organic Priority Pollutants by GC-MS). No additional compounds were discovered by these analyses. Complete reports of results are contained in Appendix H. Of the 20 wells sampled, only six displayed any trace of chlorinated organic contaminants. Observations concerning the contamination in each well are provided in Section 4.3.

TABLE 4-10. RESULTS OF SOILS ANALYSES, ZONE 4, TINKER AFB

Parameter (µg/g, except as noted)	Soil Sample									
	4B.5	4B.6	4C.5	4D.2	4E.2	4E.3	4E.4	4E.5	4F.2	4F.3
Cadmium	<.21	<.20	1.7	17	1.7	340	<.20	1.5	2.7	5.0
Cyanide	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	4.9	8.5	11	42	9.1	78	5.6	6.3	230	32
Copper	4.2	7.1	8.5	16	15	47	3.8	9.2	24	9.7
Mercury	10	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Nickel	3.0	11	8.3	11	14	39	5.4	9.6	22	8.0
Oil & Grease	780	410	290	206	1070	140	240	550	200	150
Lead	6.4	8.9	8.4	85	2.9	660	7.4	0.99	150	18
Phenol	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Total Organic Carbon (%)	0.12	0.10	0.08	0.15	0.10	0.13	0.10	0.12	0.08	0.05
Total Organic Halogen	0.20	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Zinc	5.3	9.4	7.4	57	14	1400	6.6	7.8	75	17
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)	-	-	-	-	-	None Detected	-	-	-	-

- = Not Analyzed.

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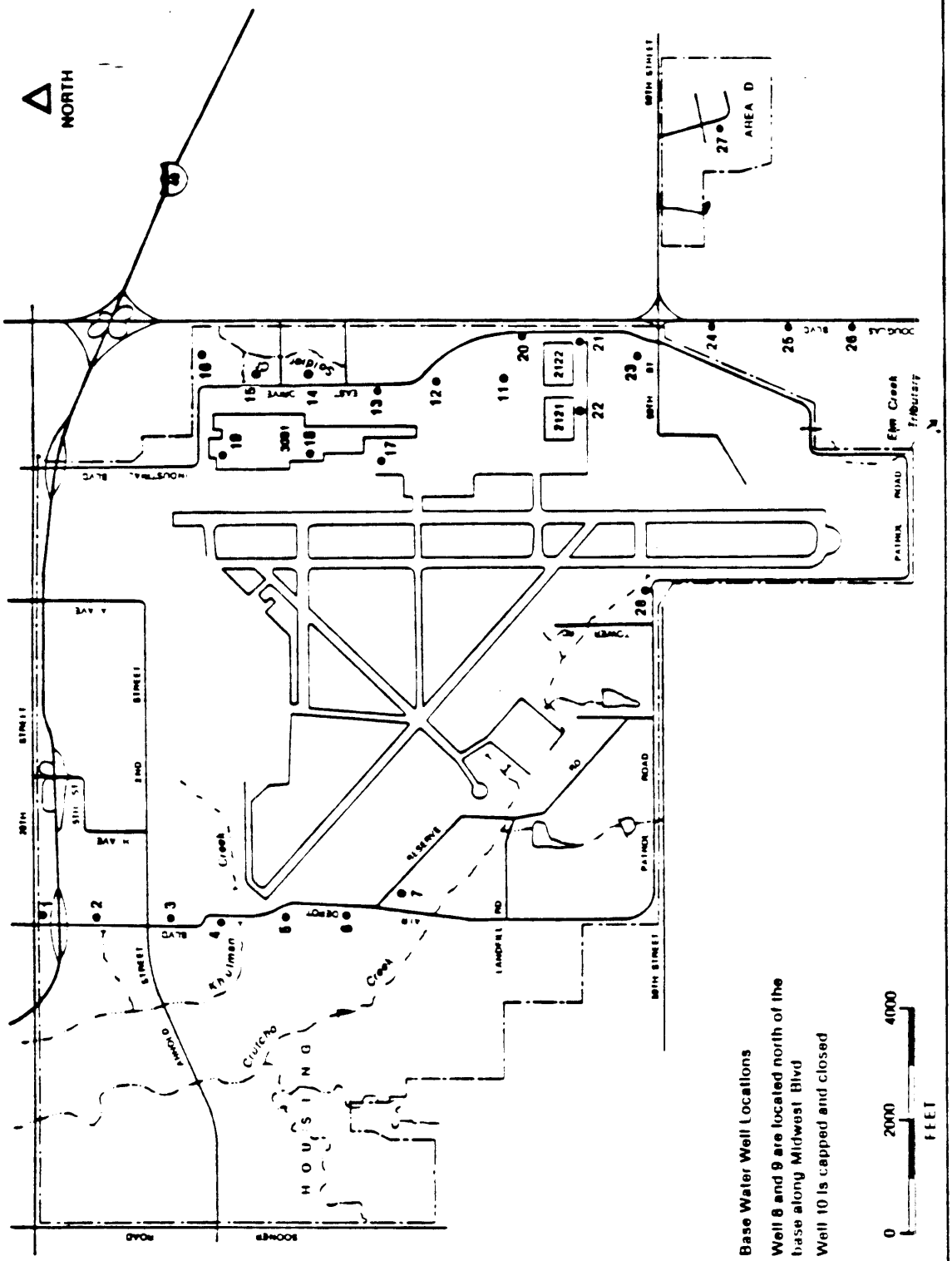

Figure 4-12. Location of Sampling Points, Zone 5 (Base Water Supply Wells).

TABLE 4-13. EPA METHOD 601 COMPOUNDS DETECTED IN BASE WATER SUPPLY WELLS (ZONE 5)

Compound (µg/L)	5	9	14	16	18	18 (resample)	19	19 (resample)
Methylene Chloride					1.1		0.6	
1,1-Dichloroethene					0.2			
1,1-Dichloroethane					1.4			
trans-1,2-Dichloroethene	1.7			1.2	31.7	32.8		
Chloroform		2.1						
1,2-Dichloroethane					25.8			
1,1,1-Trichloroethane					1.8			
Bromodichloromethane		0.4						
Trichloroethylene			0.7	2.2	1750	1530		
Tetrachloroethylene			0.3	0.7	30.1		7.8	2.8
Chlorobenzene					7.9			

TABLE 4-14. TRICHLOROETHYLENE CONCENTRATION DURING WELL 18 PUMP TEST

Sample Number T6-	Elapsed Time (hr:min)	Concentration (mg/L)
1	0:10	3.5
2	0:20	3.3
3	0:30	3.4
4	0:45	3.5
5	1:00	3.0
6	1:15	4.0
7	1:35	4.6
8	2:00	4.2
9	2:30	2.7
10	3:00	2.6
11	3:35	2.2
12	4:15	2.2
13	5:00	2.0
14	6:00	2.1
15	7:00	1.9
16	8:10	2.1
17	9:35	1.7
18	11:00	1.8
19	13:00	1.8
20	16:00	1.8

separate from that along the creek. The elevation of the water table in these three wells is about 1200 feet, compared to about 1215 to 1220 in wells 3, 4 and 5 along Crutcho Creek. Recharge from the shallow ground water to lower systems would be limited to permeable zones in the dominantly shale strata. The area of Zone 1 is a recharge zone, since piezometric heads decline with depth, as supported by the observation of the water level in core 1D, drilled to a depth of 150 feet (approximately elevation 1082). Three hours after drilling advanced to total depth, the water level was observed at 55 feet below the land surface, at approximately elevation 1183, some 20 feet below the level in wells 1A - 1C.

The measurement of water table elevation in Wells 1A - 1C allow determination of the direction of ground-water flow in the shallowest zones of the sandstone aquifer. Figure 4-14 shows the water table elevations in these three wells and the resultant inferred ground-water flow direction. Flow is to the southwest, in general agreement with the regional system (Figure 2-8). Note that this direction was derived from analytical geometry (three points define a plane in space), rather than from interpreted ground-water contours.

The analytical chemical data for Zone 1 show only limited impact of the landfills on ground-water quality. Of the three deep monitor wells, only the sample from Well 1A shows evidence of contaminant migration to deeper strata. While no human health standards or criteria are exceeded for the analyses performed, levels of total organic carbon (TOC, 5 mg/L), total organic halogen (TOX, 0.08 mg/L), iron (0.025 mg/L) and manganese (0.23 mg/L) are elevated relative to the other two deep wells. The concentration of manganese is also elevated in Well 1A relative to the secondary drinking water standard of 0.05 mg/L.

The State of Oklahoma analytical data (Appendix H) suggests the presence of volatile chlorinated organic compounds in Wells 1A (dichlorobenzene - 5 ppb) and 1C (trichloroethylene - 210 ppb and 1, 1, 2-trichloroethane - 6 ppb). The Phase II (Stage 1) study did not address these compounds. No volatile halocarbon analyses were performed. However, the

Phase II (Stage 1) analytical schedule does contain total organic halogen (TOX). This test is used as a screening parameter to test for the likely presence of chlorinated organic species. It is only a screening test, and should not be used for any final determination of the presence or absence of chlorinated compounds. It is subject to low bias due to loss of volatiles during transport and analysis and subject to high bias due to interference by inorganic chlorides. The nominal detection limit is 0.01 mg/L (10 ppb) of chlorine. TOX values reported for monitor wells 1A through 1C range from 0.06 to 0.08 mg/L (60-80 ppb), as chlorine. This is in rough correspondence with the State of Oklahoma GC-MS data, which show some volatile chlorinated organics in all three wells. In general, there is rough correspondence between TOX levels and the GC-MS data throughout the Base. In some cases, the TOX data suggest more chlorinated species were present than were found by the State of Oklahoma; in some cases, less. Additional sampling and analysis would be required to further address this issue.

Of the eight pre-existing monitor wells, only Wells 2 and 4 display contamination. Well 2 yields water with a TOC of 37 mg/L.; Well 4, water with TOC of 33 mg/L. and TOX of 0.2 mg/L. The concentration of manganese is also elevated in all shallow wells relative to the secondary drinking water standard of 0.05 mg/L. However, these data are at significant variance from the data obtained at the time the wells were drilled (Finn, 1981), when nearly all displayed large quantities of metals and TOC. Without knowledge of the conditions under which those samples were collected or the physical appearance of the samples, it is difficult to assess the cause of the difference between the two sample sets. The earlier data were collected in the fall, when leachate outflow from the landfills, rather than surface water recharge would have dominated the system. Perhaps the earlier samples merely came from a leachate-dominated system which does not persist year round. Periodic sampling over at least one full year would be required to assess the variability of the system. The State of Oklahoma data show volatile chlorinated organics in three of the six wells sampled. TOX is present in four of the eight wells.

permeable zones in the shale. A single data point is insufficient to determine a ground-water flow direction. Regional data (Figure 2-8) suggest a southerly flow at this point.

The analytical data do not provide evidence of significant contamination. No human health standards or criteria were exceeded. Monitor wells 6 through 8 display elevated manganese concentrations (relative to the secondary drinking water standard) and moderate (2 to 14 mg/L) levels of TOC. The deeper well (2B) displays TOC of 5 mg/L. The modified EPA Method 625 data also display a very low (3.2 ug/L) level of butyl benzyl phthalate, for which no human health or environmental criterion exists. Since the phthalate esters are nearly ubiquitous and are often an artifact of the analysis, detection of one at the low ppb level is probably not significant. The State of Okalahoma data (Appendix H) show appreciable levels of dichloroethene (385 ppb) and trichloroethylene (62 ppb) in existing well 6 and lesser quantities in well 7. No purgeable organic compounds were detected in Well 2B.

Landfill 6

Activities at Landfill 6 were limited to the installation and sampling of a single deep monitoring well (2A) south of the landfill. Pre-existing monitor wells 9 and 10, which were dry at the time of their installation (Finn, 1981), were not sampled. Ground water was encountered at a depth of approximately 36 feet below land surface, at approximately elevation 1259. Based on regional considerations, ground-water flow is to the south. The single data point of Well 2A is insufficient to establish local conditions.

The Phase II (Stage 1) analytical data do not provide evidence of ground-water contamination. No human health standards or criteria were exceeded. However, the State of Oklahoma data (Appendix H) report the presence of volatile chlorinated hydrocarbons (dichloroethane - 25 ppb; trichloroethylene - 30 ppb; tetrachloroethene - 12 ppb; and 1,1,1-trichloroethane - 4 ppb). These compounds were not addressed by the Phase II (Stage 1) study.

shows no evidence of contamination, whereas the well completed in the fill material (3G) shows material similar to that found in the soil cores at the site. Concentrations of Cd, Cr, Ni, Pb, Zn and phenol in Well 3G exceed human health standards or criteria. The wet chemistry phenol value of 80 mg/L is probably biased low, due to interferences with the colorometric procedure and the large dilutions required to bring the sample to within instrument range. The 220 mg/L GC-MS value is probably more accurate. The State of Oklahoma data (Appendix H) show large quantities of volatile organic contaminants in Well 3G, only. The TOX data show a similar pattern. The shallowest groundwater (that in the fill or the weathered zone near the surface) is either evaporating on a seasonal basis, or is moving downslope near the surface. The geophysical anomaly in the nearby gully (Figure 4-6) may be due to an overflow feature from the period of pit operation or to continued horizontal movement of leachate from the closed pit. The fact that a zone of near-background conductivity exists between the pit and the "overflow feature" suggests the former.

The results of the Phase II (Stage 1) investigation show a body of highly contaminated material occupying the site of the former waste pit. The geophysical results indicate that the constituents of this waste are not currently migrating away from the site. Provided that the surface is not disturbed or the effective surface drainage disrupted, it is unlikely that significant contaminant migration will occur.

4.3.4 Zone 4 (Industrial Waste Pit No. 1

The investigations at Zone 3 were designed to define the chemistry and geometry of the remains of Industrial Waste Pit No. 1. However, in contrast to conditions at Zone 3 (Industrial Waste Pit No. 2), the remains of the pit are very diffuse and not well defined. The various geophysical surveys show only one significant anomaly, with the balance of the area occupied with materials near or only slightly above background conductivity. The coring results show the waste materials to be shallow and more thoroughly mixed with soil. On the basis of available data, no reliable estimate can be made of the total volume of materials present.

4.3.5 Zone 5 (Base Water Supply Wells)

Pump samples were collected from the 20 operational Base water supply wells (out of a total of 27 existing wells). Of the 20 wells sampled, only six displayed any trace of chlorinated organic contaminants. Observations concerning the contamination in each well are provided below.

Well 9, located north of the base along Midwest Boulevard, had not been in service for over six months when sampled. It could be pumped for only five minutes, so the sample represents an inadequately purged, stagnant system. At the present time, very little can be said concerning the occurrence of the chlorinated hydrocarbons in this well. The concentration of chloroform (2.1 ug/L) does exceed the EPA toxicity criterion of 1.9 ug/L (Table 4-2). Until the well can be adequately purged, no further diagnostic testng can occur. The maintenance records should be flagged for resampling when the well is brought back on line.

Well 5, located in the western portion of the Base, is not associated with any obvious contaminant source; it is approximately 2,000 feet north of Landfill 1, the closest waste disposal area. The reported occurrence of a single chlorinated organic compound at (trans-1,2-dichloroethene) at a low level (1.7 ppb) is probably not significant. Further, there has been no toxicity guideline established for trans-1,2-dichloroethene (Table 4-1). This well should be resampled during a future activity.

Wells 14, 16, 18 and 19 are all in the vicinity of the Oklahoma City Air Logistic Center (Building 3001). Results of analyses are discussed in the context of Zone 6 (Building 3001 wells) in Section 4.3.6, below. Wells 18 and 19 are the specific object of study at Zone 6; Wells 14 and 16 are located east and northeast of the facility. It is noteworthy that none of the other wells in this area display any contamination.

With the exception of wells in the vicinity of Building 3001, all Base water supply wells appear to be substantially unaffected by contaminant migration from Base waste disposal sites.

5.0 ALTERNATIVE MEASURES

This section discusses the alternative measures available for actions at each of the zones investigated. As was discussed in the introductory material in Section 4.0, the occurrence of contaminants is significant primarily within the context of threats to a receptor. Alternative measures are considered as they relate to evaluating issues of exposure to candidate receptors. The prime receptors to be considered are the regional Garber-Wellington aquifer, a major water supply source, and the installation boundary, a defacto receptor. All zones (Figure 5-1) have the potential to impact the Garber-Wellington. Zones 2 (Landfill 6) and 6 (Building 3001) have the potential to impact the installation boundary. The categories of measures to be considered include:

- Continued monitoring of existing wells;
- Installation of additional monitoring wells;
- Initiation of other sampling; and
- No further activities.

5.1 Volatile Hydrocarbon Sampling and Analysis

The Oklahoma State Deparment of Health split samples with the Radian team for much of the monitor well sampling effort. The state samples were analyzed for volatile organic by GC-MS, an analytical procedure not addressed in the Phase II (Stage 1) Statement of Work, other than for selected Base water supply wells. Significant quantities of chlorinated hydrocarbons (dominantly solvents) were discovered in several portions of the Base. Since the occurrence of chlorinated organic compounds in the ground water at the Base is an important discovery, and since all of these analyses were done by GS-MS, a semi-quantitative method, it is appropriate to verify the observations by resampling and analysis by gas chromatography, a more accurate method of quantitation. The available alternative measures are:

- Accept the State sampling data without comment or followup.

- Repeat the State sampling and analysis, utilizing the same procedures (GC-MS). This would provide an independent verification of the State data.

- Repeat the State sampling, but with analysis by GC (EPA Methods 601 and 602). This would combine an independent verification with more accurate quantitation.

Radian recommends resampling all wells for volatile organic compounds, with analysis by gas chromatography (EPA Methods 601 and 602 with provision for double columns). The following discussions of data needs at each zone presuppose the recommended resampling.

5.2 Zone 1 (Landfills 1 through 4)

Knowledge of ground-water flow conditions at Zone 1 is adequate to define the environmental impacts of the landfills. However, the chemical quality of ground water sampled by the existing monitor wells along Crutcho Creek is not sufficiently well described. The differences between observations at the time of drilling (Fall of 1981) and at the time of the Phase II (Stage 1) effort are large and need explanation. The most plausible explanation is that of seasonal variation in ground-water quality. The available alternative measures are:

- Consider that the original samples represented a period of the year when leachate dominated the shallow ground-water system and that the Phase II (Stage 1) samples represented a period when bank storage (recharge from the stream) dominated the system. Assume that the two samples describe the extremes of the system and interpret ground-water impacts accordingly.

5.4 Zone 3 (Industrial Waste Pit No. 2)

The existing hydrogeologic and chemical data are sufficient to describe current conditions and to evaluate the probable environmental effects of the pit. Therefore, no additional work need be planned for this Zone. Provided the existing land use and cover are maintained, no changes in impacts are anticipated.

5.5 Zone 4 (Industrial Waste Pit No. 1)

The existing hydrogeologic and chemical data are sufficient to describe current conditions and to evaluate the probable environmental effects of the pit. Therefore, no additional work need be planned for this Zone. With the exception of one small area, there appear to be very few traces remaining of this facility.

5.6 Zone 5 (Base Water Supply Wells)

With the exception of wells in the vicinity of Building 3001, discussed below, all the Base water supply wells appear to be substantially unaffected by USAF waste disposal activities. With this finding, no further IRP-related activities are contemplated. However, the occurrence of volatile chlorinated hydrocarbons has been documented at the Base. Therefore, some consideration should be given to establishing an ongoing Air Force sampling program with analysis by EPA Method 601, as part of the normal drinking water surveillance activities. For most wells, annual sampling and analysis is appropriate. For wells adjacent to "problem areas" such as Building 3001, semi-annual sampling is appropriate.

5.7 Zone 6 (Building 3001 Wells)

Hydrogeologic conditions and chemical contaminant occurrence in the vicinity of Building 3001 are not well known at the present time. Substantial quantities of TCE are known to exist in Well 18, along with lesser quantities

6.0 RECOMMENDATIONS

This section contains the Phase II IRP recommendations for further actions on Tinker AFB. The recommendations are listed below in order of priority with the most important activity first. The selection and prioritization criteria are:

- o Resolution of issues concerning possible receptors; and
- o Resolution of issues concerning contaminants of interest.

Specific recommendations are as follows:

1. Investigate hydrogeologic conditions and contaminant occurrence in the vicinity of Building 3001, as provided in Stage 2.

2. Investigate hydrogeologic conditions and contaminant occurrence in the vicinity of Landfill 6, as provided in Stage 2.

3. Investigate the occurrence of volatile halocarbons and aromatics in all monitor wells by resampling and analysis by EPA Methods 601 and 602.

4. Investigate the seasonal variations in water quality in the existing monitor wells along Crutcho Creek by conducting a quarterly sampling program for a period of one year. Analysis should be for total organic carbon, total organic halogen, and the metals on the parameter list in the current Statement of Work: Fe, Mn, Cd, Cr, Ni, Cu, Zn, Pb and Hg.

Reference #5
"Building 3001: Buried Pit and Tank Survey." Radian Corp.
31 Aug. 1984

RADIAN
CORPORATION

212-027-21

7 September 1984

CPT Robert W. Bauer
USAF OEHL/TS
Brooks AFB, Texas 78235

REF: USAF/RC Contract F33615-83-D-4001, Delivery Order 0021,
Tinker AFB IRP Phase II Stage 2

Dear CPT Bauer:

Enclosed is an informal report of the Buried Pit and Tank Survey (Task 1) for reference Delivery Order. This material will all be included in the final report of activities.

Please call me if you have any questions.

Sincerely,

William M. Little

William M. Little
Project Director

WML:sg
cc: (w/Encl.)
COL Russell, HQ, AFLC
CPT Cornell, Tinker AFB

8501 Mo-Pac Blvd. / P.O. Box 9948 / Austin, Texas 78766 / (512)454-4797

RADIAN
CORPORATION

212-027-21-11

31 August 1984

M E M O R A N D U M

TO: Distribution

FROM: Robert Wallace

SUBJECT: USAF Contract F33615-83-D-4001, Delivery Order 0021, Building 3001: Buried Pit and Tank Survey, Tinker AFB

1.0 INTRODUCTION

Field activities for this survey were conducted 18-22 June 1984 at Tinker Air Force Base. The objective of this task is to inventory past and present industrial operations in the Building 3001 area to locate any buried pits or tanks. The primary focus is to identify possible causes or potential contributors to the trichloroethylene contamination of the Bldg. 3001 water supply wells. These water supply wells are located within the building on the western wall (well #18) and near the northern wall (well #19) of Bldg. 3001. This contamination is the subject of ongoing geohydrologic investigations under the Phase II of the USAF Installation Restoration Program (IRP). The data available to date suggest that the contamination is localized and that its source is nearby. This survey included the following activities:

- A review of available Tinker AFB records;
- Interviews with appropriate Tinker AFB personnel; and
- A detailed surface inspection tour.

No tanks or pits were entered or sampled during this effort. The survey was conducted by Robert Wallace of Radian Corporation. Section 2.0 provides some general background information on the present and historical industrial operations within the Bldg. 3001 area. Section 3.0 describes the activities performed under this task and Section 4.0 summarizes the results and the significance of the findings. Section 5.0 discusses alternative measures available to complete this effort and Section 6.0 provides recommendations.

2.0 ENVIRONMENTAL SETTING

Bldg. 3001 houses numerous maintenance and repair activities and shops which support the mission of the Oklahoma City Air Logistic Center. This command operates an overhaul and modification complex engaged in repairing and upgrading aircraft including a vast quantity of engines and many thousands of accessory items. Industrial operations within the Bldg. 3001 area encompass a variety of repair and maintenance facilities which include:

- Disassembly, cleaning, and inspection of aircraft systems and components;
- Plating, painting, heat treating, testing of metal parts and components;
- Accessory shops including electrical, valve and governor, gear box, tubing and cable, fuel controls, nozzles, pumps, bearings, and other specialized repair shops; and
- Assembly and testing and packaging of aircraft and aircraft components.

In addition, other functions housed within this or other nearby buildings include utility (water, power and steam production), administrative and engineering offices, parts and material storage, and others.

Construction of the Oklahoma Aircraft Assembly Plants (as the Bldg. 3001 complex was known originally) began in 1942. Since then it has been operated as an aircraft overhaul and repair facility, as it is today. Although the specific aircraft and associated engines have changed, in most cases the nature of the industrial repair functions pertinent to this investigation have remained basically the same.

Halogenated hydrocarbon solvents have been and continue to be used primarily for cleaning and degreasing of metal engine parts undergoing overhaul or repair. Trichloroethylene was the solvent of choice for most degreasing operations from the early 1940's until the early 1970's, when tetrachloroethylene began to be substituted because of its lower vapor pressure. As originally designed, degreasing operations took place in metal tanks set below the floor level in concrete pits. These pits ranged in depth from three to eight feet and in size from approximately 8x10 up to 30x90 feet. Coincident with the shift from trichloroethylene to tetrachloroethylene, these below-floor pits were closed (typically filled with sand and topped with a concrete cap) and replaced with specially designed degreasing machines (a complete system including all piping, tanks and pumps) which is above ground or floor level.

Changes in the layout and purpose of the repair shops in this complex have coincided with shift from reciprocating to jet engine repair and overhaul. These changes affected the nature and number of underground storage tanks in their Bldg. 3001 area. Most of the storage tanks were and are for use during testing of aircraft engines or components, or for fuel storage for the utility boilers and electrical generators. Also there are solvent (not halogenated) storage tanks for a variety of uses but mostly connected with aircraft surface painting and cleaning. As the function or location of various shops changed, tanks were added and old tanks were either relocated or abandoned. Storage tanks for aviation (high octane) gasoline were converted over to either kerosene type fuels used in jet engines or to solvent storage. Records and interviews at Tinker indicate a practice of "abandoning in place" old tanks which were either no longer needed or not functioning (leaking). This was accomplished by removing surface connections and filling with sand where possible.

3.0 FIELD PROGRAM

The efforts on this task included interviews with present and past Tinker AFB personnel. Those interviewed included the present base bioenvironmental engineer, the present base civil engineer, the present environmental engineer for the maintenance command within the Bldg. 3001 area, the present and former base fuel storage official, a former base bioenvironmental engineer (1950-1956, 1968-1971), and a former aircraft production branch chief who had served in the Bldg. 3001 (1942-1980).

Records that were reviewed for this task include the Tinker AFB OPLAN 19-2 (Oil, Hazardous Substance, and Hazardous Waste Spill Prevention, Control and Countermeasures), the Real Property Inventory Detail reports, Tinker AFB civil engineering drawings, and fuel oil storage records. OPLAN 19-2 provided a list of underground storage tanks in the Bldg. 3001 area which had been prepared from input from each activity which owned or used the underground storage tanks. The real property inventory detail report was useful because it also identified underground storage tanks both currently active and historically used and provided a means of tracking the disposition of older tanks. The civil engineering drawings provided specific locations and details on each underground storage tank which were currently installed and historically present. Also the original construction drawings of the Assembly Building (3001) indicated the location of degreasing pits beneath the floor. Fuel oil storage records going back to 1964 were available which indicated the type liquid hydrocarbons which were stored on base in bulk quantities.

A detailed surface inspection of the Bldg. 3001 area was made in conjunction with the environmental engineer from the repair or maintenance activity within the building. All currently active underground storage tanks were visually inspected. In addition evidence of inactive underground storage facilities or buried pits were noted during the inspection tour at locations indicated on the civil engineering drawings.

4.0 RESULTS AND FINDINGS

4.1 Buried Pits

Table 4-1 summarizes the locations of buried pits beneath Bldg. 3001 together with the visual observations and characteristics noted during the surface inspection tour and reference civil engineering drawing numbers for the precise location of the buried pits. The locations described in this task refer to the frame numbering and lettering system used within Bldg. 3001. As previously noted, these pits have all been covered or closed and no longer in use. Most were covered with a concrete cap. One pit was covered with an old wooden cover and was believed by the nearby shop personnel to be filled with water. Interviews with former base employees indicate that up to fourteen drums of trichloroethylene were used on average every day in these pits during the 1940's, 1950's and 1960's. A majority of this liquid was reportedly lost to evaporation during the degreasing process.

Disposal practices were not recorded in detail although in some cases engineering drawings are available which show that interconnections were provided to the below floor storm sewer system from these pits. Presumably, these inteconnections were designed for cooling water return or ease of cleaning of the degreasing pits following the removal of solvent sludges. However, the possibility that waste or spent solvents or sludges were periodically washed to the storm sewer system exists. Also it is hypothetically conceivable that condensation of trichloroethylene vapor on walls, floors, pipes, equipment and subsequent cleaning of these surfaces could have, over time, also washed trichloroethylene laden waters into the storm sewers (an industrial waste sewer system was extended to all the shops in the Bldg. 3001 during the early 1970's). Another possibility was that these degreasing tanks were leaking trichloroethylene through holes in the metal tanks or valves left open in the storm sewers. Pure or relatively concentrated trichloroethylene (and tetrachloroethylene) has been shown to leach or travel through very impermeable clay soils due to dehydration or chemical dessication of the clay lattices.

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TABLE 4-1. BURIED PITS BENEATH BUILDING 3001, TINKER AFB

Pit	Location	Purpose	Visible Evidence	Reference DWGS
1	81-91, P-W	Old plating shop below ground pit	None	DWG-3001-F-125, 124
2	106,K	Vapor degreaser	Concrete cap	DWG-3001-G-58, 59
3	107-103,G	Chemical cleaning pit, jet engine overhaul	Possible cement cover	Proj. No. OC-168-59 As-Built DWG, DTD 2/10/54
4	109-104, F-H	Vapor degreasing pit	Possible concrete cover, metal latch	DWG-3001-G-48
5	99,K	Pit with trenches	Trenches visible with poured-in concrete	—
6	91,L	Pit "B"	Pit cap visible	OCBA-F-63114-2
7	87,I	Pit "A"	Possible 2 pit caps	OCBA-F-63114-2
8	99,A	Pit "C"	Possible 2 pit caps	OCBA-F-63114-2
9	88-89, E-F	Pit "D"	8'x16' caps grouted with rubber trenches covered with metal plates	OCBA-F-63114-2
10	87,A	Pit "E"	Currently a foundation for a large lathe	OCBA-F-63114-2
11	77-78, F-E	Buried tank pit	No visible indications, new floor has been poured	DWG 3108-F-16-71
12	36,N	2 degreaser pits	Concrete caps visible	DWG 3001-C-44
13	56,M	Pit	Concrete cover visible	DWG 3001-D-12
14	43-42, N-O	2 degreaser pits	Pit covers visible	DWG 3001-C-44
15	51,Q	Degreaser pit	Wooden cover visible	Ref. DWG BC-U-D-22-4 (Sheet No. G-302)
16	37, S-T	Degreaser pit	Metal lined cap	"
17	North wall, Col. J	Slaked lime pit	None	BC-U-D-22-4 (Sheet No. G-303)
18	10,G	Pit covered with concrete	BCE bldg. foundations	"
19	97, F&H	King lathe foundation pits	Concrete cap	OCBA-F-63114-2

Table 4-2 provides the location of vapor degreasing machines currently in use in the Bldg. 3001 area. Spent solvents are currently drummed and sent to DPDO for disposal.

4.2 Buried Tanks

Table 4-3 is an inventory of abandoned or inactive buried or underground storage tanks in the Bldg. 3001 area which includes the location, capacity, purpose, reference drawing number, and any visible observations. This inventory was arrived at in the process of correlating information from the records reviewed for this task. As a by-product of that review, Tables 4-4, 4-5, 4-6 were prepared which are inventories of currently active underground storage facilities in the Bldg. 3001 area according to three different Air Force records: Tinker AFB OPLAN 19-2, Civil Engineering Drawing OCBA-K-1017-A (Building and Street Layout), and the USAF Real Property Inventory Detail Report. The fact that there are inconsistencies among these records is not surprising since they were prepared at different times by different people and for different purposes, none of which was specifically to inventory underground tanks. In addition, the presence of these tanks was noted in the surface inspection tour. The physical evidence of inactive tanks or tanks not listed on these records was typically the presence of a vent pipe or line which emerged from the ground and was completed with a characteristic u-type fitting at the top. The location of these inactive tanks could then be compared to the appropriate drawings to see if historically there had ever been a tank at that location. If there had and in almost all of the instances this was the case, then the real property records could be researched to see if and when the particular tank had been abandoned. Also, the real property records provided an indication of the purpose or use of the tank from which it was possible to deduce whether or not the tank may have been used to store trichloroethylene.

In no case was there a record or any evidence that an underground storage tank in the Bldg. 3001 area was designed or used for bulk storage of

TABLE 4-2. CURRENT VAPOR DEGREASER LOCATIONS, BLDG. 3001, TINKER AFB

Building	Location	Estimated Annual Quantity (gallons)	Solvent
3001	K106	3960	P
	M82	3960	P
	M82	3960	P
	L95	1650	P
	Q61	11,880	P
	Q61	3575	P
	M63	1045	P
	X65	1045	P
	X65	1045	P
	A76	3960	P
	Ka51.1	660	P
	O59	1320	T
	N37	660	P
	U45	660	P
	X69	2860	P
	S54	225	P
3105		3960	P

T - Trichloroethane

P - Perchloroethylene

TABLE 4-3. ABANDONED OR UNUSED UNDERGROUND STORAGE TANKS IN THE BLDG. 3001 AREA

Tanks	Location	Capacity	Purpose	Former USAF Facility No. or DWG No.	Visible Inspection
1	NW Corner of Bldg. 3117	500 (est) waste oil tank	Tank was designed to store chemical spills inside Bldg. 3117. Chemicals are no longer stored in Bldg. 3117.	--	Free standing 4" PVC vent/fill pipe on west side of 3117.
	SW Corner of Bldg. 3215	500 (est) gal. Reportedly now filled with water.	Tank was designed to store chemical spills inside the 3215. This building no longer used for chemical storage.	--	8" PVC vent pipe and access pit visible on south side of 3215.
3	SE Corner of Center Section of Bldg. 3108	500 gal. waste oil tank	Waste oil tank for the fuel testing system in the 3108 Hydrodynamic Test Area.	USAF DWG No. 3108-F 16-53 Rev. B 1/18/56	2" steel vent pipe visible extending to roof.
4	South 6' and 2' east of the SW corner of Bldg. 3108	1000 gal.	JP-1 supply tank for engine accessories overhaul.	3108-F-16-81 relocation of engine accessories overhaul & testing Bldg. 2108. (Possibly Facility No. 3151, 3152, 3153, 3154).	Outline of concrete pump pit & cover. Vertical lines visible on SW corner of 3108.
5		1000 gal.	JP 1 return tank for engine accessories overhaul.		
6		1000 gal.	Naphtha supply tank for engine accessories overhaul.		
7		1000 gal.	Naphtha return tank.		

(Continued)

TABLE 4-3. (Continued)

Tanks	Location	Capacity	Purpose	Former USAF Facility No. or DWG No.	Visible Inspection
8	8' N of the SE corner of the North Addition of Bldg. 3108	500 gal.	Waste fill tank for shop A/C engine depot addition (relocated).	USAF DWG NO. 3108-13-25-176 Rev. 27 Jan 72. (Shop A/C Engine Depot Addn./Alt., Mechanical, plan of piping outside Bldg. addn.	2" vent line visible.
9	90' N of the SE corner of the North Addition of Bldg. 3108	1000 gal.	Waste oil tank for shop A/C Engine Depot addition.		2" vent line visible.
10	50' W of 215' N of SW corner of Bldg. 3108	3000 gal.	Motor pump and subsurface fuel tank adjacent to railroad tracks west of Bldg. 3108.	USAF DWG.No.OCBA-F-6152-1 dated 24 Jan 1961.	Motor pump and piping visible at surface.
11-17	60' W and 80' to 160' S of SW corner of Bldg. 3108.	2-9000 gal. 5-20,000 gal.	Originally Air Corps gasoline storage tanks, listed on real estate records as solvent tanks in late 1960's.	Formerly 3140, 3141, 3142, 3144, tank 5, 3146*, 3147* Abandoned in place in 1972.	None.
18	6' W and 180' S of SW corner of Bldg. 3108.	20,000 gal.	Originally a lubricating oil storage tank which was listed on real property records as being converted to solvent storage in the late 1960's.	Austin Co. DWG No. G-141, G-142. A.C. gasoline & lubricating oil system, layout & retail (12/30/42). Formerly 3145*. Abandoned in place in 1972.	None.
19-20	15' E and 15' S of the NE corner of the Paint Bldg. (Bldg. 3105).	2-1800 gal.	1-Naphtha tank 1-Stoddard solest tank Tank for Paint Bldg. (3105). Abandoned in place.	Formerly 3132, 3133. Austin Co. DWG. No. PB 302 Oct. 7, 1942.	Vent line visible.

* Shown on current USAF DWG OCBA K-1017-A (Tinker AFB Building and Street Layout).

TABLE 4-4. LIST OF ACTIVE UNDERGROUND STORAGE TANKS CARRIED ON USAF REAL PROPERTY INVENTORY DETAIL REPORT IN BLDG. 3001 AREA

Facility	Capacity	Type	Location	OPLAN 19-2	Building & Street Lay-out DWG
3001	20,000 gal.	Fuel Oil	S of Boiler House	Yes	Yes
3002	1,000 gal.	Diesel	"	No	Yes
3003	1,000 gal.	Diesel	S of Bldg. 3406 (3001G)	No	Yes
3010	28,000 gal.	AVGAS	W of Bldg. 3001 (Col 101)	Yes	Yes
3011	28,000 gal.	AVGAS	"	Yes	Yes
3012	25,000 gal.	AVGAS	"	Yes	Yes
3100	15,000 gal.	Misc. Stur	W of Bldg. 3108 (Bldg. 3001 Col. 56)	Yes	Yes
3104	15,000 gal.	"	"	Yes	Yes
3106	30,000 gal.	"	"	Yes	Yes
3130	12,000 gal.	Solvent	S of Bldg. 3108	Yes	Yes
3131	12,000 gal.	"	"	Yes	Yes
3401	20,000 gal.	Diesel	N of Bldg. 3001 (Row F)	Yes	Yes
3404	235,000 gal.	HTG Fule Oil	"	Yes	Yes
3405	13,500	MOGAS	"	Yes	Yes

TABLE 4-5. LIST OF ACTIVE UNDERGROUND STORAGE TANKS IN THE BLDG. 3001 AREA CONTAINED IN ATTACHMENT 1 TO APPENDIX 1 TO ANNEX A (INSPECTION REPORT) OF TAFB OPLAN 19-2, "OIL, HAZARDOUS SUBSTANCE, AND HAZARDOUS WASTE SPILL PREVENTION, CONTROL AND COUNTER MEASURES"

Facility or Bldg. No.	Capacity	Type of Storage	Location	OBG Symbol	OPLAN 19-2 Reference Page No.	Bldg. Street DWG	Real Property
3001	20,000 gal.	#2 Diesel Fuel	Boiler Plant	DEMMH	A-1-67	No	Yes
3001	2,500 gal.	Solvent Waste Dump	West of Bldg. 3001, G-50	MA	A-1-69	No	No
3001G	20,000 gal.	#2 Diesel Fuel	3001 G ASC Power Plant	1985 CS	A-1-71	No	No
3010	15,000 gal.	Jet Fuel	SW of NW Corner of Bldg. 3001	DSDP	A-1-72	Yes	Yes
3011	15,000 gal.	Jet Fuel	SW of NW Corner of Bldg. 3001	DSDP	A-1-72	Yes	Yes
3012	30,000 gal.	Jet Fuel	SW of NW Corner of Bldg. 3001	DSDP	A-1-72	Yes	Yes
3100	15,000 gal.	Type 2 Calibrating Fluid	W of Bldg. 3108	MA	A-1-73	Yes	Yes
3104	15,000 gal.	"	"	MA	A-1-74	Yes	Yes
3106	30,000 gal.	"	"	MA	A-1-75	Yes	Yes
3108	500 gal.	"	E of Bldg. 3108 (center)	MA	A-1-76	No	No
3108	1000 gal.	"	E of Bldg. 3108 (north)	MA	A-1-77	No	No
3130	12,000 gal.	PD680 Solvent	S of Bldg. 3108	DSDP	A-1-80	Yes	Yes
3131	12,000 gal.	"	"	DSDP	A-1-81	Yes	Yes
3401	20,000 gal.	Diesel Fuel	N of Bldg. 3001	DEMMH	A-1-85	Yes	Yes
3404	235,000 gal.	#2 Fuel Oil	N of Bldg. 3001	DEMMH	A-1-86	Yes	Yes
3405	13,500 gal.	87 Octane Automobile Gasoline	N of Bldg. 3001	DSDP	A-1-88	Yes	Yes

TABLE 4-6. LIST OF ACTIVE UNDERGROUND STORAGE TANKS IN THE BLDG. 3001 AREA SHOWN ON THE TINKER AIR FORCE BASE BUILDING AND STREET LAYOUT (DRAWING NUMBER OCBA-K-1017-A, GENERAL UPDATE 30 SEP 81)

Facility Number	Real Property	OPLAN 19-2
3003	Yes	No
3010	Yes	Yes
3011	Yes	Yes
3012	Yes	Yes
3017	Yes	No
3100	Yes	Yes
3104	Yes	Yes
3106	Yes	Yes
3130	Yes	Yes
3131	Yes	Yes
3145	Yes[1]	No
3146	Yes[1]	No
3147	Yes[1]	No
3401	Yes	Yes
3404	Yes	Yes
3405	Yes	Yes

[1]Real property records indicate that these tanks were abandoned in place.

trichloroethylene or other halogenated solvent. There was evidence that storage tanks were found to be leaking and that this was the primary reason that old storage tanks were abandoned. The tanks listed in Tables 4-4, 4-5, and 4-6 are known (by current TAFB personnel) to contain and have contained materials other than the solvents of interest. The abandoned tanks listed in Table 4-3 are unlikely but possible candidates for unauthorized storage or disposal of spent solvents or sludges.

4.3 Significance of the Findings

Figure 4-1 summarizes the locations of the buried pits and tanks relative to the location of wells 18 and 19 beneath the floor of Bldg 3001. Although each of the pits and tanks would be considered candidates for possible sources of contamination, the survey results suggest that the trichloroethylene contamination is most likely the result of past industrial operations which occurred in degreasing pits throughout Bldg 3001 and over a period of up to 30 years.

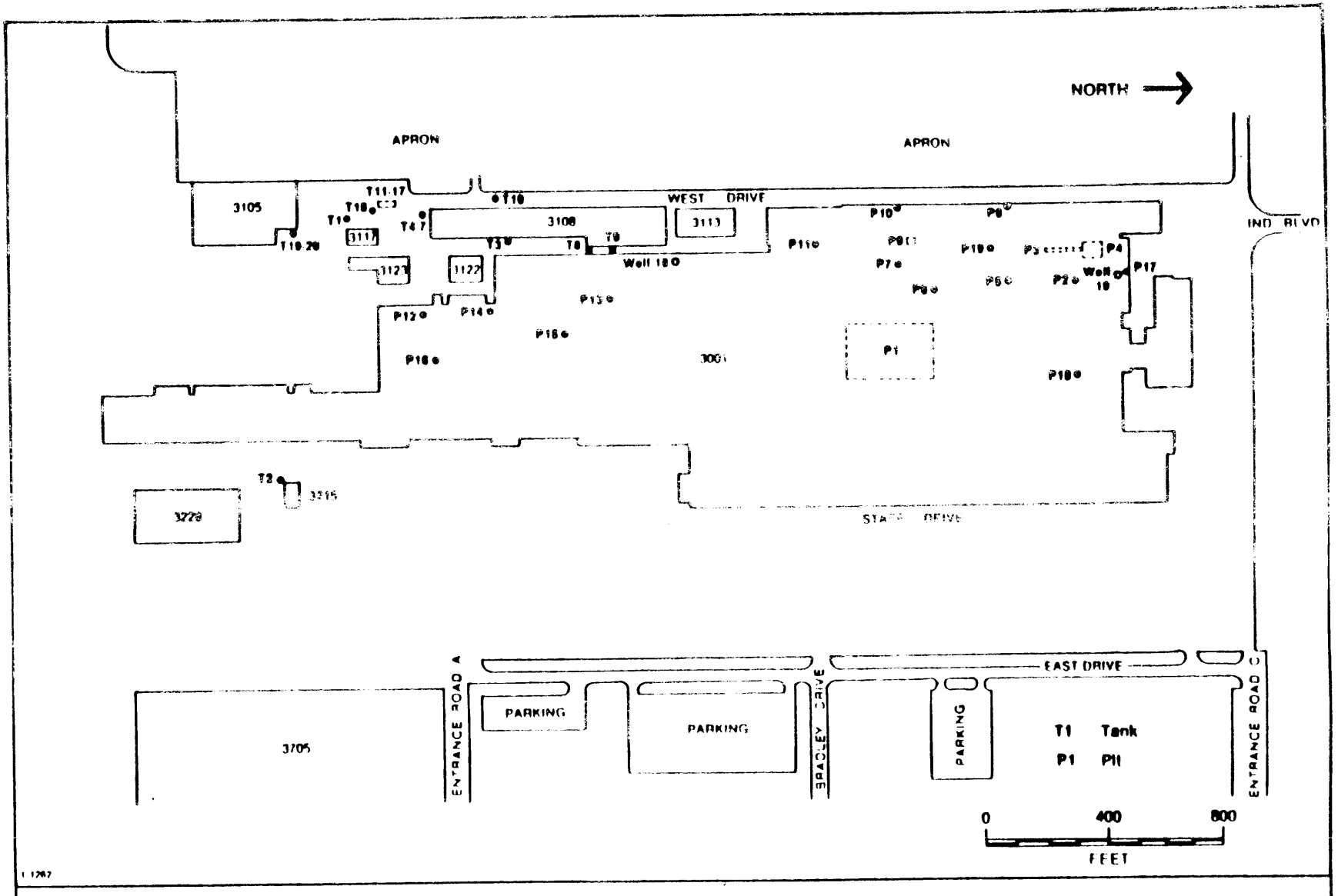


Figure 4-1. Locations of Buried Pits and Tanks Relative to Wells 18 and 19 in the Bldg. 3001 Area.

5.0 ALTERNATIVE MEASURES

This section discusses alternative measures available for actions relating to the buried pits and tanks in the Bldg. 3001 area.

The available measures relating to the buried pits beneath Bldg. 3001 are:

- Enter, inspect, and obtain samples for analysis of any liquid or fill material contained within each of the identified pits;
- Select one or two pits that can be easily entered for inspection/sampling; and
- No further activities.

Access to these buried pits will require either removal of the concrete cap (and temporary removal of any utilities or shop equipment which have subsequently been emplaced) or drilling one or more inspection ports through six inches of the concrete caps and possible coring through fill materials or depth-integrated sampling through any liquids to obtain a representative sample. Given the age of these pits and the length of time since their closure, it appears unlikely that much useful information can be gained from entering and sampling all of the pits identified. However, since these pits are known to have contained the solvents it would be of interest to verify the method of closure and the condition of the concrete subsurface flooring/storm sewer connections in at least one or two of these pits. Also, analysis of soil samples from below the pit floor would provide an indication of historical contamination if it exists.

The available alternative measures relating to the buried tanks in the Bldg. 3001 area are similar although in the case of the tanks there may be less difficulty in terms of access. In a majority of the cases, the tanks

identified were noticed by the presence of a vent tube or pipe which could provide access for the detection and sampling of any liquids remaining in the tanks. Access to those old tanks for which surface connections had been removed could be accomplished by coring either into the tank (filled with sand) or in the vicinity to obtain soil samples for analysis which would indicate the presence or extent of contamination from leaking tanks.

5.0 RECOMMENDATIONS

This section contains recommendations for further actions relating to the buried pits and tanks in the Bldg. 3001 area. The recommendations are listed below in order of priority with the most important activity first. The recommended actions are as follows:

1. Enter, inspect, and obtain samples from the contents and subsurface soils from selected pits buried beneath Bldg. 3001. Analyze samples for the presence of chlorinated solvents by EPA Method 601.

2. Obtain samples of any liquids from abandoned tanks buried in the vicinity of Bldg. 3001 where access is possible through vent pipes or surface connections. Analyze these samples for the presence of chlorinated solvents and hydrocarbon content.

Further, it is recommended that a general update or reconciliation of records concerning the size, location, use, and monitoring responsibilities for underground storage tanks containing hydrocarbons or other chemicals be conducted for all areas of Tinker AFB.

Reference #6
"Public Water Supply Report" for Midwest City and for Tinker AFB. 1982

Oklahoma State Department of Health
Environmental Health Services
State Environmental Laboratory
1000 N.E. Tenth
Oklahoma City, OK 73152

PUBLIC WATER SUPPLY REPORT

MAJOR
THROUGH
OTTAWA

1982

PUBLIC WATER SUPPLY REPORT

FACILITY: MIDWEST CITY

OPERATOR: MIDWEST CITY

ADDRESS: BOX 10570
MIDWEST CITY OK 73110

PHONE: 405 7322281

MSIS-NUMBER: 1020806

COUNTY: OKLAHOMA

POPULATION SERVED: 55400

SOURCE OF WATER:	WELLS	LEGAL DESCRIPTION
THUNDERBIRD LK	00	SE1/4 SE1/4 NW1/4 S25 T09N R01W IM
GARBER-WELLING	32	S10 T11N R02W IM

Note: OSDH informed us that the computer cutoff point is 32 wells: wells beyond #32 will thus not be recorded by this report page.

STORAGE CAPACITY: 5900000 GALLONS
AVERAGE PRODUCTION: 4900000 GALLONS/DAY

PRODUCTION CAPACITY: 6000000 GALLONS/DAY

TREATMENT:

PERCHLORINATION	-	YES
COAGULATION	-	ALUM
SEDIMENTATION	-	UPFLOW CLARIFIER
FILTRATION	-	ANTHRACITE
CORROSION CONTROL	-	LIME
TASTE/ODOR	-	CARBON
DISINFECTION	-	CHLORINE GAS

FACILITY: MIDWEST CITY

MSIS-NUMBER: 1020806

PARAMETERS	UNITS	1982	1981	1980

FACI TINKER AFB

OPERATOR. TINKER AFB

ADDRESS : 2854 ABGP/DE
TINKER AFB OK 73145

PHONE : 405 7327321

MSIS-NUMBER : 2005508

COUNTY : OKLAHOMA

POPULATION SERVED: 3320

SOURCE OF WATER:	WELLS	LEGAL DESCRIPTION		DEPTH
GARBER-WELLINGT	27	S23	R02W IM	0661-1256
OKLAHOMA CITY				

STORAGE CAPACITY : 17500000 GALLONS
AVERAGE PRODUCTION: 49000000 GALLONS/DAY

PRODUCTION CAPACITY: 95300000 GALLONS/DAY

A-3

Reference #7
"Inspection Report - Tinker Air Force Base." Oklahoma Water Resources, Water Quality Division. Dated June 19, 1984

JAMES R. BARNETT, Executive Director
MICHAEL R. MELTON, Assistant Director

OKLAHOMA WATER RESOURCES BOARD

P.O. BOX 53585 • 1000 N.E. 10TH STREET • OKLAHOMA CITY, OKLAHOMA 73152 • (405)271-2555

September 27, 1984

Mr. Roger Hartung (6W-E)
U.S. Environmental Protection Agency
Region VI
1201 Elm Street
Dallas, Texas 75270

Dear Mr. Hartung:

Enclosed is a copy of the Tinker Air Force Base state inspection report. We apologize for any inconvenience that we may have caused due to the lengthy report preparation. However, we feel that the quality of this report will speak for itself and is worth the delay.

If you have any questions regarding this report, please contact me or J. Fred Heitman at (405) 271-2541.

Sincerely,

Ron Jarman, Chief
Water Quality Division

RLJ:JFH:ft

Enclosure

GERALD E. BORELLI, Chairman
EARL WALKER, Vice-Chairman
L. L. MALES, Secretary

ERNEST R. "Jack" TUCKER, Member
BILL SECREST, Member
ROBERT S. KERR, JR., Member

R. G. JOHNSON, Member
RALPH G. McPHERSON, Member
GARY W. SMITH, Member

OKLAHOMA WATER RESOURCES
Water Quality Division

INSPECTION REPORT

REPORT DATE: June 19, 1984

PERMIT NO.: WD-79-031
Effective Date:
Expiration Date:

ENFORCEMENT:
( )New
(X)Scheduled (CEI, X CSI)
( )Complaint (No.)
( )Follow-up
( )Letter Follow-up
( )Other

FURTHER ACTION REQUIRED:
( )Enforcement; to:
(X)Permitting; to: NC Initial

PERMITTING:
( ) New ( ) Follow up
( ) Revision ( ) Other

INSPECTION DATE: April 17 thru 20, 1984
May 9 thru 11, 1984
June 11 thru 12, 1984

INSPECTORS: T. H. Maiello with J. J. Black and D. C. Schreiber

TITLE: Senior Environmental Specialist

INDUSTRY: Tinker Air Force Base

TYPE: Federal, Aircraft repair & support AWACS

MAILING ADDRESS: Oklahoma City Air Logistics Center

CITY: Oklahoma City

STATE: Oklahoma

ZIP: 73145

PLANT LOCATION: N½ Section 21 and Sections 14, 15, 16, 22 and 23, Township 11N, Range 2W1M, Oklahoma County

GENERAL LOCATION: East of Sooner Road, South of SE 29th Street, North of SE 74th Street and West of Douglas Boulevard

COMPANY RESPONSIBLE OFFICIAL: Col. Ray D. Reaves

TELEPHONE: (405) 734-2101

TITLE: Base Commander

FACILITY REPRESENTATIVE: Col. Danny Rivera

TELEPHONE: (405) 734-3451

TITLE: Base Civil Engineer

OTHER REPRESENTATIVE: Bob Coleman

TELEPHONE: (405) 734-3201

TITLE: Environmental Engineer

SUMMARY:

An extensive State inspection was performed of Tinker Air Force Base (TAFB) during April, May, and June, 1984. This followed an initial inspection which was an EPA NPDES Compliance Sampling Inspection. The state inspection was performed in response to a spill/complaint report and investigation (OWRB #WR-84-117) in February 1984.

TAFB consists primarily of three industrial/maintenance areas, each drained by separate watersheds. Area 1 contains Buildings 2280 and 2121, the 507th Squadron with various support facilities, the fire training pit, "South 40" storage, the 3rd Mobil Communication Group and support facilities, and on-base housing. The area is drained by Crutcho Creek and one of its tributaries. There are no industrial waste sewer lines in Area 1 leading to the industrial treatment plant. Area 2 contains base operations offices, various warehouses and distribution centers, the central AWACs command with maintenance and support facilities, flight control operations, and base personnel services. The area is drained by the headwaters of Kuhlman Creek, a tributary to Crutcho Creek. Area 3 contains the heavily industrialized facilities of Building 3001 and numerous support operations, the industrial and sewage waste treatment plants, the fuel unloading/distribution facility and various storage facilities. The area is drained by the headwaters of two unnamed tributaries to Soldier Creek: one drains the west side of Building 3001 and the other (commonly called East Soldier Creek) drains the east side of Building 3001 and other support and maintenance facility areas. Both tributaries flow to Soldier Creek which is a tributary of Crutcho Creek. All watersheds on TAFB ultimately flow to the North Canadian River north of Midwest City.

Legal descriptions of the watershed areas are listed below. All sections are in Township 11N and Range 2WIM (Figure 1).

Area 1 - Crutcho Creek watershed including: Sections 21 and 22; west 3/4 of Section 16; southwest ¼, northwest ¼ and west ½ of the southeast ¼ Section 23; and a majority of SW¼ of Section 14.

Area 2 - Kuhlman Creek watershed including: east ¼ of Section 16; and west ½ of northwest ¼ of Section 14.

Area 3 - East Soldier Creek watershed including: most of Section 14 except the NE¼ and the remainder of Section 23. The East Soldier Creek watershed includes all of Building 3001, the water treatment area and all permitted discharges Outfalls 001 through 005. East ½ of northwest ¼, southeast ¼ and a portion of the southwest ¼, Section 14; and northeast ¼ and the east ½ of southeast ¼ Section 23.

During this inspection a problem was encountered involving the organization of base personnel in responding to spills, improper waste discharge connections and other pollution problems. No single group or person has direct authority to correct or eliminate pollution problems. When more than one base group must be utilized for earth-work, blueprint verification, waste material disposal, or other corrective action, a long delay results due to administrative paper work channeling authority up and down a multitude of chains-of-command. Response time to pollution episodes often stretches into months or years resulting in continued contamination to state waters and frustration for both base personnel and environmental regulatory agencies.

The facility's blueprints were out of date and erroneous. Waste lines identified as "industrial waste" became storm sewers and/or storm sewers were connected to industrial waste process areas. Buildings constructed after the last blueprint update were connected to lines identified as "industrial waste" which were actually storm sewers. This constitutes a violation of OWRB Rules and Regulations 1045.11(c) in that the blueprints do not represent actual field conditions. The magnitude of this problem is enormous and can only be rectified by an intensive, thorough and inter-disciplinary survey of 1) all industrial sanitary and storm sewers; 2) all lift station hook-ups to verify proper industrial or storm sewer connections; and 3) all floor drain and in-building connections to discharge sewers to verify if the waste liquids are going to the industrial treatment plant or to the storm sewers.

Field investigation across a majority of the base revealed major problems including unpermitted discharges, toxic material discharges, current and past spill events, improper storage of hazardous or toxic materials, and base procedures resulting in potential or immediate contamination to waters of the state.

TAFB rests atop the Garber Wellington aquifer which is a primary water supply aquifer for central Oklahoma including all of Oklahoma and Cleveland Counties and portions of Logan, Lincoln and Pottawatomie Counties. Freshwater stored in this aquifer results from the continuous downward percolation of surface waters that have entered at its recharge area. TAFB lies directly over the known recharge area for the Garber Wellington aquifer. The facility is underlain by fine-grain sandstone irregularly interbedded with shale and siltstone which are outcrops of the aquifer itself. These outcrops provide a hydraulic connection between the aquifer and uncontained surface contamination sources as are described in the body of this report.[1]

The inspection began with a review of available blueprints of the industrial waste, sanitary waste and storm sewer lines utilized by TAFB personnel for waste disposal and determination of waste stream flow to the treatment facilities. The remainder of the inspection consisted of examining a majority of the facility's 5.6 square mile area. Key areas of concern were unpermitted discharges, waste disposal, chemical and hydrocarbon storage, and permit and application verification.

FINDINGS:

The following violations and/or problems were discovered:

A. Building 1030 - 507th Squadron (Inset 1):

1. An oil and grease trap discharges to the spill pond (photo 1). This discharge also violates Oklahoma Water Quality Standards (OWQS) 4.3(d) for the oil sheen present in the discharge.

2. Truck wash on the west side discharges to unknown location, possibly to the oil and grease trap in Building 1030. This may be a violation of OWRB Rule 1020.2(a).

[1] Johnson, K. S. 1983. Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahom. Groundwater Resources in Oklahoma, Oklahoma State Department of Health.

B. Building 1071 - Oil and grease trap discharges through manually operated valve on the north to a tributary of Crutcho Creek and then to the spill pond (photos 2 and 3)(Inset 1). This violates OWRB Rule 1020.2(a).

C. Spill Pond - (photo 4). The pond is actually a portion of Crutcho Creek which has been impounded to contain spills. Contained water is discharged either to Crutcho Creek through a valve or to the Del City sewage treatment plant through a manhole in the pond. The banks and substrate of the pond were black, supporting sparse vegetation and the pond surface had a visible oil sheen with standing white foam (The foam is described in item E.2. of Area 1). This pond receives discharge and runoff from Building 1071 oil and grease trap, fire training area, Tower Road 72" storm drains, Building 1030 oil and grease trap, "South 40" storage area, watershed area runoff, and possibly Building 1030 truck wash water. This is a violation of Board Rule 1020.2(a). The pond and its discharge also violate OWQS 4.3(d) for visible oil (Inset 1).

D. South Forty Storage:

1. Building 1123 (Inset 1) consists of a Quonset hut with a dirt floor equipped with concrete curbing and corner valves for stormwater release. The hut is used for temporary storage of barrels and small containers of various chemicals. Spillage was evident near stored trichloroethylene (TCE) barrels and in other locations inside the building. At the time of the inspection, a water main break was being repaired immediately adjacent to Building 1123. The leak had unknowingly existed for quite some time but was masked by the lack of surfacing water. This demonstrates the highly porous nature of the local soils and the danger of groundwater contamination as a result of spills in the hut and on adjacent surfaces. Additionally, the stormwater corner drain valves were open, defeating the purpose of the curbing. Generally, this area is not functional as a chemical control/storage area unless the surface soils are covered or sealed with an impermeable substance for groundwater protection. Storage of materials in this area violates OWRB Rule 1050.1 because the storage area is capable of causing pollution if accidentaly discharged. The pressence of spilled material in the storage area violates OWRB Rule 1050.3 for failing to immediately initiate and complete appropriate steps to contain and clean up the spilled material. The OWRB was neither immediately notified of the spills nor was written notification to the OWRB received within one week concerning these spills. This also violates OWRB Rule 1050.3.

2. The outside storage areas for chemicals in the vicinity of Building 1123 are not provided with curbing or impermeable surface to prevent runoff or groundwater contamination. This improper storage of materials violates OWRB Rule 1050.1.

3. An outside storage area consisting of a concrete, curbed containment structure, 30 yards northeast of Building 1123, is used for the storage of a variety of chemicals. This structure has an old, deteriorated asphalt floor and no valves in the concrete walls to allow controlled discharge of stormwater. Stormwater soaks into the ground or evaporates. Minor spillage in this area was evident during

the inspection. The storage of materials in this area violate OWRB Regulation 1050.1 because the deterioriated floor may allow any spillage to cause pollution. OWRB Rule 1050.3 was violated because proper spill clean up had not been initiated and the OWRB had not been notified of the spills.

E. 72" storm drain (discharge point) at north end of Tower Road (Inset 1).

1. Building 2280 is used for aircraft maintenance and has discharges similar to the other maintenace areas on the base (Figure 1). The discharges are evidently connected to storm sewers which flow beneath the runway to this discharge point. During this inspection a "sweet airplane glue" odor (aromatic hydrocarbons) was apparent and was emanating from the 72" storm drain. This umpermitted discharge violates OWRB Rule 1020.2(a).

2. In and around Buildings 2280 and 3102 (Figure 1), fire safety procedures involve the use of AFFF fire suppressant foam. During an emergency, a six foot wall of foam is sprayed across the hanger floor and adjacent taxiways. Such an emergency occurred on April 20, 1984 when an elecrical fire broke out in Building 3102. After use of the foam, the foam was apparently washed off the surfaces and into the storm drain. This foam is very persistent, as was evident during the inspection with foam still present in the 72" storm drain two weeks later (photo 5). Foam was also visible from this storm drain in and along Crutcho Creek to the outside of the spill pond containment dam (photo 4). This unpermitted discharge violates OWRB Rule 1020.2(a) and also violates OWQS 4.10(d) for foam on the waters of the state.

F. Two 72" storm sewers north of SE 59th Street and Midwest Boulevard (Figure 1).

Although no discharge was noted, storm drains from Buildings 2121, 2122 and 2101 discharge at this location. Any discharge from these buildings to these storm sewers would constitute a violation of OWRB Rule 1020.2(a). Blueprints showing industrial waste, sanitary sewage, and storm drains lines should be verified to confirm that only uncontaminated stormwater enters the storm drains. Vehicle maintenance and fuel storage in and around the buildings should be contained so that no spillage or unpermitted discharges occur.

G. Fire training area (Inset 1):

1. The fire training area was renovated after a July 19, 1981 state/NPDES inspection. Existing soil in the area, which was saturated with aviation fuel (JP-4), was removed to allow construction of a concrete collection system to stop discharges into Crutcho Creek. The soil was placed in two large piles that were still present during the current inspection (photos 6 and 7). JP-4 in the soil piles is possibly contaminating groundwater and surface stormwater which enters Crutcho Creek. This condition constitutes violations of OWQS 4.3(d) for oil and grease (petroleum related) discharge, OWRB Rule 1050.1 for an inadequate storage system, and 1020.2(a) unpermitted discharge.

2. The renovated fire training area consists of a gravel bed surrounded by a concrete trench which channels unburned JP-4 and contaminated fire water through a drain to an underground recovery tank. A slightly elevated berm surrounds the trench and bed to prevent fuel and fire water from running into Crutcho Creek. The recovery tank is approximately 25 yards east of the drainage basin on the perimeter of the fire training area. On April 20, 1984, a discharge of JP-4 from the recovery tank occurred through a vent pipe on the top of the tank. The tank contents were vacuumed at the request of state inspector Jerry Black. The discharged JP-4 was not removed or cleaned up (photos 8 and 9). Additionally, on April 20, 1984 the fire pit area discharged over the berm to Crutcho Creek. These incidents were neither reported nor were contaminants cleaned up which constitutes a violation of OWRB Rule 1045.11. The discharges violate OWRB Rule 1020.2(a), umpermitted discharge, and OWQS 4.3(d), petroleum related oil in waters of the state.

Area 2

A. Multiple storm drain basin at the headwaters of Kuhlman Creek located at the center of Section 5, Township 11N, Range 2WIM (Inset 2).

Continuous unpermitted discharges are flowing to this basin from 60" and 72" storm drains and into Kuhlman Creek. Origination of the 72" drain discharge could not be determined, but the 60" pipe discharge was identified as originating in Building 230. The discharge from this building was located in the storm drain north of Building 230 which discarges to Kuhlman Creek through the 60" pipe. Evidence of contamination in this discharge is present in the form of oil and solvents on the water surface and in the common basin for the three storm drains. This unpermitted discharge violates OWRB Regulation 1020.2(a).

An additional discharge into the 60" storm drain was discovered as a result of a complaint received on January 30, 1984 (OWRB #WR-84-117) which alledged that oil was being discharged to Kuhlman Creek from TAFB. Investigation on February 10, 1984 revealed lift station #3 on TAFB was discharging contaminated process water (OWRB #8621, Figure 1) to Kuhlman Creek through the above mentioned 60" storm sewer in this basin. The discharge violated Oklahoma Water Quality Standards 4.3(h) for chromium, copper, and oil and grease [4.3(d)]. This investigation led to the discovery of potential problems with lift stations on the base being designed to bypass wastes into the storm sewer in the event of breakdown of the lift stations or wastewater back-up in the individual sewer lines. Evidence of continued dischage of solvent and oil and grease was still present during a July 27, 1984 follow-up inspection by the OWRB. This discharge constitutes a violation of OWRB Regulation 1020.2(a) if intentional, 1045.9 if it constitutes a bypass, or 1045.1(d) if the discharge is accidental. In any event, appropriate agencies were not notified when base personnel became aware of the discharge which violates OWRB Regulation 1050.3.

B. Kuhlman Creek oil and grease trap (Inset 2) - An oil and grease trap is located adjacent to Kuhlman Creek (north side) south of the intersection of "L" Avenue and South Street. This trap receives water from Kuhlman

Creek below the industrial and storage areas in Area II. The trap contained copious amounts of oil and solvent at the time of the inspection. The discharge is not permitted and constitutes a violation of OWRB Regulation 1020.2(a0 and OWQS 4.3(d) for oil and grease.

C. Fuel storage tank discharges - Tanks 273, 274, 483, 484 (Inset 2) and tank 349 (Figure 1) feed fuel by gravity to underground tanks. Condensate and other water inside the tanks are discharged through an oil and grease separator to either the storm sewer or directly to Kuhlman Creek. The traps are not listed on the permit application, and the discharges are not permitted or sampled. This is a violation of OWRB Regulation 1020.2(a) for unpermitted discharge.

D. Cooling towers near Building 210 (Figure 1) are reported to be discharging to the sanitary sewer but this could not be verified by base personnel. These discharges may constitute a violation of OWRB Regulation 1020.2(a) for unpermitted discharge.

E. Storm lines connected to off-base drains or discharging off base (Figure 1). Based on the "Master Plan Storm Sewage System" blueprint, two stormwater lines have connections to off-base storage drains. One line extends north along Air Depot Boulevard and the other extends north of "F" Avenue from a wide spread area between 4th Street to I-40. These lines could be conduits for unpermitted discharges which would violate OWRB Regulation 1020.2(a).

Area 3

A. Building 3001 (Insets 3 and 4). An internal inspection of 3001 by Tinker personnel revealed 116 discharge connections to storm drains leading to waters of the state. None are permitted. These storm drain discharges violate OWRB Regulation 1020.2(a).

1. Westside - Discharge ditch parallel to Building 3001 receives cooling water at south end from permitted Outfall 004. Three pipes on the east side of ditch, originating within Building 3001, discharge into the ditch without a permit (photos 10, 11, 12 and 13). Sample analyses from the common discharge point at the north end of the ditch (photo 14) revealed high concentrations of tetrachloroethylene, chromium, and other volatile hydrocarbons (OWRB #8719 and #8727). This ditch discharges directly off base to an unnamed tributary of Soldier Creek. One line discharging to the ditch contained waste plastic bags originating from within Building 3001. The entire ditch contained an oil sheen as evidenced by stained banks (photos 15 and 16) and stains on a dual oil skimmer across the ditch (photo 17). These unpermitted discharges violate OWRB Regulation 1020.2(a) as well as OWQS 4.3(h) for toxic substances and chromium, and 4.3(d) for oil and grease.

2. Eastside -

a. North storm drain (30") has a constant clear water discharge. The appearace of fish, algae and lush vegetation and the sample analysis (OWRB #8712) indicate this discharge source could be a

drinking water line leak. Chromium at 56 ug/L was detected in this discharge. This unpermitted discharge violates OWRB Regulation 1020.2(a).

b. Middle storm drain (60") has a constant discharge which is reported by TAFB to be entirely composed of cooling water discharge monitored at Outfall 002. However, analysis (OWRB #8715), indicate additional sources discharge here. On May 3, 1984 inspectors discovered an estimated 15 gallons-per-minute discharge of purple water from this 60" storm drain (photos 18 and 19). This discharge had a pH of 12.5 S.U. and sample analysis revealed the presence of tetrachloroethylene at a concentration of 72.9 micrograms per liter (OWRB #8728). The source was determined to be a lift station which was erroneously connected to the storm sewer instead of the industrial waste sewer. Base personnel were unaware of the discharge but responded to the incident upon the inspectors request. The incident was not reported to appropriate state and federal agencies and a letter of explanation was not received by the OWRB which constitutes a violation of OWRB Regulation 1045.11(d). Sediments in the runoff path from this storm sewer discharge were black with oil and grease, violating OWRB Regulation 1025.13 for accumulation of deleterious substances in uncontained areas. The stream banks contained thick oil deposits up to 6" deep. When the drainage ditch substrate was stirred, a thick oil sheen appeared on the water's surface. Therefore, this discharge also violates OWQS 4.3(d) for oil and grease and 4.3(h) for toxic substances (tetrachloroethylene).

c. South storm drains (2x60") receive contaminated runoff and uncontrolled dumping of liquid wastes (paints, solvents, etc.) from inside and outside of the south end of Building 3001 and from the area south of the storm drain discharge point. Several outside storm drain grates were stained with paints, solvents, and oil and grease indicating improper disposal of waste materials from south of the 60" storm drains. A cooling tower, located on the south side of Building 3773, discharges to this storm sewer and is not described in the facility's permit application. The fuel receiving area, located east of Building 3211, had spillage around the piping system, and the sediments in the storm water ditch smelled of JP-4. Contaminated runoff from this ditch flows to the south storm drains. The areas were not cleaned up which constitutes a violation of OWRB Regulation 1025.13(a). Contaminated water from inside and outside of tanks 3716 and 3718 is discharged to the storm sewer. Storm drains on the south side of Building 3001 are located so as to receive wash water, condensate, and other wastes originating from maintenance and processes inside and outside of this end of Building 3001. These unpermitted discharges violate OWRB Regulations 1020.2(a) and 1025.13.

d. Underground tank 3405 (Inset 3) located on the north end of Building 3001 had a leak of motor vehicle gasoline of unknown quantity. The tank was emptied but not removed or filled with

inert material. The spilled gasoline was never quantified or cleaned up and the spill was never reported to appropriate agencies. This constitutes a violation of OWRB Rules, Regulations and Modes of Procedure 1045.11(d) for no clean up or reporting and OWQS 4.1(e) for petroleum related oil and grease in a location to contaminate a water supply.

B. Underground industrial waste line along outside of east side property line fence.

1. Concrete box access port to the industrial waste line north of 59th Street lift station contained wastewater with a metallic blue sheen (Photo 20). The liquid indicates the underground line is leaking. Dead vegetation on the surface along the industrial line also indicates line leakage (Photo 21).

2. Another concrete box access port to the industrial waste line near Gate 24 contained a valve with a discharge hose (Photo 22). Soil immediately adjacent to the concrete box was saturated with JP-4 fuel and a runoff track was evident leading to the barrow ditch and then to Soldier Creek (Photos 23 and 24). The runoff track was also saturated with JP-4 fuel. This situation constituted a spill event which was not reported or cleaned up and violates OWRB Regulation 1045.11(d).

II. SPCC and/or Storage Systems for Materials:

A. The following storage buildings, areas, or tanks are not listed on the facility's SPCC plan:

1. Buildings 1130, 1131, and 1132 in the "South 40" storage area.

2. Underground spill containment tank at northwest corner of Building 16.

3. Underground and above ground storage tanks around Building 1030; including "mo-gas" underground tank and outside barrel storage.

4. The spill pond north-northwest of Building 1030.

5. Underground retention tank at fire training pit for containment of JP-4 and contaminated water.

6. All outside storage in the "South 40" storage area.

7. Building 53 storage shed.

8. New above ground storage tanks at the AWACS alert facility.

9. Underground JP-4 transfer lines connecting fuel receiving area to above ground tanks located around the base, including lines to south side of base. Leaks are known to have occurred from the transfer lines with no cleanup and no listing of such spills in the plan. The lines were installed in the early 1960's.

B. The following storage buildings, areas, or tanks need to be modified or contained to protect surface and/or groundwaters of the state. The fate of spillage through floor drains, storm drains into the ground or to treatment systems must be certified. Descrepancies in proper and effective spill prevention and/or containment violated OWRB Regulation 1050.1 for inadequate storage systems for materials.

1. Verification of floor drains in Building 16 going to the outside underground storage tank.

2. Verification on the fate of floor drain in Building 212 surfuric acid tank containment structure.

3. Building 1123 (Quonset hut) is not constructed to prevent groundwater contamination and drain valves in curbing were open during inspection. Surface water contamination can result from precipitation events from spills which were evident inside the hut. Surface and groundwater contamination can occur because the curbing was constructed away from the hut roof, allowing rain water to enter inside the curbing. Storm water will inundate the hut floor and carry spilled material into groundwater and/or be discharged to surface waters when the valves are opened or left open.

4. North of Building 210, a storage building sits on concrete blocks with no curbing to contain or prevent a spill from reaching an adjacent storm drain.

5. Fenced storage north of Building 209 needs curbing to prevent spillage from reaching nearby storm drain.

6. Building 53 needs safeguards to prevent spillage from reaching storm drains.

7. Fire training pit retention tank needs safeguards to prevent overfill/spillage from occurring and to prevent such spillage from reaching Crutcho Creek.

8. Buildings 1130, 1131, and 1132 need safeguards to prevent internal spills from exiting the structures and contaminating nearby grounds and Crutcho Creek.

9. Sampling of spill pond sediments for toxics or hazardous wastes to determine if groundwater contamination is occurring. The pond may need to be dredged and lined.

10. Integrity test run on JP-4 transfer lines on a periodic and frequent basis.

11. All abandoned or leaking underground storage tanks which are leaking should be removed or emptied and filled with an inert substance.

C. Evaluation of SPCC Plan/storage systems for materials:

1. The OWRB is not listed on the SPCC plan for notification in the event of a spill and is not notified of spills which constitutes a violation of OWRB Rule 1045.11(d).

2. The plan appears to be excellent. However, the plan is not always followed. This was exemplified in the May 5, 1984 lift station discharge of "purple water" to East Soldier Creek. The discharge met all five TAFB Oplan 19-2 criteria for reportable spills and yet was not reported to appropriate state or federal agencies.

3. Need to update regional response telephone number which is (214) 767-2720.

4. Review of Site Inspection Reports contained in the SPCC plan (TAFB Oplan 19-2) revealed the following deficiencies which constitutes a violation of OWRB Rule 1050.1 and/or 1025.6 for the permitee's application:

   a. Buildings A01F & A01M & N - Need listing of types of pollutants stored, as none were listed, no volume listed and no attachment of list as cited by report.

   b. Building A16 - Identify the route that pollutants would flow in the event of a spill.

   c. Building 1123 (South 40 storage) - Need to seal bottom of outside dike area and install storm valve to discharge stormwater after sampling.

   d. Buildings 201, 209, 212, 2210, 2122 & 3117; portable tank on south end of Building 3108; Building 3703 "Syn-lub" oil and perchloroethylene tanks; 5728, 3750, open storage east of Building 3772 - Inspection report states, "There is no way to contain a spill." The recommended safeguards should be performed. See specific inspection sheet in TAFB Oplan 19-2.

   e. Buildings 214 & 2110 - Verify fate of a spill to floor drain as going to industrial sewer rather than storm sewer.

   f. Buildings 228 & 289, inspection report states, "There is no way to contain a spill of material stored outside." Proper containment should be provided to abate a spill. Also, determine fate of discharge from oil and grease separator to assure connection to industrial sewer instead of the storm sewer. Large tanks need dikes or berms capable of holding the contents of the single largest container within each containment structure.

   g. Storage tanks 273, 274, 349, 482, 483, 484 and 2108; Building 2121 tank; Building 3306 sulfuric acid tank; storage tanks 3732, 3735, 3716, 3718, 3730 & 3731 - Spills inside the dikes should

be cleaned up and contaminated soils removed and replaced. Contaminated stormwater must be sampled prior to discharge and the discharge must be permitted. Water from the inside of the tanks must be permitted and sampled prior to discharge. Periodic integrity tests must be performed on the tanks and piping to assure protection of groundwater.

h. All underground storage tanks and waste dump tanks, specifically tank 3405 - All underground tanks must be emptied in the event of a leak and the leaked or spilled materal cleaned up including soil removal and replacement. Periodic hydrostatic integrity tests must be performed to assure groundwater protection.

i. Building 1010 - Tank needs dike or berm capable of containing contents of tank. Contaminated gravel and soil should be removed in the event of a spill. Washrack drain should be verified to be connected to sanitary sewer since no industrial line runs to this portion of TAFB.

j. Building 1123 - Spilled material must be cleaned up including removal of contaminated soil. The curbing and quonset hut floor are inadequate for surface and groundwater protection and valves in the curbing were open during the inspection. The spilled material cannot be contained in dike area.

k. Building 2101 - Verify that floor drains go to industrial sewer or construct recommended structure rather than allowing waste to flow to storm sewer for spill containment.

l. Building 2112 - Spill containment structure should be constructed to abate spill from above-ground storage and during fuel unloading. Safeguards recommended in Oplan 19-2 inspection report should be followed.

m. Building 62516 Waste phenol, chromic acid, sulfuric acid and cyanide tanks - Verify integrity of plaster-lined tanks periodically to assure protection of groundwater.

5. Fuel jettison site - The TAFB OPlan 19-2 has a designated area for emergency fuel and/or fuel container jettison site to provide increased safety for emergency landings on base. The jettison site is located on the McClain-Cleveland County border, including the east half of Sections 1 and 12 in Township 19N and Range 4WIM in McClain County; and the west half of Sections 6 and 7 in Township 9N and Range 3WIM in Cleveland County. The Canadian River runs directly through the center of the designated site. Base personnel stated that at least two events have occurred involving fuel or container jettison since this area was designated. The events were not reported to state or federal environmental agencies and no attempt was made to determine the impact of the dumpings. Inquiries made to base personnel revealed that landowners in this area have not been informed that their property has been designated for emergency fuel

jettison. Inspection reports by state inspectors (NPDES inspections on January 14, 1982 and July 14, 1981) noted that no environmental assessment has been made as to fuel jettison impact on the site and that landowners had not been notified of their designation. Response from base personnel indicated that they were not required to assess the area or notify landowners but that notification should be done out of courtesy. Landowners have not been notified as of yet and an environmental impact assessment has not been performed.

RECOMMENDATIONS:

I. Organizational problems must be rectified to allow for efficient and timely handling of environmental incidents. It is recommended that one group of personnel be responsible for all environmental concerns. This groups should be endowed with the authority to activate the necessary personnel and equipment for proper environmental response. Any attempt to continue the current haphazard system, which does not allow personnel from different areas of command a direct line of authority or supervision, will undermine attempts to gain control of TAFB environmental problems. Significant reorganization of personnel and priorties is needed for TAFB to properly manage its environmental concerns.

II. Send Tinker Air Force Base a compliance letter requiring correction or verification of all the violations or potential problems found herein, not limited to the following:

A. Update facility industrial/sanitary/storm sewer blueprint by verifying that:

1. Lift stations are connected to industrial sewer and do not have bypass capability to storm sewer. If the lift stations have bypass capability for emergencies, alarms must be installed to notify appropriate personnel of the emergency discharge so sampling can be performed and discharge volumes calculated.

2. All floor drains are connected to industrial sewers, sanitary sewers or collection tanks. Those not so connected must be designated for outfall sampling or re-routed to appropriate industrial or sanitary sewer.

3. All discharges to industrial sewers are actually connected to industrial lines and not to storm sewers or sanitary sewers. Should connections lead to storm sewers, they should be re-routed to industrial or sanitary sewers or be identified for outfall designation and sampling. If the connections lead to the sanitary sewer instead of the industrial sewer, the discharge should be re-routed or identified as a contribution to the sanitary discharge on the permittee's application.

B. Update state application to include additional chemicals and compounds to be routed to the industrial and sewage treatment plants. Include expected volumes, concentrations and treatability of each compound or chemical and the expected discharge concentrations and loadings from each treatment

facility. Also, include industrial discharges which flow into the sewage treatment plant, i.e. cooling towers and truck washing. The updated application must meet the requirements of OWRB Rules, Regulations and Modes of Procedure 1025, especially 1025.6 for each operation on base. OWRB Rule 1025.6(b) must be addressed base wide and should include buildings used specifically for the storage of chemical compounds and raw materials.

C. Designate which unpermitted discharges which will not be re-routed so that outfall numbers and parameter discharge limits can be issued for each additional discharge. List pollutants, water treatment methods, and discharge loadings for each additional outfall.

D. Provide the OWRB with the total volume of additional loading(s) to industrial and/or sewage treatment plant as a result of re-routing unpermitted discharges.

E. Additional pollutants to be received by the treatment plants and the ability of the treatment plant to handle the additional waste compounds.

F. Collect representative sample sediments and/or water in the following locations for priority pollutants and heavy metals and submit to an OWRB certified laboratory for analysis. The analyses are to be submitted to the OWRB for environmental evaluation and possible corrective actions.

1. Area 1:

   a. spill pond;
   b. Crutcho Creek as it leaves the base;
   c. below 72" storm drain north end of Tower Road;
   d. floor of Building 1123 - composite of various spill material;
   e. substrate of concrete retainment area northeast of Building 1123; and

2. Area 2:

   a. Kuhlman Creek as it leaves base;
   b. below oil and grease trap discharge into Kuhlman Creek;
   c. above low water dam adjacent to oil and grease trap;
   d. common basin for 36", 72" and 60" storm drain north of tank 274 below discharges; and
   e. storm drain discharge from storm drain exiting base north of "F" Avenue. Sediments should be sampled at the discharge point off base.

3. Area 3:

   a. common discharge point on north end of storm ditch on west side of Building 3001;
   b. below Outfall 001;
   c. immediately above Outfall 005 from the bottom of the impounded water;
   d. in the oil skimmer basin above Outfall 002;
   e. above low water dam below 60" storm drain which discharges from Outfall 003; and
   f. above low water dam below 3 storm drains on south end (upper most) of East Soldier Creek.

G. Evaluate contamination of water and sediments in Crutcho Creek and unnamed tributary with head waters in Area 1, Kuhlman Creek, Soldier Creek, and related tributaries. Evaluation should include sample analyses for heavy metals and priority pollutants, both on base and downstream off base, representative of any contamination which has historically or is presently discharged from TAFB operations. Analytical results are to be submitted to the OWRB for environmental evaluation and possible corrective actions.

H. Provide the OWRB with all sample results from past and recent on-base sampling of waters and sediments. The information should specifically include results from Bio-monitoring personnel sampling including heavy metals and priority pollutants.

I. If base lab is to continue analytical capabilities for the purpose of the state permit, then Tinker is required to secure OWRB laboratory certification. If certification is not acquired, then TAFB must use a certified commercial lab.

J. Report all current and future spills which occur on base to the OWRB for logging and clean-up evaluation. Follow all steps in SPCC plan including clean-up and reporting procedures. All spills must be logged into SPCC plan.

K. Locate and remove, or fill all abandoned underground storage tanks with an inert material and remove soils contaminated by tank leakage.

L. Develop groundwater monitoring program to assess contamination arising from leakage in underground tank, chemical spillage, and creek bed contamination from unpermitted discharges. The program should specifically include the north and west sides of Building 3001, the fire training pit area, the spill pond, the low water dam in Kuhlman Creek and all underground storage tank areas. Any program should be approved by the OWRB prior to monitor well installation. This program should include the following information:

1. Report on specific past incidents of leaks or spills from underground tanks or lines and remedial action performed, to include tank 3405 and JP-4 across base transfer lines tanks.

2. Verify integrity of the following:

   a. JP-4 lines across base and clean-up areas of known leakage, past and present.

   b. All fuel transfer lines.

   c. All industrial sewage lines or provide records showing intergity tests, test methods used and frequency of tests.

This facility has approximately 2.4 million gallons of underground storage. Interviews with base personnel indicate that a majority of the underground storage tanks were installed in the 1940's. In order to assure protection for the groundwater of the state and to prevent loss of the product stored, reliable and accurate integrity tests should be performed periodically and with sufficient frequency to prevent groundwater and/or surface water contamination.

The inspector recommends that Tinker Air Force Base personnel provide the following information to allow assessment of potential and/or ongoing groundwater contamination:

1. Age and contents of each underground tank and the material of which the tank is constructed.

2. Age of all underground transfer lines.

3. Backfill material around each underground tank.

4. Type of corrosion protection or integrity protection for each underground tank or line.

5. Specific method and frequency of integrity testing for tanks and transfer lines.

6. Number and location of abandoned underground tanks.

7. Standard operating procedure for handling abandoned underground tanks.

Table 1. Tinker Air Force Base sample analyses from State/NPDES inspection by Oklahoma Water Resources Board, Spring 1984.[1]

OWRB #	DATE	SITE	TYPE	TOTAL CHROMIUM	TOTAL NICKEL	TOTAL COPPER	TOTAL ZINC (mg/L)	TOTAL LEAD	H-C	T-P	TCE[2]	DCE[3]	TTCE[4]	pH (s.u.)	OBSERVATION COMMENT
8719	4-18-84	NW	Grab	90	13	12	24	<20	<0.1	46	--	--	--	--	O/G sheen
8727	5-3-84	NW	Grab	--	--	--	--	--	--	--	4.6	24.7	54.6	--	O/G sheen
8717, 8716	4-17-84	SE	Grab	11	--	7	24	76	140	44	--	--	--	8.1	solvent sludge
8729	5-3-84	SE	Grab	--	--	--	--	--	--	--	--	--	27.0	--	solvent sludge
8715	4-17-84	mid-E	Grab	16	<10	72	45	20	<0.1	200	--	--	--	--	black
8728	5-3-84	mid-E	Grab	--	--	--	--	--	--	--	--	--	72.9	12.5	black
8712	4-17-84	NE	Grab	56	42	27	18	<20	--	10	--	--	--	--	--
8718	4-18-84	001	24-hr. comp.	286	329	13	8	<20	--	--	--	--	--	7.4	--
8710	4-17-84	001	Grab	515	476	20	158	--	--	1480	--	--	--	7.3	4000 ug/L Manganese, purple
8621	2-13-84	Lift Stn #3	Grab	8620	--	320	133	<200	6.7	3140	--	--	--	7.3	O/G sheen solvent odor
8711	4-17-84	01s	Grab	--	--	--	--	--	--	8970	--	--	--	--	

[1] All units in micrograms per liter except where noted.
[2] Trichlorethglene.
[3] Trans-1,2 Dichloroethylene.
[4] Tetrachloroethylene.

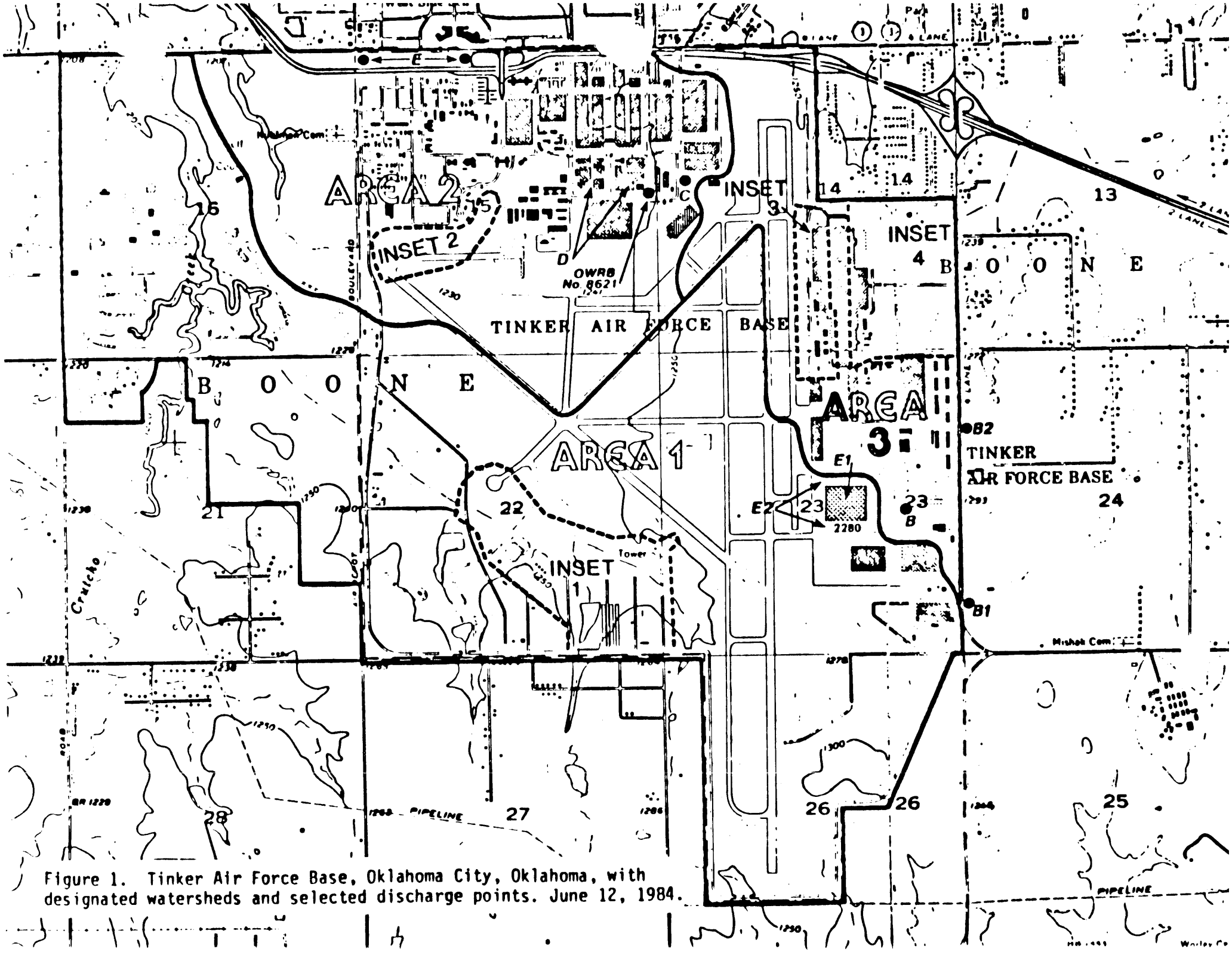
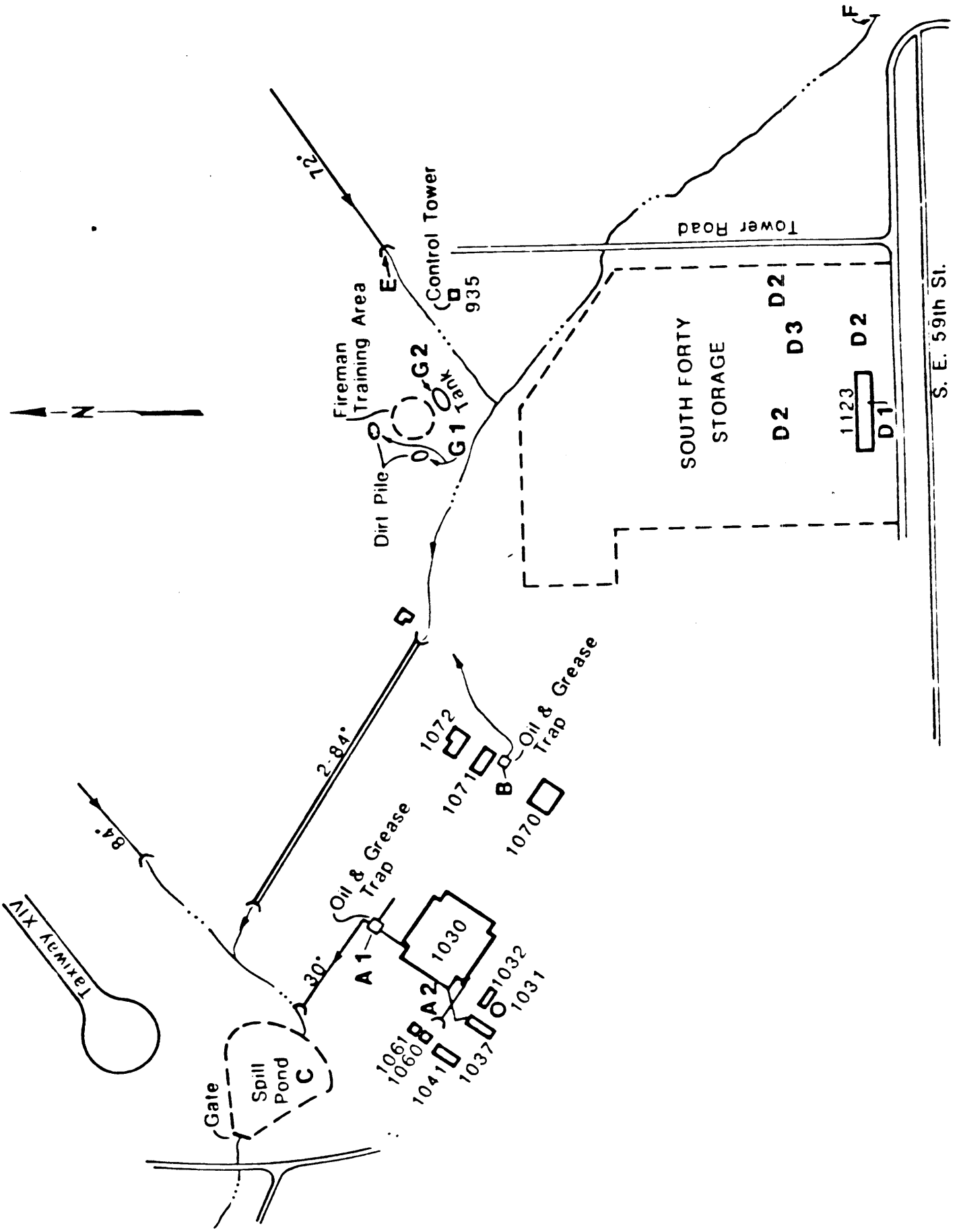
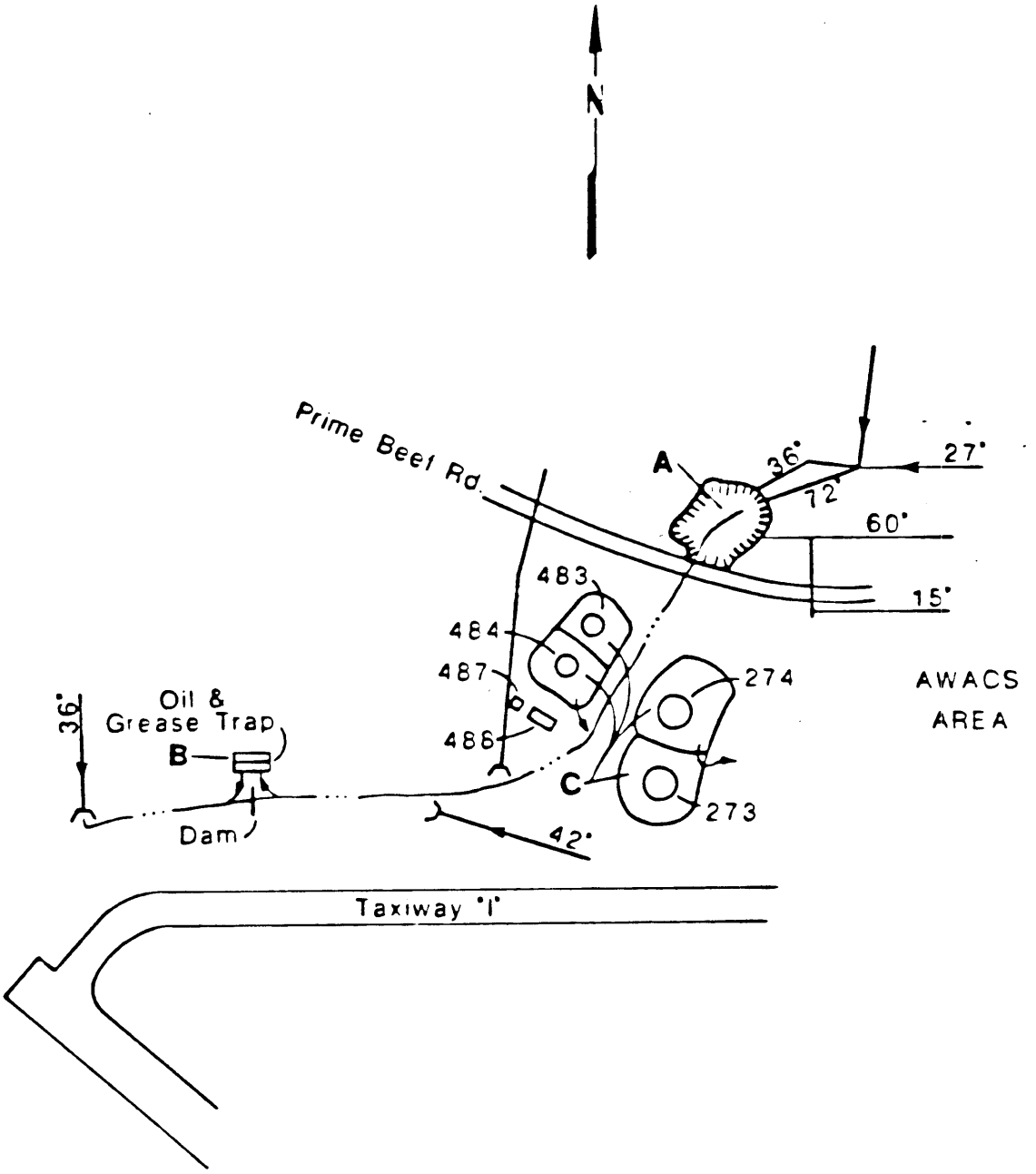


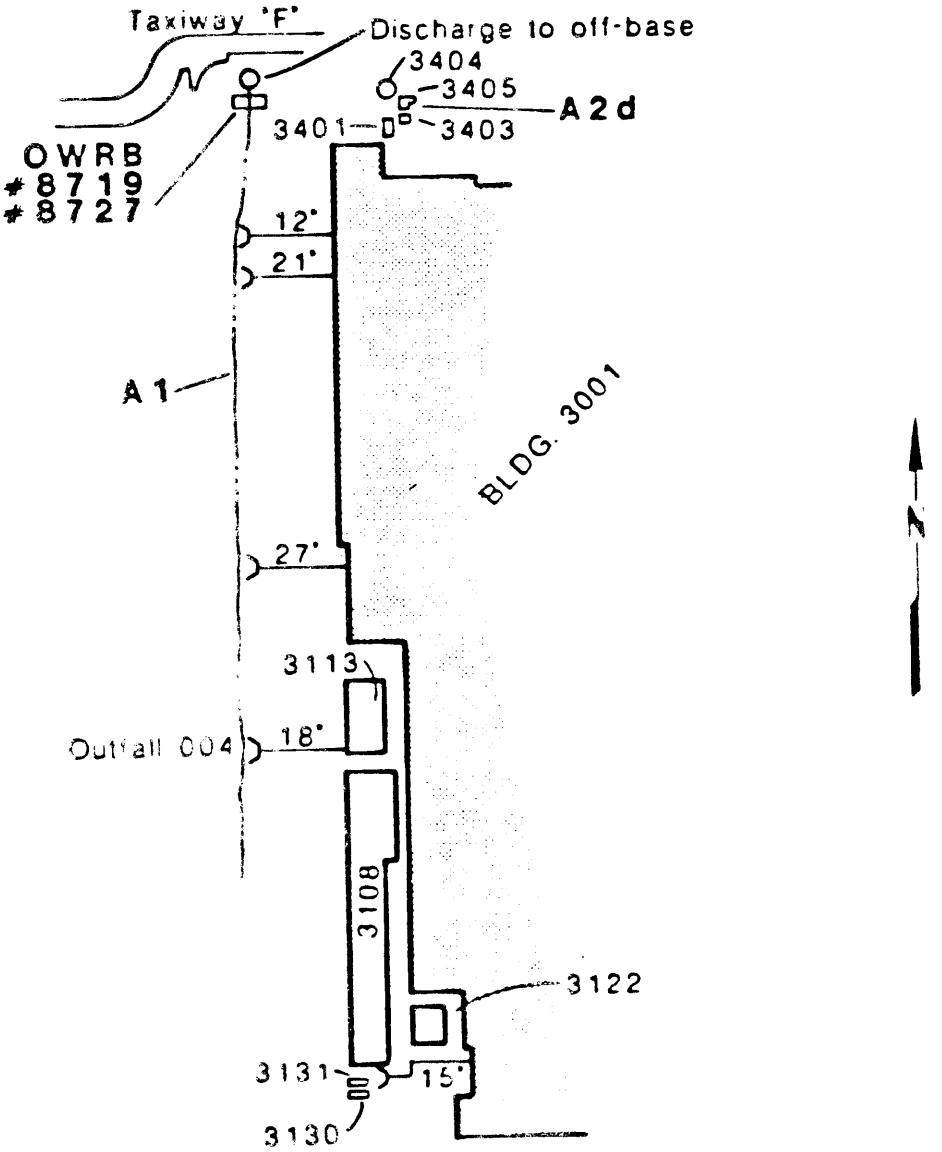
Figure 1. Tinker Air Force Base, Oklahoma City, Oklahoma, with designated watersheds and selected discharge points. June 12, 1984.



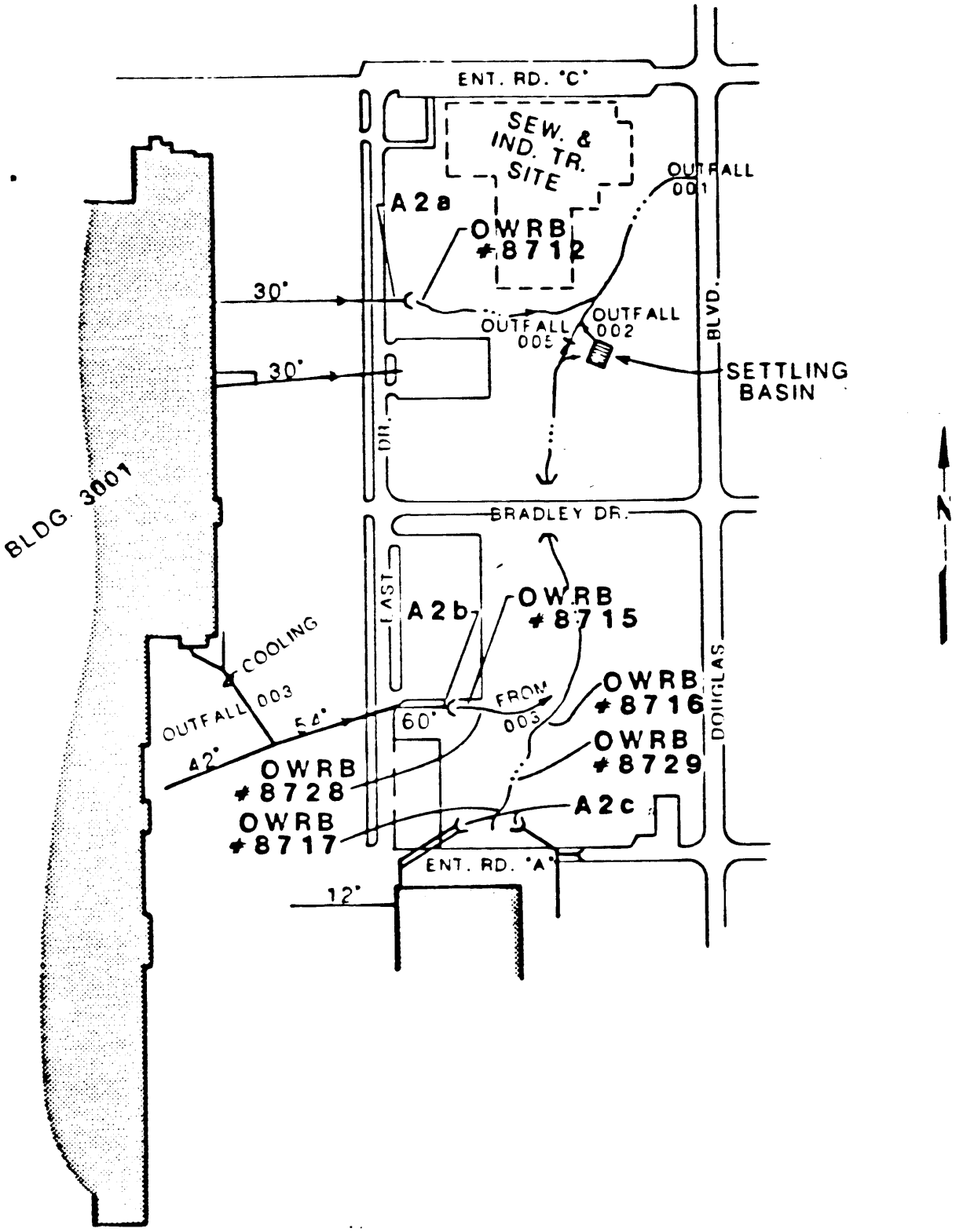
Inset 1 - Tinker Air Force Base Crutcho Creek drainage (Area 1) with maintenance and storage areas and discharge points. June 12, 1984.



Inset 2 - Tinker Air Force Base Kuhlman Creek drainage (Area 2) with discharge sources and locations. June 12, 1984.



Inset 3 - Tinker Air Force Base Soldier Creek drainage (Area 3) with discharge points. June 12, 1984.



Inset 4 - Tinker Air Force Base East Soldier Creek drainage (Area 3) discharge points and treatment plants. June 12, 1984.

Photo 1 - 5/11/84 - Discharge point for oil and grease trap at Bldg. 1030; view is to southeast. Trap lies 25 yds. southeast of pictured outlet. Discharge channel had visible oil and sheen and oil was released when sediments were stirred. Flow goes to spill pond.

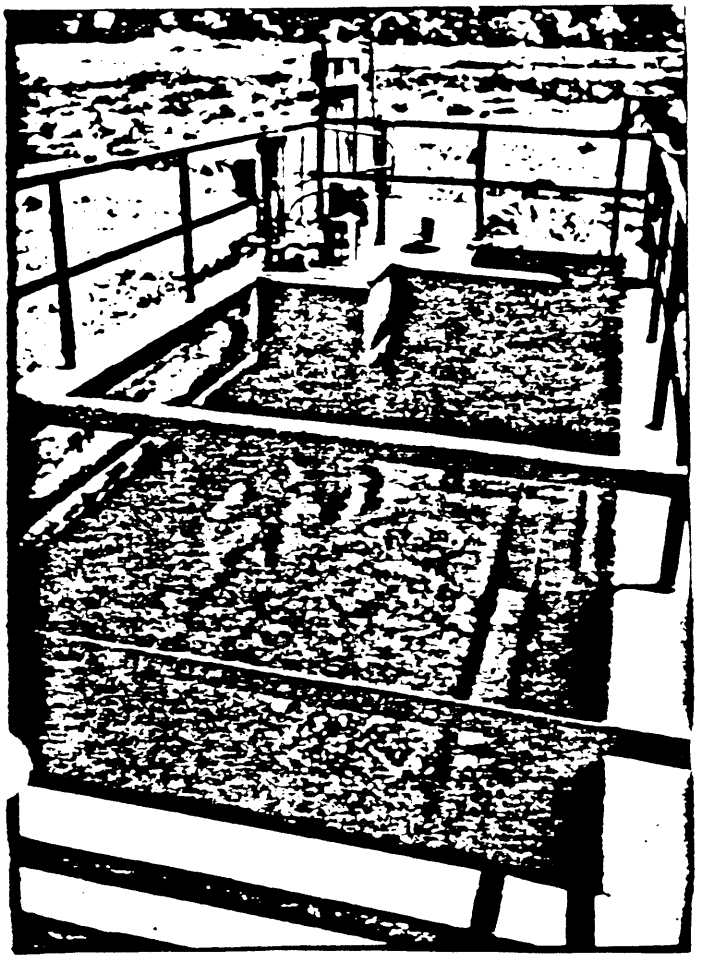


Photo 2 - 5/11/84 - Oil and grease trap at Bldg. 1071. Water is discharged from trap with oil and grease retained until sufficient quantity accumulates for hauling and disposal. Discharge flows to Crutcho Creek tributary to spill pond.

Photo 3 - 5/11/84 - Bldg. 1071 oil & grease trap with on-going surface discharge. Note dark color of water, oil sheen, and sparse vegetation where discharge contacts the soil surface.

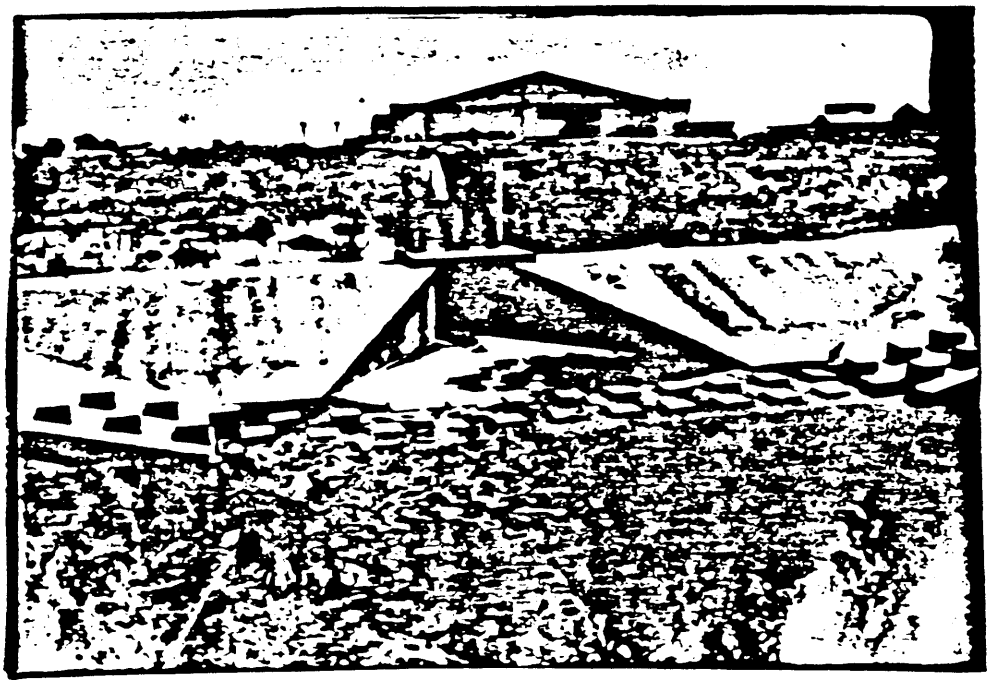


Photo 4 - 5/11/84 - Pond containment structure with manually operated gate for discharge. Note foam outside of structure and sparse vegetation in and around the spill pond.

Photo 5 - 5/10/84 - View to east-northeast of 84" storm drain. Note visible foam. Air in and around drain pipe smelled of aromatic hydrocarbons.

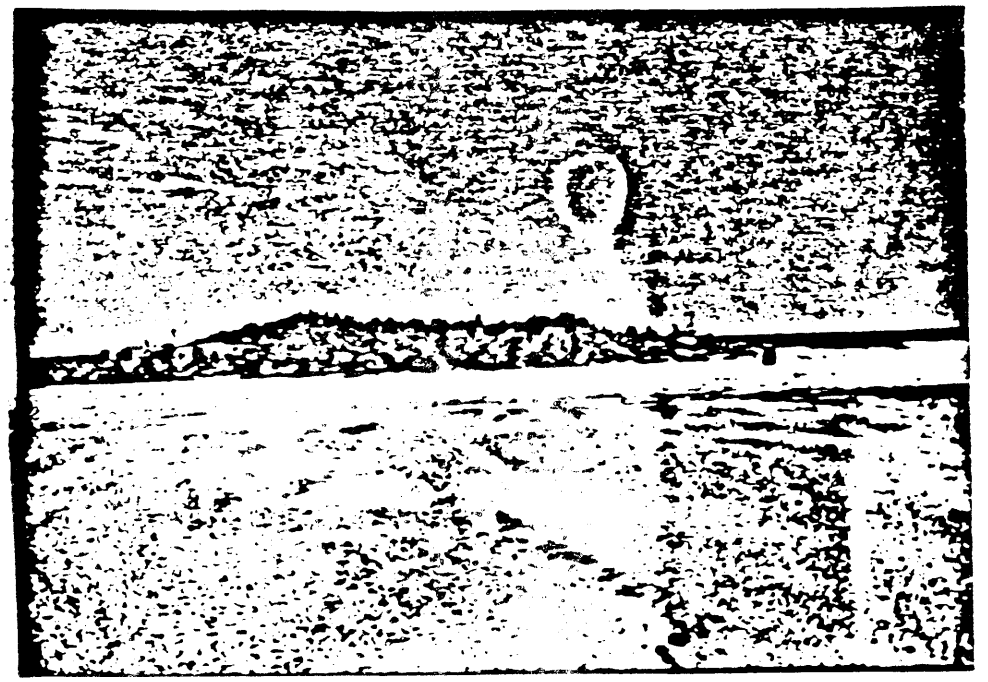


Photo 6 - 5/10/84 - Dirt pile on northeast corner of fire training pit area. This soil is contaminated with JP-4 and is improperly disposed. Runoff flows into Crutcho Creek.

Photo 7 - 5/10/84 - Additional JP-4 contaminated dirt pile from fire pit renovation. See photo 6.

Photo 8 - 5/10/84 - Vent pipe and access port for underground waste fluid retention tank at fire training pit area. One month prior to this photo, an overflow fill occurred resulting in the contaminated flow path at left leading to Crutcho Creek.

Photo 9 - 5/10/84 - Contaminated flow path of JP-4 and contaminated water from April overfill event. Note that no clean up has occurred.

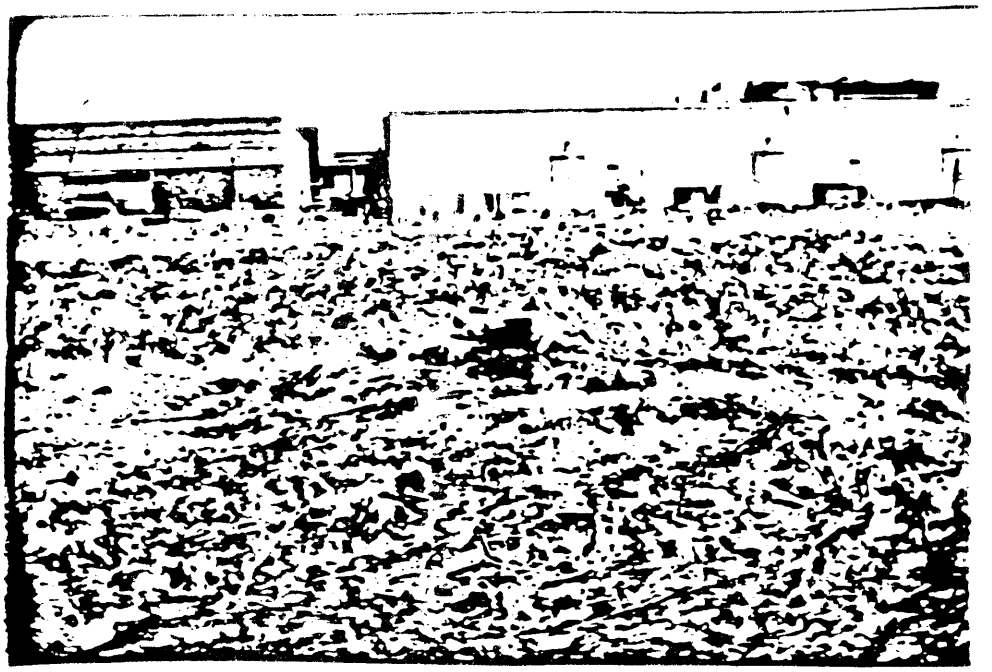


Photo 10 - 5/10/84 - 18" discharge pipe from Outfall 004 and other process areas. Pipe is located on west side of Bldg. 3001, approximately 1500 ft. above underground discharge pipe to Soldier Creek. Oil sheen was visible on the water surface when sediments were stirred. This discharge is a contributor to OWRB #8719 and #8727.

Photo 11 - 5/10/84 - 27" discharge pipe from Bldg. 3001. Pipe is located on the west side of Bldg. 3001, approximately 1250 ft. above underground discharge pipe to Soldier Creek. Flocculated material on substrate, with visible oil sheen and hydrocarbon odor released when sediments are stirred. This discharge is a contributor to OWRB #8719 and #8727.

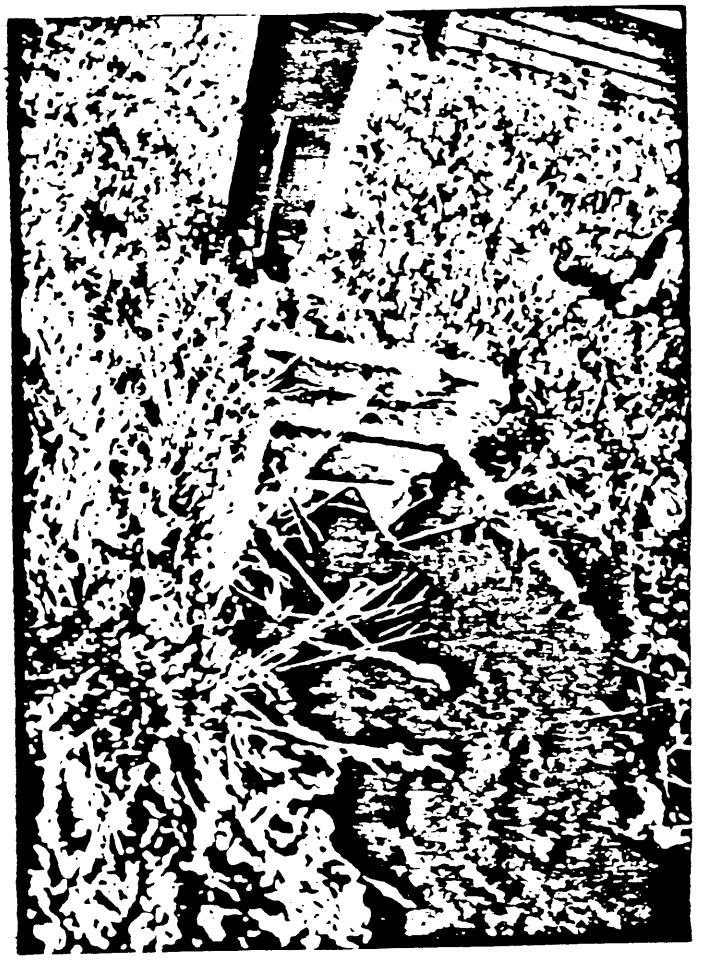


Photo 12 - 5/10/84 - 21" discharge pipe from Bldg. 3001. Pipe is located on west side of Bldg. 3001, approximately 500 ft. above underground discharge pipe to Soldier Creek. Note oil sheen. this discharge contributes to OWRB #8719 and #8727.

Photo 13 - 5/10/84 - 12" discharge pipe from Bldg. 3001. Pipe is located on west side of Bldg. 3001, approximately 450 ft. above underground discharge pipe to Soldier Creek.

Photo 14 - 5/10/84 - Underground discharge pipe to Soldier Creek and sample site for OWRB #8719 and 8727. This pipe receives wastewater from Outfall 004 and several other unpermitted sources. See photos 10-13 and photos 15-17.

Photo 15 - 5/10/84 - View to south-southeast of westside ditch of Bldg. 3001. Photos 10 and 11 were taken above (south) this point. Note staining on banks, hydrocarbon or oil sheen on the water surface and filamentrous algae on the substrate.

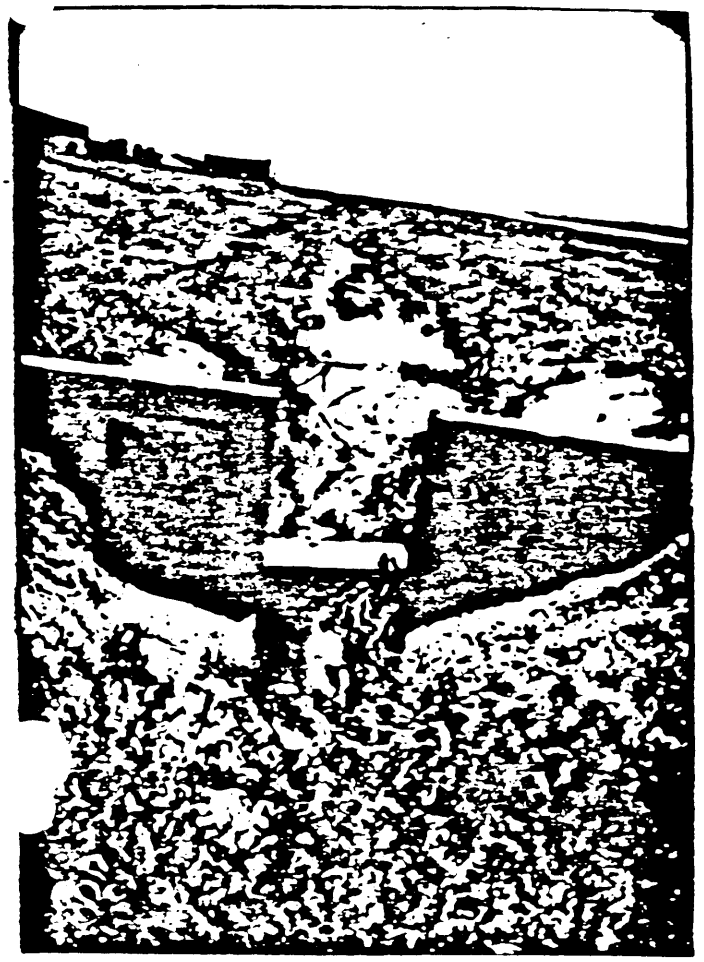


Photo 16 - 5/10/84 - Sample site for OWRB #8719 and #8727. View to south from atop underground discharge pipe to Soldier Creek. Note stained banks upstream and old flow control structure in foreground.

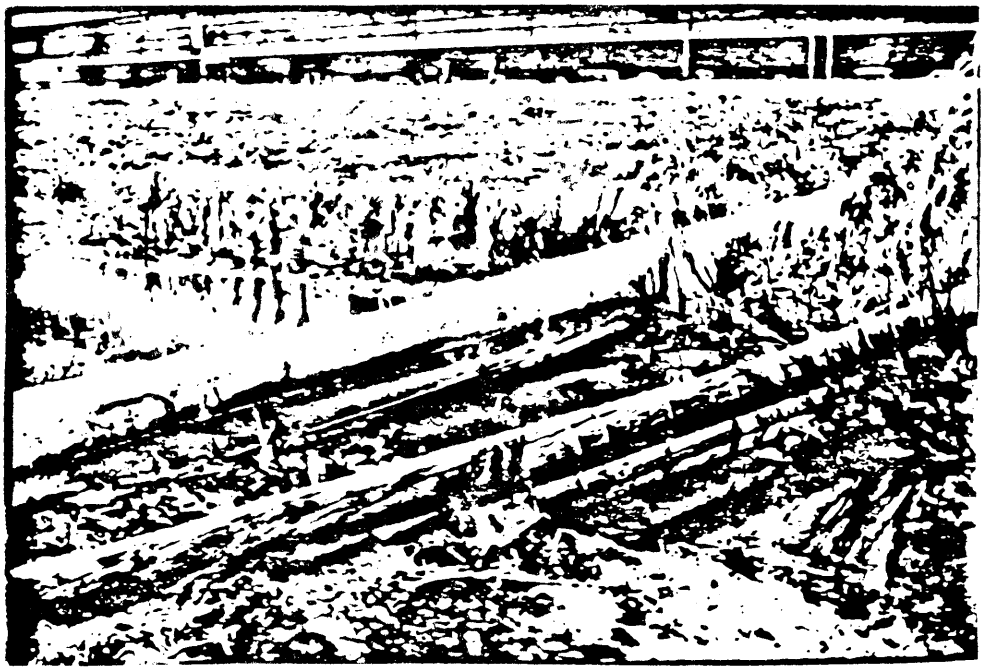


Photo 17 - 5/10/84 - Concrete and telephone pole oil skimming devices in storm drain on west side of Bldg. 3001. Skimmers are located approximately 1150 ft. above underground discharge pipe to Soldier Creek. Note oil sheen on water surface, staining on skimmers, black dried material on bank, and water level below skimmer.

Photo 18 - 5/3/84 - "Purple" water discharge (spill) from lift station near Outfall 003. Site location is approximately 20 yds. below 60" storm drain on east side of Bldg. 3001 (middle storm drain).

Photo 19 - 5/3/84 - "Spill" discharge from lift station near Outfall 003. Flow rate was approximately 15 gallons per minute.

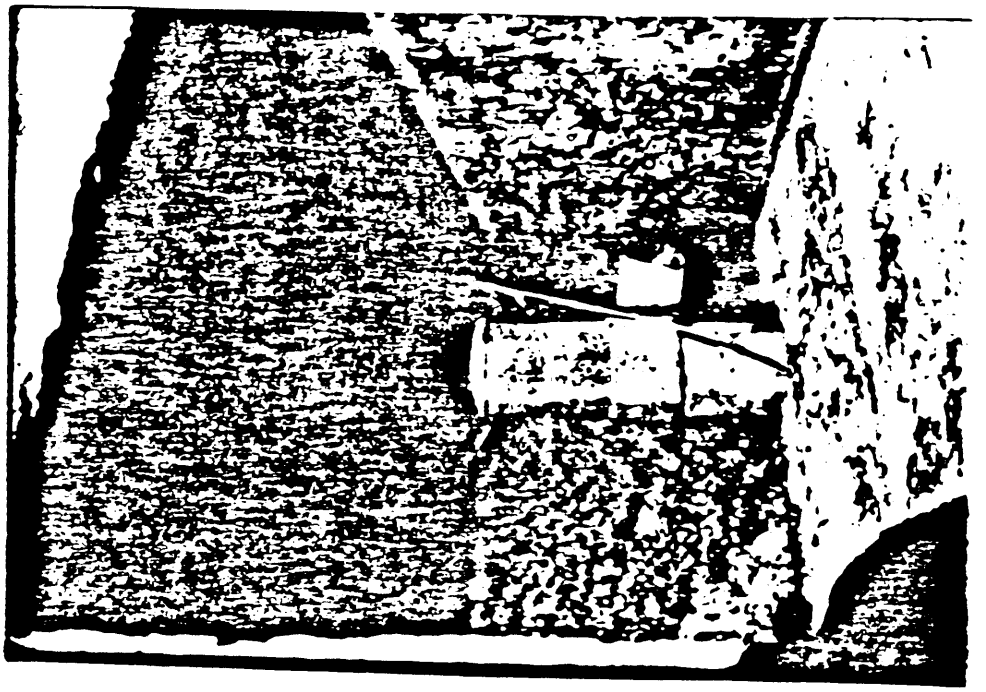


Photo 20 - 5/11/84 - Access port to industrial waste line along Douglas Boulevard. Line is underground outside of TAFB fence. Liquid in concrete box indicates possible leakage from line. Metallic blue sheen visible on liquid surface and area around box and over waste line does not support plant life.

Photo 21 - 5/11/84 - Dead vegetation over and along underground industrial waste sewer line north of 59th Street lift station near Bldg. 2100.

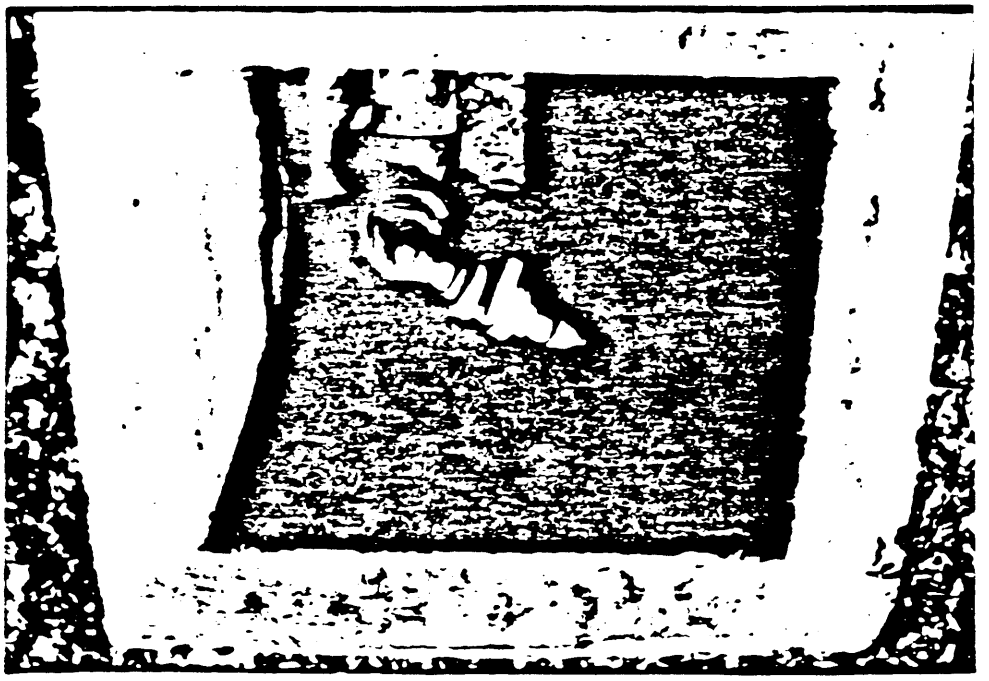


Photo 22 - 5/11/84 - Access port to underground industrial sewer line on outside of east fence near Gate 24. Line has valve with hose connected to it allowing discharge out of concrete box. JP-4 spillage on ground apparently originated from this hose.

Photo 23 - 5/11/84 - Flow path of JP-4 spill to storm drain then to Soldier Creek. Soil was saturated with JP-4. No clean up was performed. Flow went to concrete storm drain on left side of photo.

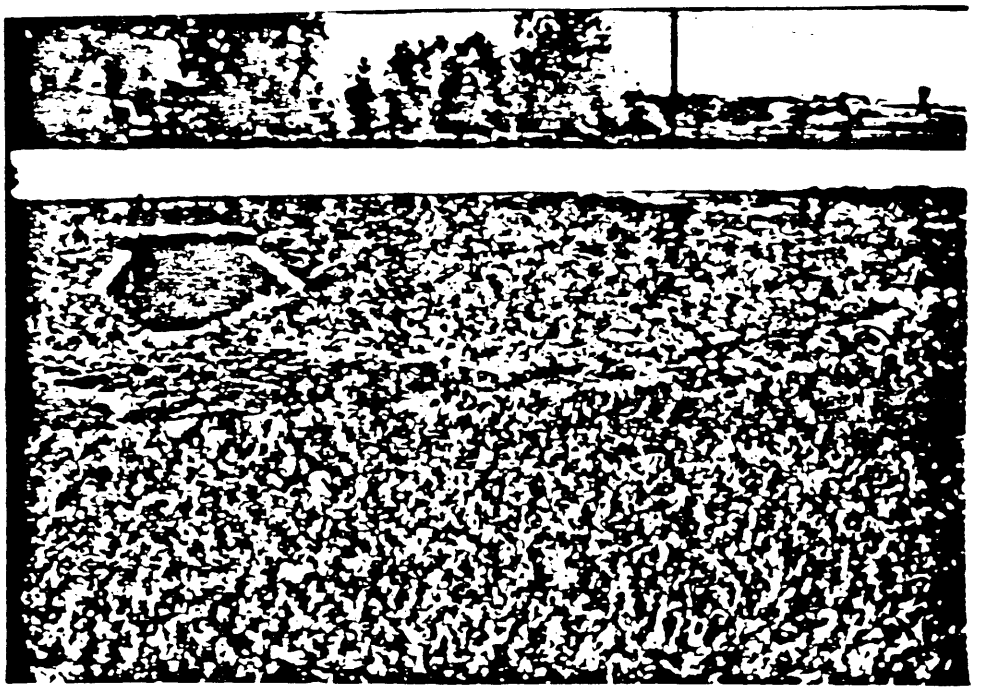


Photo 24 - 5/11/84 - JP-4 spill flow under Douglas to Soldier Creek drainage in top of photo.

Reference #8
Record of Communication. Drew Puffer, USEPA, to Lt. Bill Johnson, Tinker AFB. Location of wells 8 & 9, along with map showing location
11/28/84

RECORD OF COMMUNICATION

☑ PHONE CALL ☐ DISCUSSION ☐ FIELD TRIP ☐ CONFERENCE
☐ OTHER (SPECIFY)
(Record of item checked above)

TO: Lt. Bill Johnson
Civil Engineering
Tinker AFB

FROM: Drew Puffer

DATE: 11/28/84

TIME: 2:50 PM

SUBJECT: Location of wells #8 and #9 (base water supply wells)

SUMMARY OF COMMUNICATION

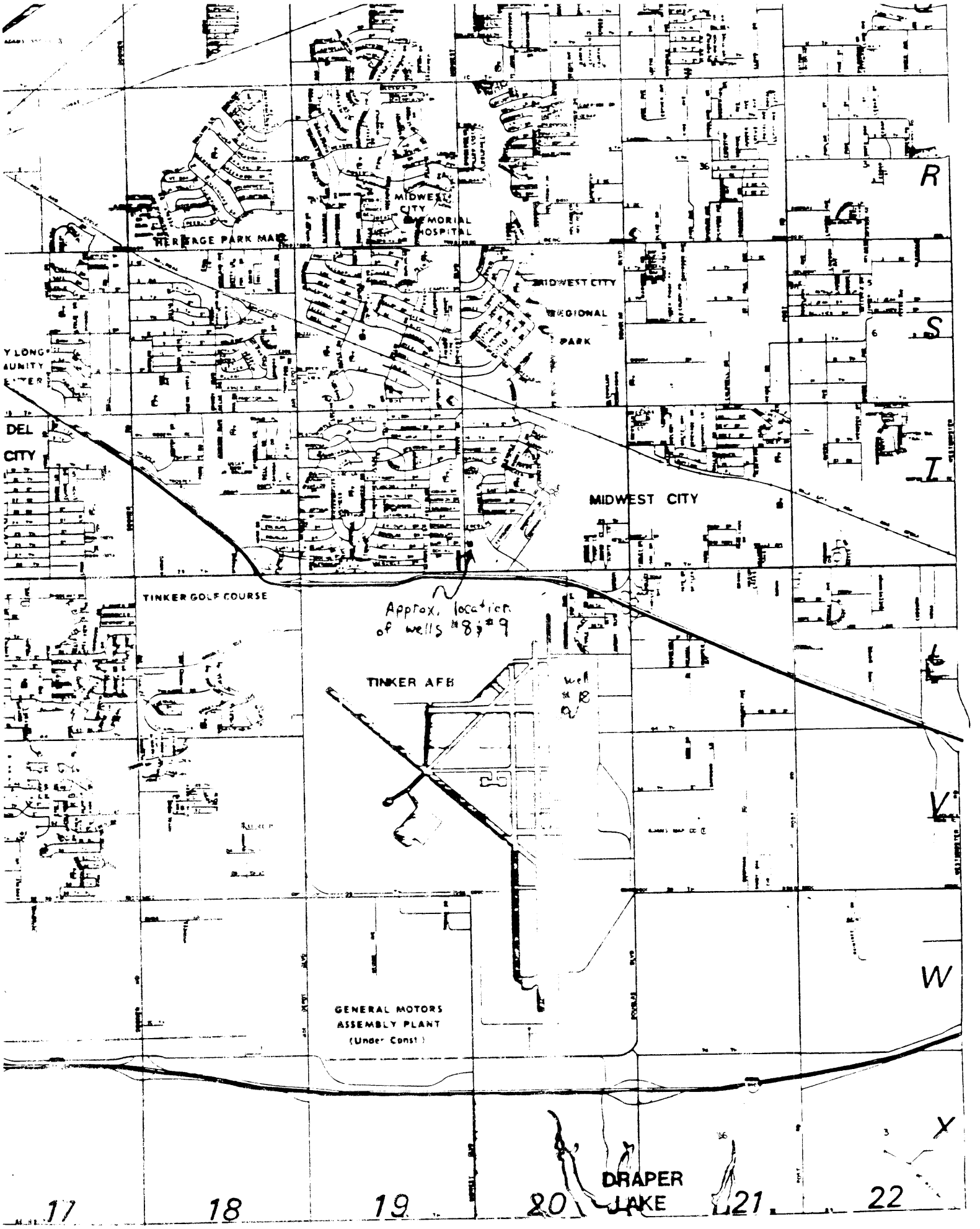
Lt. Johnson said that wells #8 and #9 were 1/4 mile North of the base along Midwest Blvd. The wells are within approximately 200 yds. of each other. I asked if these wells were close to 29th St. and Lt. Johnson said yes; they were within a couple hundred yards north of 29th St. next to a restaurant called "El Rancho", on Midwest Blvd.

CONCLUSIONS, ACTION TAKEN OR REQUIRED

INFORMATION COPIES

File

EPA Form 1200-4 (7-73) REPLACES EPA FORM 1200-4 WHICH MAY BE USED UNTIL SUPPLY IS EXHAUSTED.


MIDWEST CITY MEMORIAL HOSPITAL
HERITAGE PARK MALL
MIDWEST CITY REGIONAL PARK
MIDWEST CITY
TINKER GOLF COURSE
Approx. location of wells #8 & #9
TINKER AFB
well #8
GENERAL MOTORS ASSEMBLY PLANT (Under Const.)
DRAPER LAKE
R
S
I
V
W
X
11
18
19
20
21
22

Reference #9
CERCLA 103C Notification, Tinker AFB. 28 May 81

OKS-000-001-054 000725

This initial notification information is required by Section 103(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and must be mailed by June 9, 1981

Please type or print in ink. If you need additional space, use separate sheets of paper. Indicate the letter of the item which applies

Washington, DC 20460

RECEIVED

JUN 09 1981

6AEP

Manifest # 03646

A Person Required to Notify:

Enter the name and address of the person or organization required to notify

OK1 57 172 4341

Name: Tinker Air Force Base

Street: 2854 CES/DEEX

City: Oklahoma City State: OK Zip Code: 73145

B Site Location: ~~OKD 98 062-0959~~

Enter the common name (if known) and actual location of the site

HAZ-OK03646

Name of Site: Landfill Rd, Tinker Air Force Base

Street: Landfill Road, Tinker Air Force Base

City: Oklahoma City County: Okla. State: Ok Zip Code: 73145

C Person to Contact:

Enter the name, title (if applicable), and business telephone number of the person to contact regarding information submitted on this form.

Name (Last, First and Title): Burris, David--Environmental Engineer

Phone: 405-734-3201 (2854 CES/DEEX)

D Dates of Waste Handling:

Enter the years that you estimate waste treatment, storage, or disposal began and ended at the site

From (Year): 1941 To (Year): 1969

F Waste Type: Choose the option you prefer to complete

Option I: Select general waste types and source categories. If you do not know the general waste types or sources, you are encouraged to describe the site in Item I—Description of Site

General Type of Waste: Place an X in the appropriate boxes. The categories listed overlap. Check each applicable category

1 ☒ Organics
2 ☒ Inorganics
3 ☒ Solvents
4 ☐ Pesticides
5 ☒ Heavy metals
6 ☒ Acids
7 ☒ Bases
8 ☐ PCBs
9 ☒ Mixed Municipal Waste
10 ☒ Unknown
11 ☐ Other (Specify)

Source of Waste: Place an X in the appropriate boxes

1 ☐ Mining
2 ☐ Construction
3 ☐ Textiles
4 ☐ Fertilizer
5 ☐ Paper/Printing
6 ☐ Leather Tanning
7 ☐ Iron/Steel Foundry
8 ☒ Chemical, General
9 ☒ Plating/Polishing
10 ☒ Military Ammunition
11 ☐ Electrical Conductors
12 ☐ Transformers
13 ☐ Utility Companies
14 ☒ Sanitary/Refuse
15 ☐ Photofinish
16 ☐ Lab/Hospital
17 ☒ Unknown
18 ☐ Other (Specify)

Option 2. This option is available to persons familiar with the Resource Conservation and Recovery Act (RCRA) Section 3001 regulations (40 CFR Part 261)

Specific Type of Waste:
EPA has assigned a four-digit number to each hazardous waste listed in the regulations under Section 3001 of RCRA. Enter the appropriate four-digit number in the boxes provided. A copy of the list of hazardous wastes and codes can be obtained by contacting the EPA Region serving the State in which the site is located.

K054	F006	U032
D000	F007	U054
D001	F008	U057
D002	F009	U080
D011	F010	U112
F001	F017	U159
F002	F018	U210
F003	P030	U220
F004	P097	U226
F005	U002	U238
		U239

Form Approved
OMB No. [illegible]
EPA Form [illegible]

Attach [illegible]

Facility types found at the site

2 ☐ Land Treatment
3 ☒ Landfill
4 ☐ Tanks
5 ☐ Impoundment
6 ☐ Underground Injection
7 ☐ Drums Above Ground
8 ☒ Drums Below Ground
9 ☐ Other (Specify) _____

gallons _____

Total Facility Area

square feet _____

acres Acres total 35-40

Known, Suspected or Likely Releases to the Environment:

Place an X in the appropriate boxes to indicate any known, suspected, or likely releases of wastes to the environment

☒ Known ☒ Suspected ☐ Likely ☐ None

Note Items H and I are optional Completing these items will assist EPA and State and local governments in locating and assessing hazardous waste sites Although completing the items is not required, you are encouraged to do so

H Sketch Map of Site Location: (Optional)

Sketch a map showing streets highways, routes or other prominent landmarks near the site Place an X on the map to indicate the site location Draw an arrow showing the direction north You may substitute a publishing map showing the site location

See attached U.S.G.S. map of the Tinker Air Force Base Area.

Description of Site: (Optional)

Describe the history and present conditions of the site Give directions to the site and describe any nearby wells, springs, lakes, or housing Include such information as how waste was disposed and where the waste came from Provide any other information or comments which may help describe the site conditions

This landfill site has been used by Tinker Air Force Base for as long as anyone can remember. There are no records of what exactly was placed into the landfill over the years, but one can assume that the same industrial wastes were dumped at this disposal site as are being generated today.

Tinker Air Force Base is an Air Force Logistics Command (AFLC) base. Its primary mission is aircraft maintenance and jet engine rebuilding. The Installation Restoration Program, established by Defense Environmental Quality Program Policy Memorandum 80-6, is a three-phase effort to identify, monitor, and restore all suspect DOD landfills. Tinker AFB is scheduled for a tour by HQ AFLC to identify our landfill sites.

Signature and Title:

The person or authorized representative (such as plant managers, superintendents, trustees or attorneys) of persons required to notify must sign the form and provide a mailing address (if different than address in A) For other persons providing information, the signature is optional Check the boxes which best describe the ownership to the site of the person required to notify If you are not required to notify check "Other"

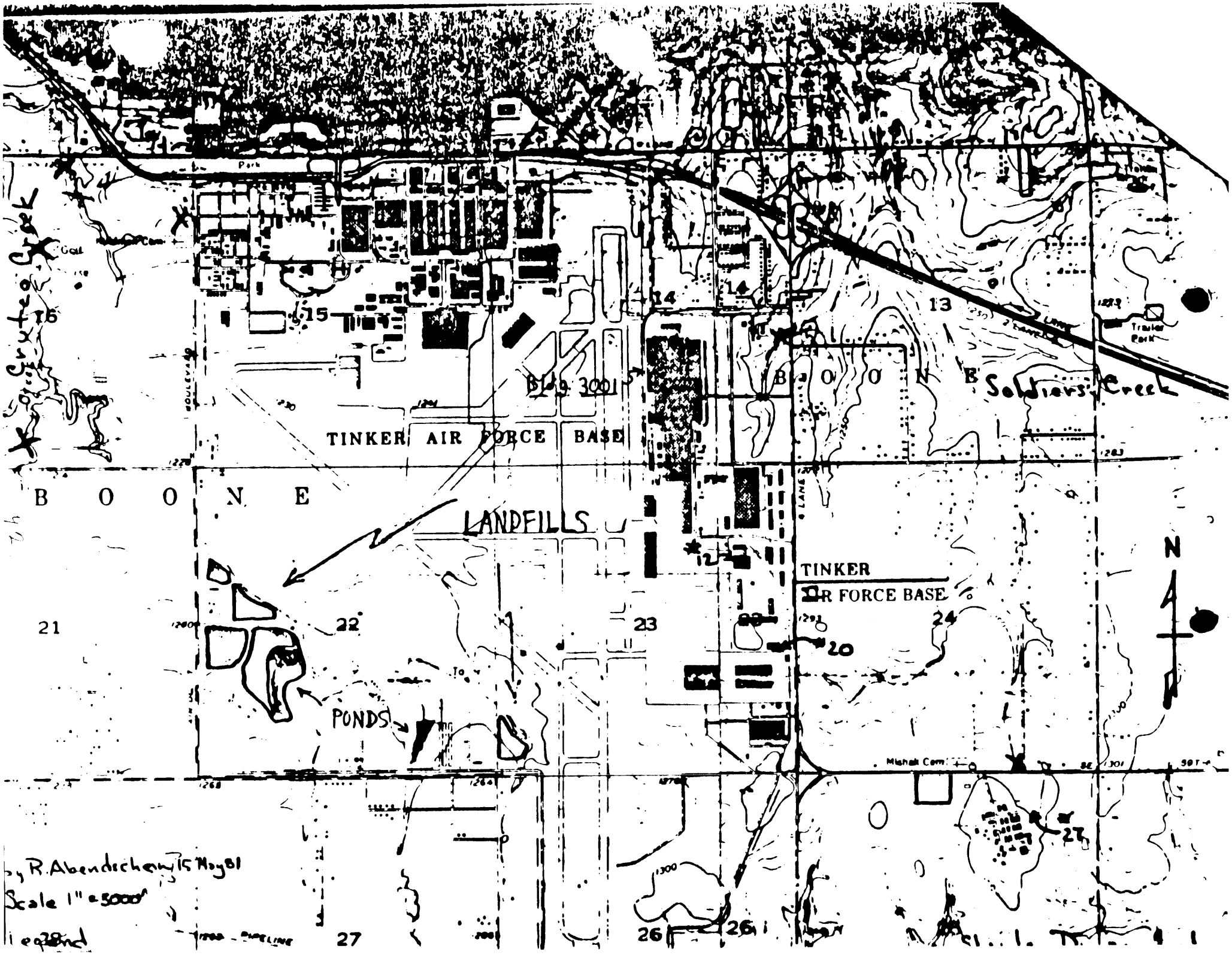
Name I.L. Piersall

Street 2854 CES/DEEX, Tinker AFB

City Oklahoma City State OK Zip Code 73145

Signature [signature] Date 28 May 1981

☐ Owner, Present
☐ Owner, Past
☐ Transporter
☐ Operator, Present
☐ Operator, Past
☒ Other



Crutco Creek
Soldiers Creek
Trailer Park
Bldg 3001
TINKER AIR FORCE BASE
B O O N E
LANDFILLS
PONDS
TINKER
AIR FORCE BASE
Mishak Cem
N
13
14
15
16
20
21
22
23
24
26
27
R. Abendschein 15 May 81
Scale 1" = 5000'

Reference #10

Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahoma: Sheet 2 - Bedrocks Aquifers and Recharge Areas. Compiled by K.S. Johnson, Oklahoma Geological Survey, 1963

MAPS SHOWING PRINCIPAL GROUND-WATER RESOURCES AND RECHARGE AREAS IN OKLAHOMA:

SHEET 2 - BEDROCK AQUIFERS AND RECHARGE AREAS

(Reduction and composite of original)

Compiled by
Kenneth S. Johnson
Oklahoma Geological Survey

1983

EXPLANATION

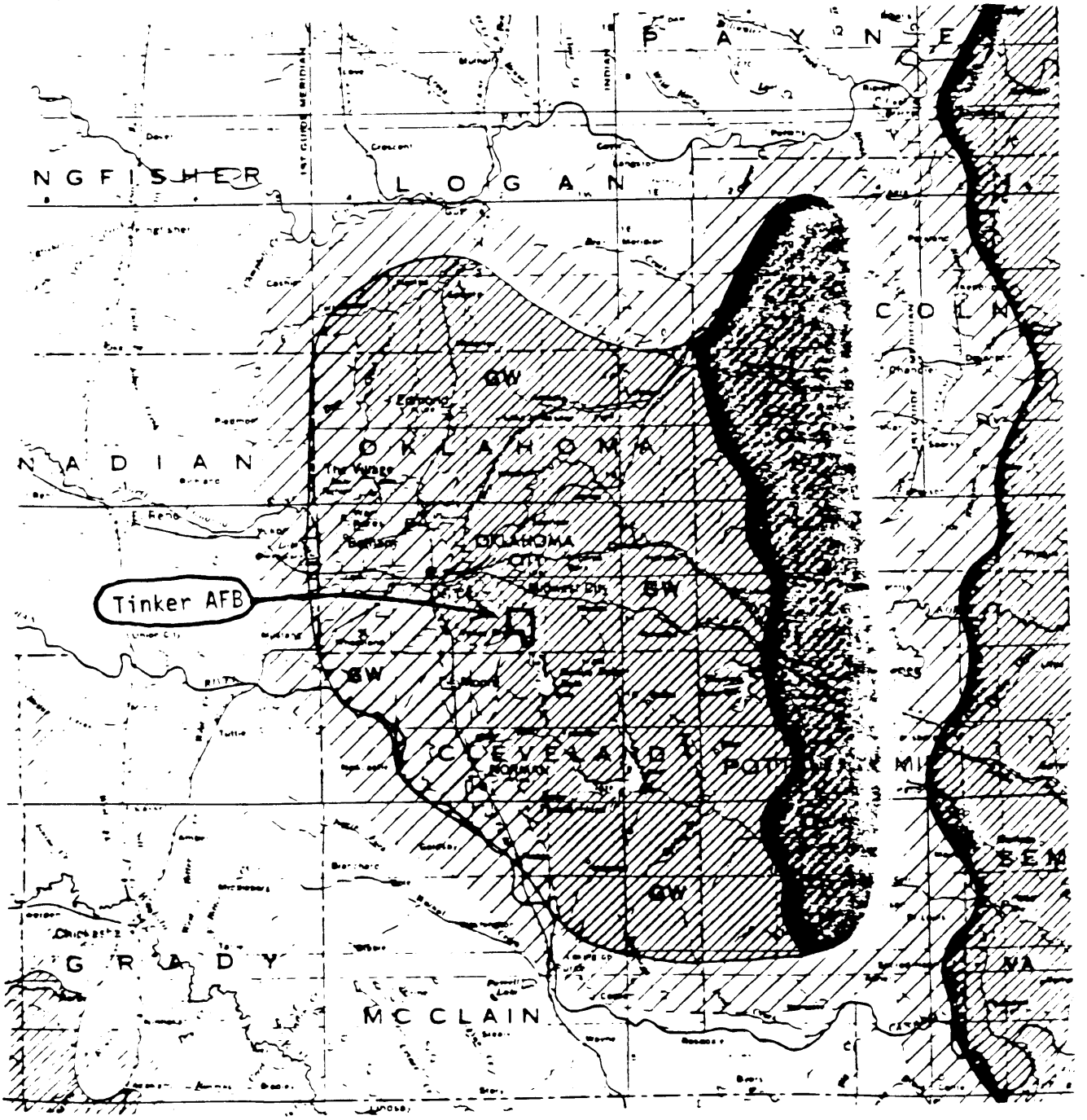
RECHARGE AREAS

Patterns of red lines on the map show known or potential recharge areas for the various bedrock aquifers.

Recharge Areas: This pattern shows areas that are known to be part of the recharge area for a bedrock aquifer; includes outcrops of the aquifer and of overlying porous and permeable rocks hydraulically connected with the aquifer.

Potential Recharge Areas: This pattern shows areas that may be part of the recharge area for a bedrock aquifer; includes areas where confining strata may contain pathways for downward movement of water to the aquifer, and later zones (generally extending 4 miles beyond the known limits of the aquifer) that may overlie unknown extensions of the aquifer or rocks hydraulically connected with the aquifer.

GW — Garber Sandstone and Wellington Formation (Permian in age). Fine-grained sandstone irregularly interbedded with shale and siltstone in central Oklahoma; grades into shale to north and south. Thickness of aquifer ranges from about 300 ft in the south to about 800 ft in the north. Wells commonly yield 25 to 400 gpm of water that is of good quality (generally 200 to 1,000 mg/l dissolved solids). Recharge areas consist of outcrops of the aquifer and extend eastward to the approximate top of shales that make up much of the lower one third of the Wellington Formation. Potential recharge areas include areas in the west where aquifer underlies younger Permian strata; also areas that extend 4 miles south, west, and north of aquifer limits. References: NA-4; also Other Reports 4, 5, 29, 33, 61, 67, 68.



Reference #11
Testimony: Dr. C.J. Mankin, Director, Oklahoma Geological Survey, at Tinker Air Force Base Hearing, Subcommittee on Environment, Energy and Natural Resources, Dec. 12, 1984

Tinker Air Force Base Hearing

Subcommittee on Environment, Energy and Natural Resources

December 12, 1984

Testimony of Dr. Charles J. Mankin, Director

Oklahoma Geological Survey

Thank you, Mr. Chairman. I am Charles Mankin. I serve as Director of the Oklahoma Geological Survey and as Executive Director of the Energy Resources Institute at The University of Oklahoma. In connection with this testimony it should be noted that I also serve on the Board of the Environmental Institute for Waste Management Studies at the University of Alabama.

This presentation has been developed with assistance from the staff of the Oklahoma Geological Survey with special acknowledgment to Dr. Kenneth Johnson, Associate Director of the Survey, who assembled much of the technical information for this purpose. It should be noted also that much of this information has been derived through the cooperative program between the Oklahoma Geological Survey and the Water Resources Division of the U.S. Geological Survey.

Geohydrology of Tinker Air Force Base Area

Outcropping rock units in and around Tinker Air Force Base (TAFB) include sandstones and shales that make up a major ground-water aquifer for the greater Oklahoma City area (Figure 1). These sedimentary rocks were laid down as part of a complex of alluvial and deltaic sediments deposited by streams that flowed westward across central Oklahoma during the Permian Period of geologic time, about 250 million years ago. The rock units are the Hennessey Group, consisting mainly of shale that mantles TAFB, and the thick, underlying Garber Sandstone and Wellington Formation,

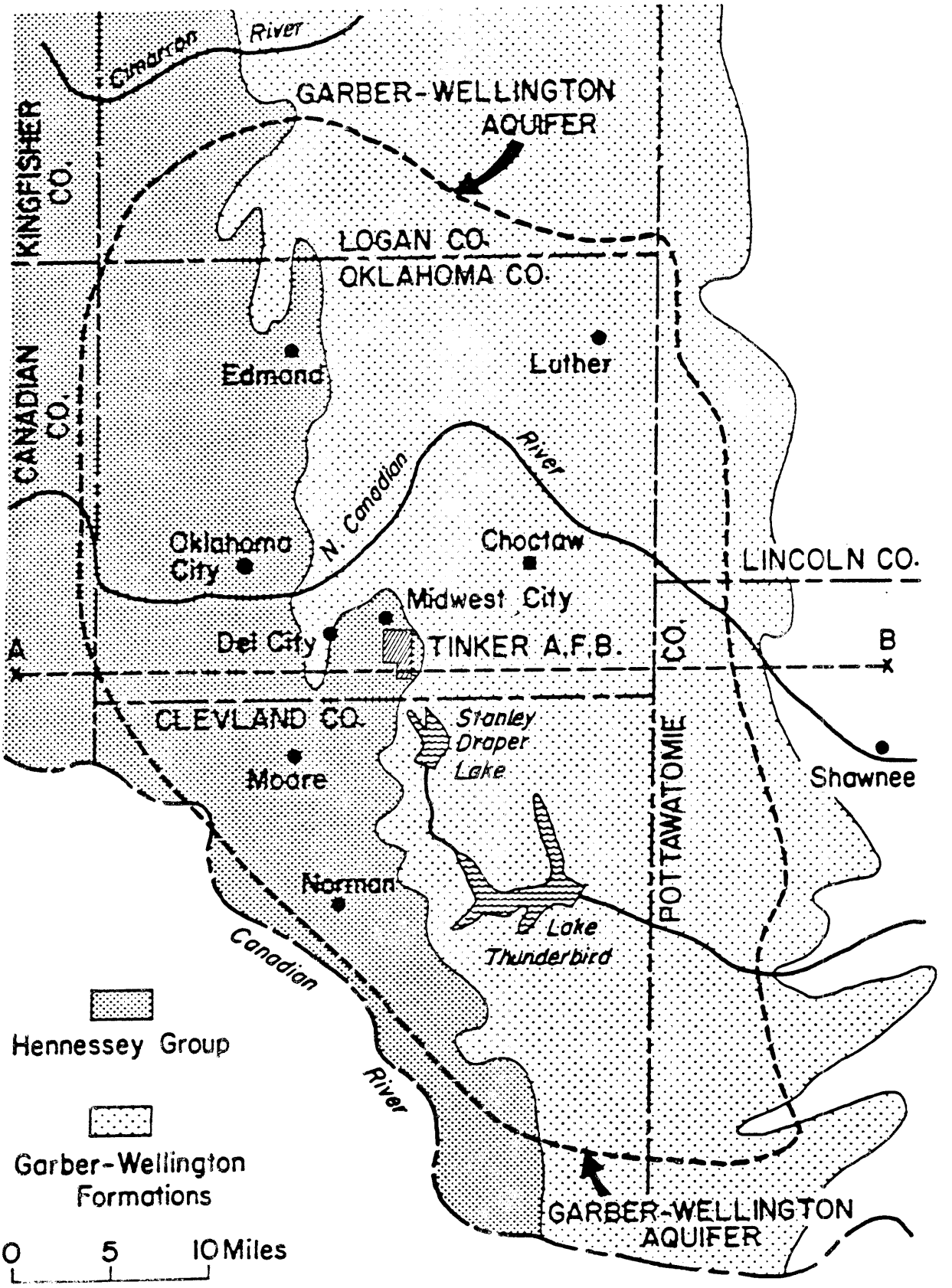


Figure 1. Generalized bedrock geologic map of central Oklahoma showing outcrops of Garber-Wellington formations and Hennessey Group. Also shown is outline (dashed line) of area where Garber-Wellington aquifer is a major ground-water resource. Cross section A-B shown on next figure. Modified from Miser and others (1954), Wood and Burton (1968), and Bingham and Moore (1975).

both of which consist mainly of sandstone and comprise the major aquifer for the region. All three of these sedimentary rocks units dip gently to the west (Figure 2) at an angle of about one-third of a degree (about 30 feet per mile).

The Hennessey Group consists mainly of reddish-brown shale with some layers of siltstone and fine-grained sandstone (Wood and Burton, 1968). The shales are clayey to silty, and the siltstones and sandstones commonly contain large amounts of clay. Inasmuch as the upper and middle portions of the Hennessey have been eroded from the TAFB area, only the basal 10 to 50 feet of the Hennessey strata are still present at TAFB. Shales of the Hennessey generally have a low permeability, and thus disposal of waste materials in trenches dug into the Hennessey probably was regarded as acceptable. However, closeness of the disposal sites to the underlying aquifer makes it possible that some of the waste material could eventually migrate downward into the aquifer through natural and/or man-made pathways that penetrate the base of the Hennessey into the top of the Garber.

As noted previously, immediately underlying the Hennessey are red-bed sandstones and shales of the Garber Sandstone and the Wellington Formation. The Garber and Wellington are similar in lithology and are not readily distinguishable in the area. The two formations also have similar water-bearing characteristics and therefore they commonly are mapped as a single unit (Figures 1 and 2) and treated as a single aquifer (the Garber-Wellington aquifer). The total thickness of the Garber-Wellington in the vicinity of TAFB is about 800 to 1,000 feet.

The contact between the Garber Sandstone and the overlying Hennessey is gradational in parts of central Oklahoma; locally, sandstone layers having a lithology similar to the Garber grade laterally into shales resembling the Hennessey (Wood and Burton, 1968). Therefore, at times there has been uncertainty in the detailed mapping of the TAFB area. Wood and Burton (1968) mapped most of the TAFB outcrops as Hennessey, whereas a later, reconnaissance mapping program by Bingham and Moore

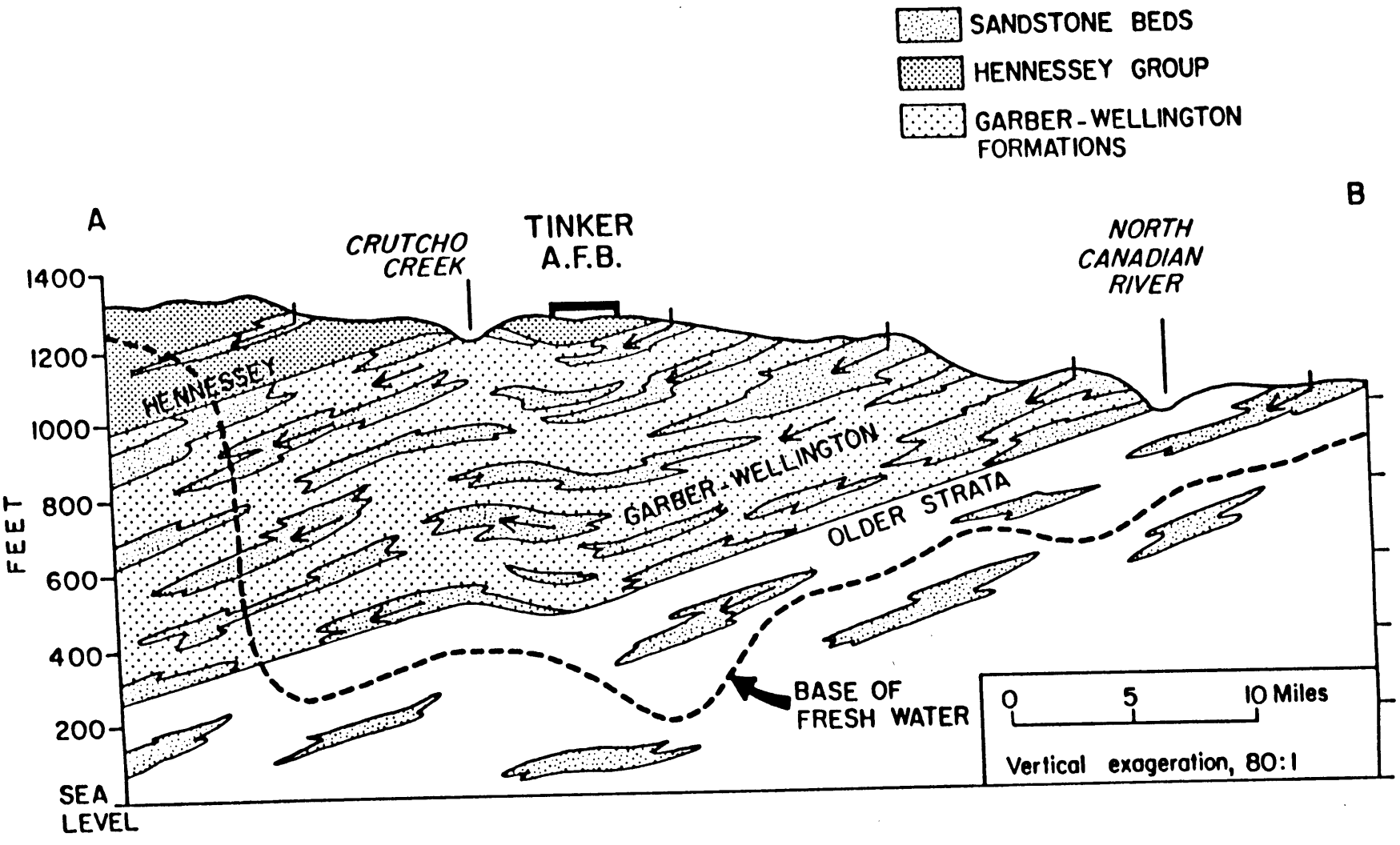


Figure 2. Schematic east-west cross section A-B through southern Oklahoma County, showing irregular distribution of sandstones (stipple) in the Garber-Wellington aquifer, recharge of sandstone aquifers (arrows), and the base of fresh water in the aquifer (dashed line). Modified from Wood and Burton (1968).

(1974) mapped most of the same outcrops as Garber: current data indicate that Wood and Burton's work was correct in assigning TAFB outcrops to the Hennessey Group.

The Garber and Wellington consist of lenticular beds of massive-appearing, cross-bedded sandstone irregularly interbedded with shale which is in part sandy to silty (Wood and Burton, 1968; Carr and Marcher, 1977). The sandstone layers are fine- to very-fine-grained, loosely cemented, and typically are highly porous and permeable. Variability in thickness and distribution is characteristic of the individual sandstone units. Individual sandstone layers range in thickness from a few inches to as much as 50 feet, and these thicknesses vary greatly in short distances. Although some of the sandstone beds are quite thick, beds 5 feet or less in thickness are more common. In general, the sandstone content of the Garber and Wellington is greatest in southeastern Oklahoma County, where about 75 percent of the exposed rock is sandstone and 25 percent is shale.

Ground water occurs in the porous and permeable sandstone layers of the Garber-Wellington aquifer beneath and in the vicinity of TAFB (Figure 2). The aquifer is recharged where surface waters (precipitation, surface runoff, streams, and lakes) percolate into the permeable sandstone layers and eventually migrate downward to the zone of saturation (water table). This is a dynamic system inasmuch as the Garber-Wellington aquifer is being recharged continuously, and ground water is migrating slowly downdip to the west within the sandstone layers and lenses.

The Garber-Wellington aquifer may also be recharged locally on TAFB by percolation of surface waters downward through the lower Hennessey strata until the water reaches the top of the Garber. Such recharge may occur where the Hennessey contains naturally-occurring high-permeability layers, joints, and fractures, or man-made boreholes, trenches, and other excavations. Any of the natural or artificial features that penetrate through the Hennessey strata into the underlying Garber-Wellilngton

aquifer represents a potential pathway for surface waters locally to enter the aquifer (Johnson, 1983).

Owing to the irregular thickness and distribution of sandstone layers and lenses in the Garber and Wellington formations, the aquifer is not a continuously uniform, saturated rock unit, but instead is a series water-bearing zones enveloped in shale. Each water-bearing zone has its own potential for storing water. Wells drilled into the aquifer commonly tap a number of individual sandstone beds, and thus may penetrate 200 to 300 feet of water-bearing sandstone while being drilled to a total depth of 400 to 500 feet. Other wells drilled to similar depths nearby may tap only a few relatively thin beds of sandstone, and thus penetrate only 50 to 100 feet of water-bearing strata. Thus it is clear that the ability of the Garber-Wellington aquifer to store and transmit water varies markedly from place to place, and without understanding the distribution and permeability of the principal sandstone units it is difficult or impossible to adequately evaluate or monitor ground-water flow in the Garber-Wellington aquifer.

The Garber-Wellington aquifer is the most important source of potable ground water in the greater Oklahoma City area. Cities in southern Oklahoma County, such as Midwest City, Del City, Jones, Spencer, and Choctaw, all have municipal wells drilled into the Garber-Wellington aquifer, and they use ground water as a principal water supply (Wickersham, 1979). A number of institutions and industries in southern Oklahoma County and northern Cleveland County also are heavy users of the Garber-Wellington aquifer. TAFB draws heavily upon the aquifer beneath the base itself to supply its water needs. Also, a great number of wells have been drilled in the Oklahoma-Cleveland County area as domestic and stock wells. All these uses and demands for water from the Garber-Wellington aquifer should increase in the future as the population of the area continues to rise.

Wells drilled into the Garber-Wellington aquifer commonly yield from 25 to 400 gallons per minute, and the water is typically of good quality, containing about 200

to 1,000 milligrams of dissolved solids per liter of water. Wells drilled to depths in excess of about 800 to 1,000 feet near TAFB may pass through the good-quality water and encounter brackish or salty water that underlies the fresh-water zone.

The potential for contamination of the Garber-Wellington aquifer is clear and immediate. Inasmuch as the recharge area is being developed more and more by urban expansion, industrial growth, and petroleum exploration, there is an ever-increasing likelihood that contaminants will accidentally be placed within or upon some parts of the recharge area. If contaminants are in liquid form, or if a leachate can be generated from the contaminant, then contaminated fluids may percolate into the permeable sandstone layers, migrate downward to the zone of saturation, and eventually disseminate through a portion of the aquifer. Fractures, boreholes, or other openings that penetrate the base of the Hennessey may enable rapid migration of contaminants downward into the Garber-Wellington aquifer. Such may be the case with the detection of contamination in TAFB wells 18 and 19, as mentioned in the report by Radian Corporation (1984).

Data presented by Wickersham (1979) indicate that in 1976 the ground water in the upper part of the Garber-Wellington would flow toward the west and northwest across TAFB (Figure 3). Water in the upper part of the aquifer that might emerge as springs after passing under TAFB would most likely be emitted along the banks or tributaries to Crutcho Creek to the northwest, or perhaps the North Canadian River, some 5 to 8 miles northwest of parts of TAFB. Therefore, most of the surface waters or ground waters that could be contaminated by leachate from the disposal sites existing on TAFB apparently would flow northwestward to Crutcho Creek, and eventally to the North Canadian River. Leachate from landfill 6 and perhaps from industrial-waste pit 2, in the extreme southeast part of TAFB, apparently would flow southward into the tributaries that enter Stanley Draper Lake, a major municipal water supply located about one mile south of landfills 2 and 6.

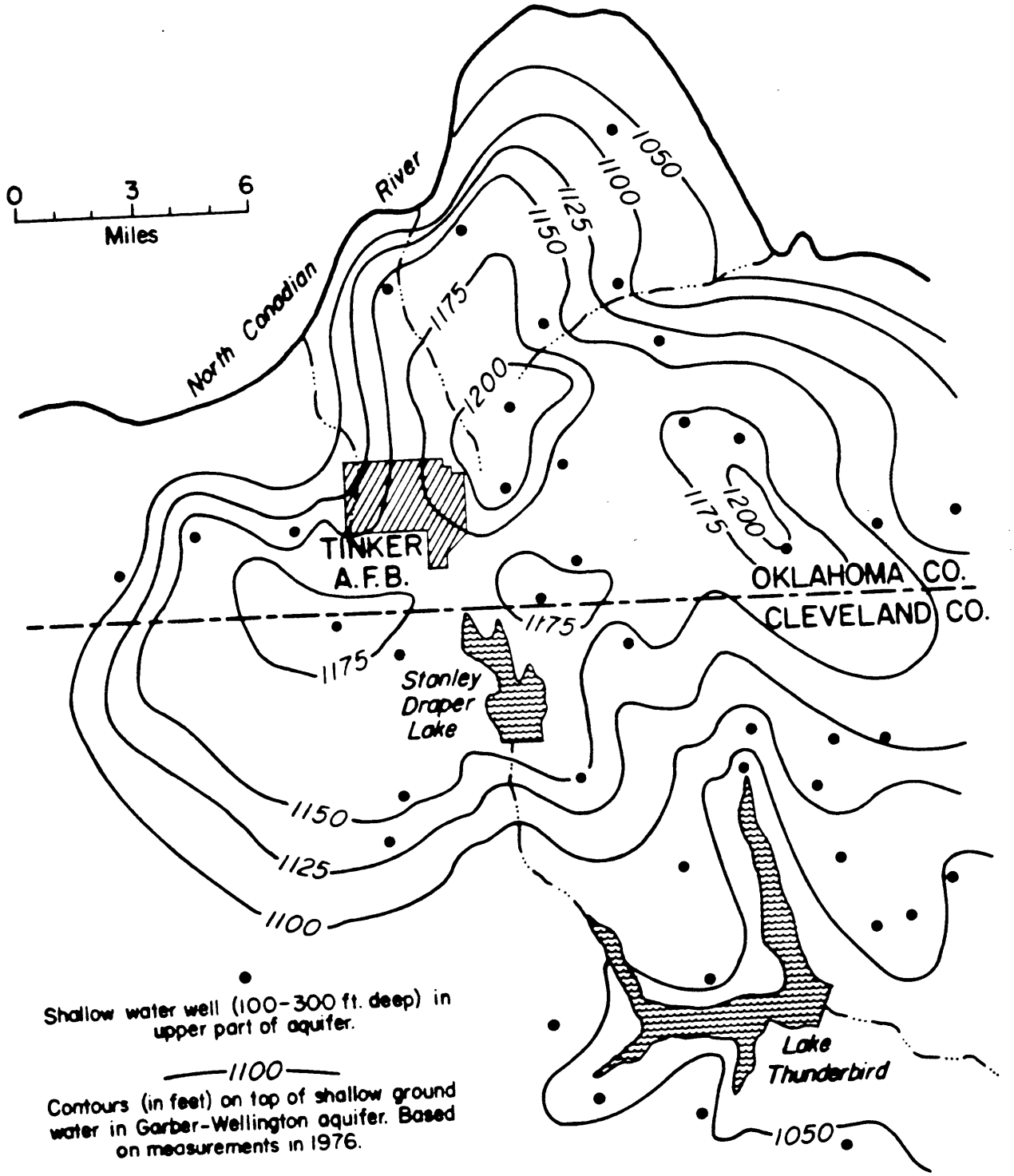


Figure 3. Elevation of ground-water surface in upper parts of Garber-Wellington aquifer in the vicinity of Tinker Air Force Base. Modified from Wickersham (1979).

Contamination from Waste-Disposal Sites

Shales and clays are generally the most desirable rock units for geologic containment of waste materials (Johnson and others, 1980). Most shales and clays, when wet, have more soil-like rather than rock-like properties, and they consist chiefly of clay minerals, such as illite, montmorillonite, chlorite, and kaolinite, that generally have the ability to absorb metals and other ions. Owing to their low permeabilities, shales and clays also have the property of retarding the lateral and/or vertical migration of leachates and other fluids.

As illustrated in Figure 4, leachate from an improperly sited or constructed waste-disposal site can filter laterally or downward to the water table, where it can then cause contamination of ground water, water wells, ponds, and streams. Although the bedrock at TAFB consists mainly of shales of the Hennessey Group, the fact that there is only some 10 to 50 feet of shale overlying a major ground-water aquifer requires extreme care in the siting, construction, maintenance, closure, and monitoring of waste-disposal facilities operated in such a setting.

Comments Concerning Studies Done to Date

The major concern regarding the study done at TAFB (Radian Corporation, 1984) is that there are inadequate data concerning the detailed hydrogeology of the area to enable characterizing ground-water flow and to monitor actual or potential contamination of the ground water from the waste-disposal sites. The work by Wickersham (1979) is regional in scope, and no additional water-well data within one mile of TAFB have been included in the current study in order to determine more accurately the ground-water flow directions. Such data are essential in order to plan the location of monitoring wells around the various waste-disposal sites at TAFB. For instance, the water table in wells drilled by Radian on the south side of TAFB is typically 1,200 to 1,260 feet above sea level (Radian Corporation, 1984, Figure 2-5), whereas the earlier data by

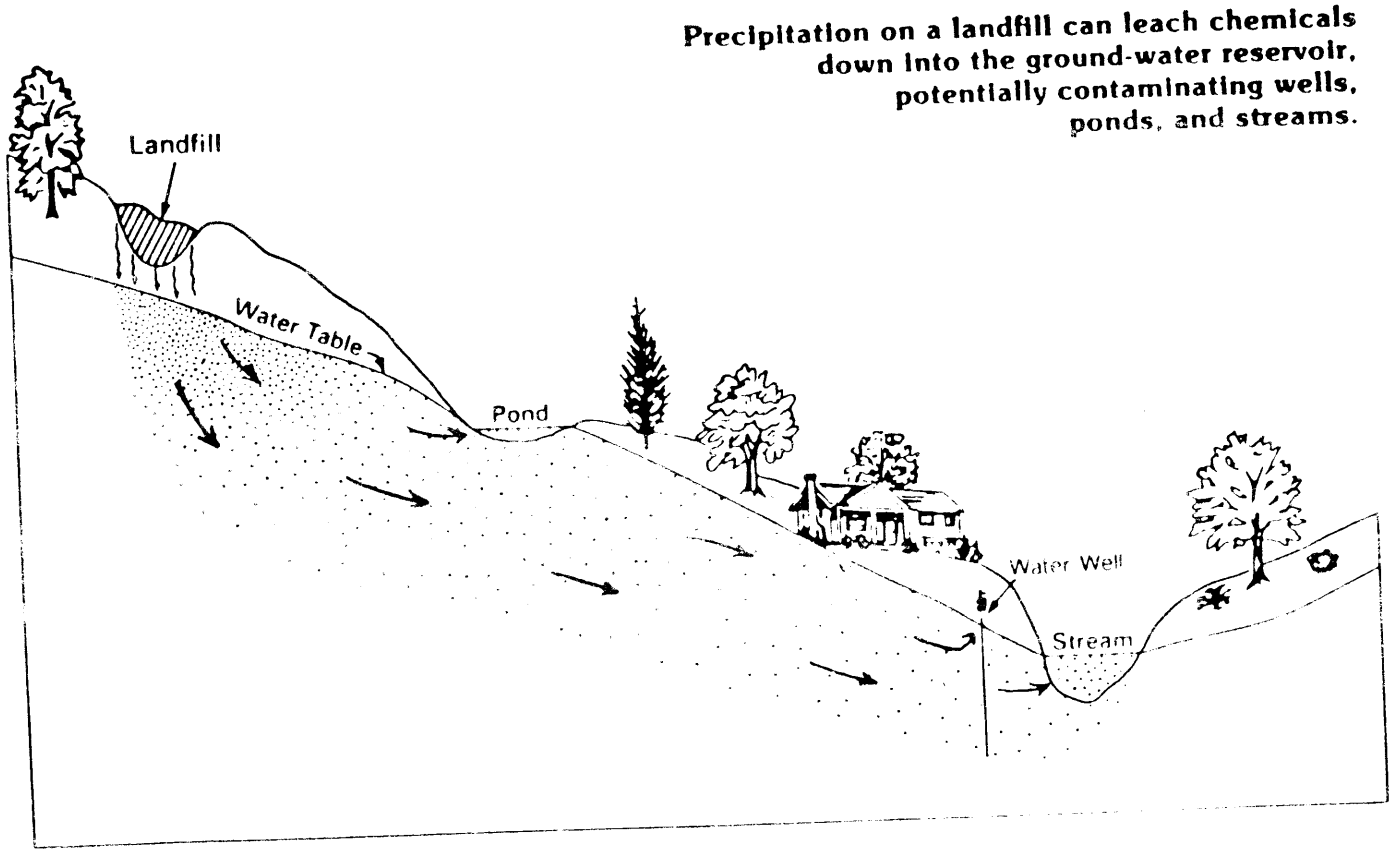


Figure 4. In various parts of the country, rain and snow on a landfill may carry dissolved substances downward, delivering pollutants to the ground water. The degree of hazard depends on the geology of the site, design of the landfill, and character of the wastes. Modified from American Institute of Professional Geologists (1984).

Wickersham (1979) indicate the water table in that area should be between 1,150 and 1,175 feet above sea level. These new data obtained by Radian need to be reconciled with the earlier data of Wickersham.

The sandstone beds in the Garber-Wellington aquifer at TAFB are irregular in terms of both their thickness and their distribution, and there are inadequate borehole data to enable characterizing the location and distribution of the principal water-bearing zones. Such data are needed in order to determine the likely pathways for rapid ground-water flow that might carry leachate from a waste-disposal site to other parts of the aquifer. An understanding of the distribution, thickness, permeability, and continuity of these principal water-bearing zones, and the pathways to them, is needed to set up an adequate monitoring-well program for the various waste-disposal sites.

The presence of trichloroethylene (TCE) in 2 wells (wells 18 and 19) in the vicinity of Building 3001 could be a very serious problem. There are insufficient data available on the hydrogeology of the area to enable determination of the source of TCE, the migration path of TCE to the two boreholes, the depth to the contaminated zone in the boreholes, the extent of contamination, and whether the aquifer in that area is permanently damaged and/or contaminated.

In summary, the lack of adequate detailed hydrogeologic data for the TAFB area, and the positioning of monitoring wells without such data, makes me uncertain as to what the long-term effect of the waste-disposal sites will be on the local environment, and particularly upon the Garber-Wellington aquifer.

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Carr, J. E., and Marcher, M. V., 1977, A preliminary appraisal of the Garber-Wellington aquifer, southern Logan and northern Oklahoma Counties, Oklahoma: U.S. Geological Survey Open-File Report 77-278, 23 p.

Johnson, K. S., 1983, Maps showing principal ground-water resources and recharge areas in Oklahoma: Oklahoma State Department of Health, 2 sheets, scale 1:500,000.

Johnson, K. S., Luza, K. V., and Roberts, J. F., 1980, Disposal of industrial wastes in Oklahoma: Oklahoma Geological Survey Circular 80, 82 p.

Miser, H. D., and others, 1954, Geologic map of Oklahoma: U.S. Geological Survey and Oklahoma Geological Survey, scale 1:500,000.

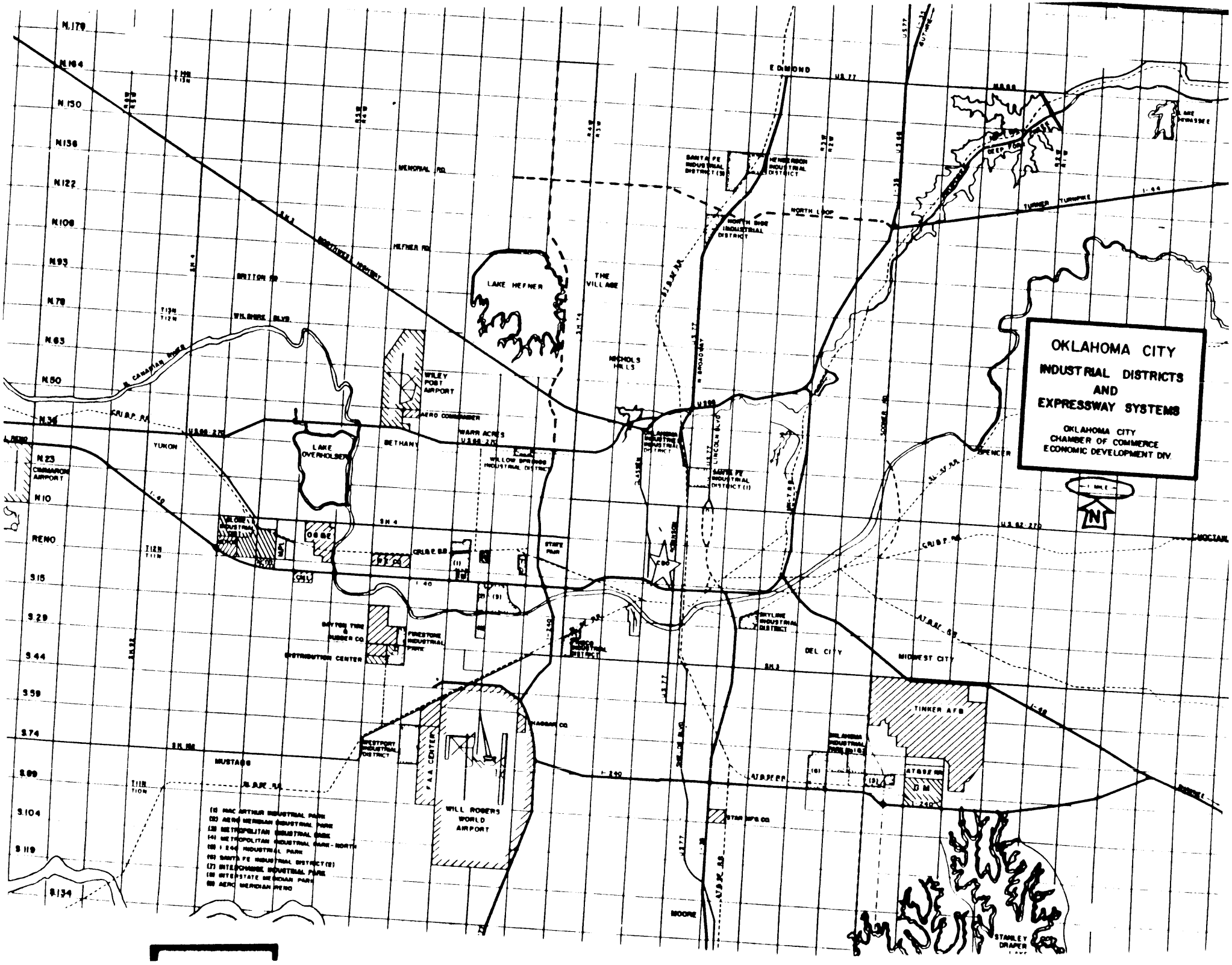
Radian Corporation, 1984, Installation Restoration Program, phase IIB field evaluation, Tinker AFB, Oklahoma: Draft Report, June 1984, prepared for U.S. Air Force Occupational and Environmental Health Laboratory, Brooks AFB, Texas.

Wickersham, Ginia, 1979, Ground-water resources of the southern part of the Garber-Wellington ground-water basin, in Cleveland and southern Oklahoma Counties and parts of Pottawatomie County, Oklahoma: Oklahoma Water Resources Board Hydrologic Investigations Pub. 85, 3 sheets, scale 1:250,000.

Wood, P. R., and Burton, L. C., 1968, Ground-water resources in Cleveland and Oklahoma Counties, Oklahoma: Oklahoma Geological Survey Circ. 71, 75 p.

Reference #12

Map: Oklahoma City Industrial Districts and Expressway Systems.
Oklahoma City Chamber of Commerce, Economic Development Division


OKLAHOMA CITY
INDUSTRIAL DISTRICTS
AND
EXPRESSWAY SYSTEMS
OKLAHOMA CITY
CHAMBER OF COMMERCE
ECONOMIC DEVELOPMENT DIV.
N
EDMOND
MEMORIAL RD.
HEFNER RD.
BRITTAIN RD.
WILSHIRE BLVD.
LAKE HEFNER
THE VILLAGE
NICHOLS HILLS
WILEY POST AIRPORT
AERO COMMANDER
WARR ACRES
BETHANY
YUKON
LAKE OVERHOLSER
CIMARRON AIRPORT
RENO
MUSTANG
WILL ROGERS WORLD AIRPORT
FAA CENTER
DISTRIBUTION CENTER
FIRESTONE INDUSTRIAL PARK
STATE FAIR
DEL CITY
MIDWEST CITY
TINKER AFB
SPENCER
MOORE
STANLEY DRAPER
(1) MAC ARTHUR INDUSTRIAL PARK
(2) AERO MERIDIAN INDUSTRIAL PARK
(3) METROPOLITAN INDUSTRIAL PARK
(4) METROPOLITAN INDUSTRIAL PARK - NORTH
(5) I 240 INDUSTRIAL PARK
(6) SANTA FE INDUSTRIAL DISTRICT (2)
(7) INTERCHANGE INDUSTRIAL PARK
(8) INTERSTATE MERIDIAN PARK
(9) AERO MERIDIAN RENO

Reference #13
Analytical Results, Wells 6A through 6G, 1984. Transmitted by WM Little, Radian Corp, to Cpt. R.W. Bauer, Tinker AFB. 8/8/84 and 9/13/84

RADIAN
CORPORATION

212-027-21-01

13 September 1984

CPT Robart W. Bauer
USAF OEHL/TS
Brooks AFB, Texas 78235

REF: USAF/RC Contract F33615-83-D-4001, Delivery Order 0021,
Tinker AFB IRP Phase II Stage 2

Dear CPT Bauer:

Enclosed are the analytical results of the GC-MS analyses (EPA Methods 624 and 625) of ground-water samples from Tinker AFB. The EPA 601 (GC) results have been forwarded separately. A sketch map of well locations is also provided.

Please call me if you have any questions.

Sincerely,

William M. Little

William M. Little
Project Director

WML:sg

cc: (w/Encl)
COL Russell, HQ, AFLC
CPT Cornell, Tinker AFB

Enclosures (a/s)

8501 Mo-Pac Blvd. / P.O. Box 9948 / Austin, Texas 78766 / (512)454-4797

RADIAN
CORPORATION

212-027-21-01

13 September 1984

CPT Robert W. Bauer
USAF OEHL/TS
Brooks AFB, Texas 78235

REF: USAF/RC Contract F33615-83-D-4001, Delivery Order 0021,
Tinker AFB IRP Phase II Stage 2

Dear CPT Bauer:

Enclosed are the balance of the analytical results from the ground-water sampling at Tinker AFB. A sketch map of well locations is also provided. Note that a second-column confirmation step was performed for many samples. The GC-MS results for these samples have been forwarded separately.

Please call me if you have any questions.

Sincerely,

William M. Little

William M. Little
Project Director

WML:sg

cc: (w/Encl)
COL Russell, HQ, AFLC
CPT Cornell, Tinker AFB

Enclosures (a/s)

8501 Mo-Pac Blvd / P.O Box 9948 / Austin, Texas 78766 / (512)454-4797

RADIAN
CORPORATION

212-027-21

9 August 1984

CPT Robart W. Bauer
USAF OEHL/TS
Brooks AFB, Texas 78235

REF: USAF/RC Contract F33615-83-D-4001, Delivery Order 0021,
Tinker AFB IRP Phase II Stage 2

Dear CPT Bauer:

Enclosed are partial analytical results from the first round of ground-water sampling at Tinker AFB. A sketch map of well locations is also provided. Note that a second-column confirmation step was performed for all samples. The GC-MS results for these samples will be forwarded as soon as they are available.

Please call me if you have any questions.

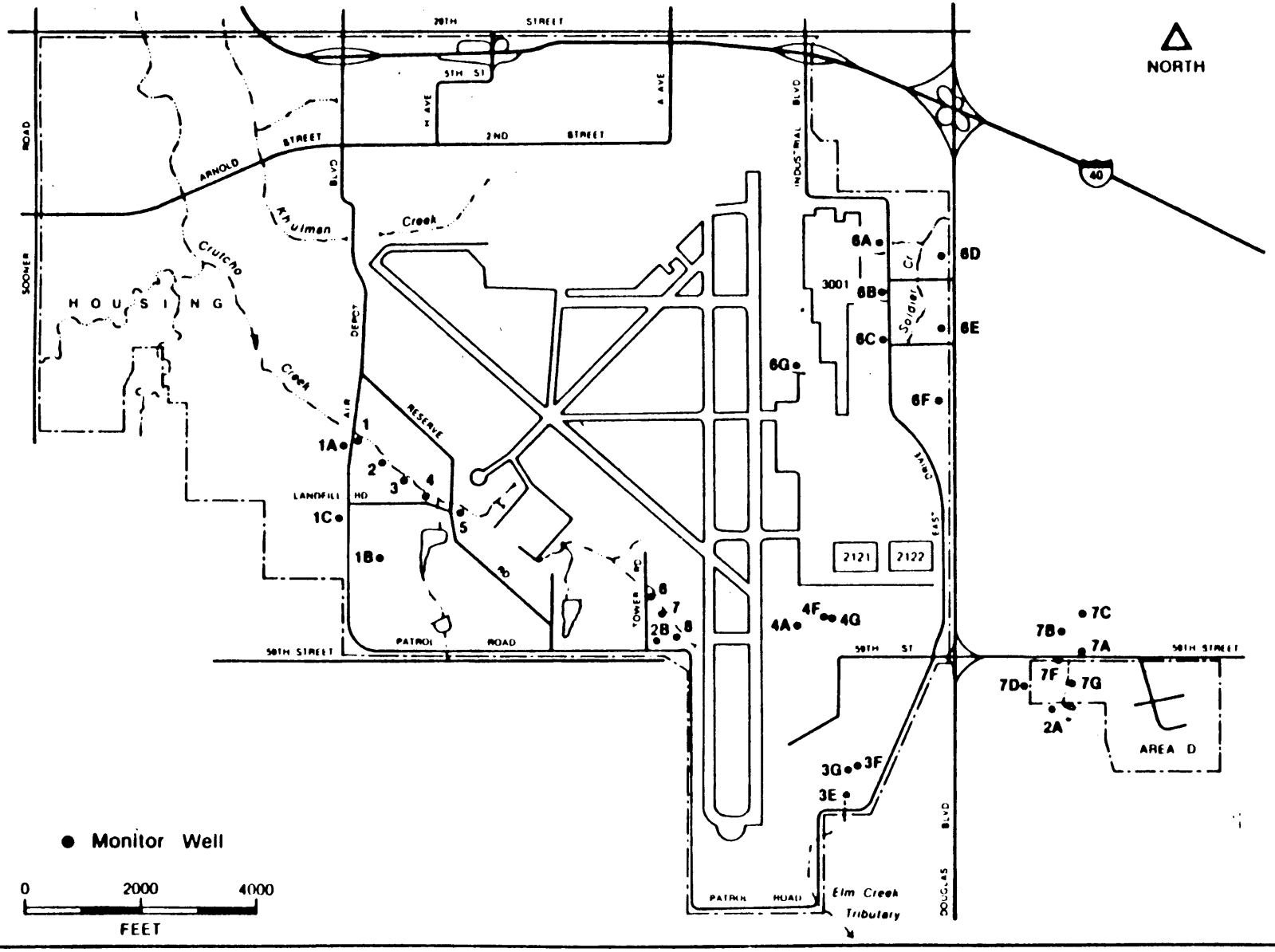
Sincerely,

William M. Little

William M. Little
Project Director

WML:sg
cc: (w/Encl): COL Russell, HQ, AFLC
CPT Cornell, Tinker AFB

8500 Shoal Creek Blvd. / P.O. Box 9948 / Austin, Texas 78766 / (512)454-4797



Monitor Well Locations - Tinker AFB.

CORPORATION

AGE 1 Analytical Serv ORK ORDER LAB # 84-07-131

IENT: TINKER CON: CONOVER CAT: DO_21 RCVD: 07/23/84 DUE: 08/06/84

PROJ: GROUP #0 07/27/84 09:13:48 STAT: TRANSMITTED 07/24/84

OMPANY Tinker AFB
FACIL

REP William Little
PHONE Radian

ORK ID USAF, Well Water
TAKEN 7/18/84, Nancy Stein
TRANS federal express
TYPE H2O

REPORT Radian
TO Bl 4
Austin

ATTEN William Little

NVOICE Accounting
TO Radian
Austin
Building 6
ATTEN David Browning
P.O. # 212-027-21-05

	TRANSMIT	REPORTED	INVOICED	TOTAL $
PREV	07/24/84			
FIRST				

ORK ORDER COMMENTS

INVOICE BY R
% SURCHARGE
% DISC: ALL
TEST/JOB
REP/INV 3 3

SAMPLES 6
KEEP FOR 60
KEEP TIL 10/05/84 07 16
DISP D

QUOTED $ 3605.00
SAMPLE $ 4000.00 11 5
MISC $
TOTAL $ 3605.00
INV #

CREATED 07/24/84
WRITTEN 07/27/84
TRANSMIT 07/24/84
COMPLETE
REPORTED
INVOICED

DEPTS/ TESTS		DASH	SAMPLE IDENTIFICATION	JOB
		Q1A	6A	
		Q1B	6A	
		Q1C	6A	
		Q2A	6B	
		Q2B	6B	
		Q2C	6B	
		Q3A	6C	
		Q3B	6C	
		Q3C	6C	
		Q4A	7G	
		Q4B	7G	
		Q4C	7G	
		Q5A	14F	
		Q5B	14F	
		Q5C	14F	
		Q6A	Trip Blank	

5/6 7F

624 | 625

CORPORATION

PAGE 5 Analytical Serv WORK ORDER LAB # 84-07-131

CLIENT: TINKER CON: CONOVER CAT: DO_21 RCVD: 07/23/84 DUE: 08/06/84

PROJ: GROUP #0 FRACTION DESCRIPTIONS STAT: TRANSMITTED 07/24/84

DASH #06A ID Trip Blank 07/24/84 STORED Sac-VOA JOB

CATEGORY WHEN COLLECTED 07-MS 624

SAMPLE AND WORK DESCRIPTION

RECEIVED: 07/23/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-131
Continued From Above

SAMPLE ID 6A

FRACTION 01B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 624, (Federal Register, 12/3/79).

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RECEIVED: 07/23/84

Analytical Serv REPORT LAB # 84-07-131
Results by Sample

SAMPLE ID 6A FRACTION 01B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

DATA FILE 4CU07131V01 DATE INJECTED 07/25/84 ANALYST BWS VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT #4 COMPOUNDS DETECTED 1

NPDES	SCAN	EPA	COMPOUND	RESULT	NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND	17V		32V	1,2-dichloropropane	ND
2V		3V	acrylonitrile	ND	18V		33V	cis-1,3-dichloropropylene	ND
3V		4V	benzene	ND	18V		33V	trans-1,3-dichloropropylene	ND
6V		6V	carbon tetrachloride	ND	19V		38V	ethylbenzene	ND
7V		7V	chlorobenzene	ND	22V		44V	methylene chloride	ND
15V		10V	1,2-dichloroethane	ND	21V		45V	methyl chloride	ND
27V		11V	1,1,1-trichloroethane	ND	20V		46V	methyl bromide	ND
14V		13V	1,1-dichloroethane	ND	5V		47V	bromoform	ND
28V		14V	1,1,2-trichloroethane	ND	12V		48V	dichlorobromomethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND	30V		49V	trichlorofluoromethane	ND
9V		16V	chloroethane	ND	13V		50V	dichlorodifluoromethane	ND
4V		17V	bis (chloromethyl) ether	ND	8V		51V	chlorodibromomethane	ND
10V		19V	2-chloroethylvinyl ether	ND	24V		85V	tetrachloroethylene	ND
11V		23V	chloroform	ND	25V		86V	toluene	ND
16V		29V	1,1-dichloroethylene	ND	29V	313	87V	trichloroethylene	779
26V		30V	1,2-trans-dichloroethylene	ND	31V		88V	vinyl chloride	ND

Analytical Serv EPORT

LAB # 84-07-112

CEIVED: 07/20/84

Results by Sample

Continued From Above

MPLE ID 6A

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

TES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

b3

Analytical Serv REPORT LAB # 84-07-112

CEIVED: 07/20/84

Results by Sample

MPLE ID 6A FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/25/84 ANALYST RGS MCL VERIFIED BY JSG

NC. FACTOR 1 INSTRUMENT b COMPOUNDS DETECTED 9

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	1.2
2	1,1-Dichloroethene	1.7
3	1,1-Dichloroethane	1.4
4	trans-1,2-Dichloroethene	18.1
	Chloroform	ND
5	1,2-Dichloroethane	2.6
6	1,1,1-Trichloroethane	4.2
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
7	1,2-Dichloropropane	0.3
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
8	Trichloroethene	642
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
9	Tetrachloroethylene *	4.7
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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RECEIVED: 08/02/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-020
Continued From Above

SAMPLE ID 6A

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2 tetrachloroethane and tetrachloroethylene co-elute.

PAGE 2
RECEIVED: 08/02/84

Analytical Serv REPORT LAB # 84-08-020
Results by Sample

SAMPLE ID 6A FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE A DATE INJECTED 08/09/84 ANALYST RAM VERIFIED BY JSG
CONC. FACTOR: INSTRUMENT a COMPOUNDS DETECTED 9

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
1	Methylene Chloride	1.4
	Trichlorofluoromethane	ND
2	1,1-Dichloroethene	0.8
3	1,1-Dichloroethane	1.3
	trans-1,2-Dichloroethene	ND
4	Chloroform	9.9
5	1,2-Dichloroethane	2.0
6	1,1,1-Trichloroethane	2.5
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
7	1,2-Dichloropropane	0.2
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
8	Trichloroethene	444
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
9	1,1,2,2-Tetrachloroethane #	2.7
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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Analytical Serv REPORT

LAB # 84-07-112

CEIVED: 07/20/84

Results by Sample

Continued From Above

MPLE ID 6B

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

OTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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E 4
EIVED: 07/20/84

Analytical Serv REPORT LAB # 84-07-112
Results by Sample

PLE ID 6B FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/25/84 ANALYST RGS VERIFIED BY JSG
C. FACTOR INSTRUMENT b COMPOUNDS DETECTED 9

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
1	Methylene Chloride	0.9
2	Trichlorofluoromethane	2.7
	1,1-Dichloroethene	ND
3	1,1-Dichloroethane	1.4
4	trans-1,2-Dichloroethene	33.2
	Chloroform	ND
	1,2-Dichloroethane	ND
5	1,1,1-Trichloroethane	0.2
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
6	Trichloroethene	102
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
7	Tetrachloroethylene *	1.7
8	Chlorobenzene	1.3
	1,3-Dichlorobenzene	ND
9	1,2-Dichlorobenzene	1.1
	1,4-Dichlorobenzene	ND

HC

RECEIVED: 08/02/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-020
Continued From Above

SAMPLE ID 6B

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601. (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/02/84

Analytical Serv REPORT LAB # 84-08-020
Results by Sample

SAMPLE ID 6B FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST RAM VERIFIED BY JSC
CONC. FACTOR INSTRUMENT b COMPOUNDS DETECTED 2

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
1	Chloroform	19 b
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
2	Trichloroethene	52 B
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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RECEIVED: 07/23/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-131
Continued From Above

SAMPLE ID 6B

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 624. (Federal Register, 12/3/79).

ECEIVED: 07/23/84

Analytical Serv REPORT LAB # 84-07-131

Results by Sample

AMPLE ID 6B

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS

Date & Time Collected 07/18/84 Category

DATA FILE 4CU07131V02 DATE INJECTED 07/25/84 ANALYST BWS VERIFIED BY LAK

DNC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 2

PDES	SCAN	EPA	COMPOUND	RESULT	NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND	17V		32V	1,2-dichloropropane	ND
2V		3V	acrylonitrile	ND	18V		33V	cis-1,3-dichloropropylene	ND
3V		4V	benzene	ND	18V		33V	trans-1,3-dichloropropylene	ND
6V		6V	carbon tetrachloride	ND	19V		38V	ethylbenzene	ND
7V		7V	chlorobenzene	ND	22V		44V	methylene chloride	ND
15V		10V	1,2-dichloroethane	ND	21V		45V	methyl chloride	ND
27V		11V	1,1,1-trichloroethane	ND	20V		46V	methyl bromide	ND
14V		13V	1,1-dichloroethane	ND	5V		47V	bromoform	ND
28V		14V	1,1,2-trichloroethane	ND	12V		48V	dichlorobromomethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND	30V		49V	trichlorofluoromethane	ND
9V		16V	chloroethane	ND	13V		50V	dichlorodifluoromethane	ND
4V		17V	bis (chloromethyl) ether	ND	8V		51V	chlorodibromomethane	ND
10V		19V	2-chloroethylvinyl ether	ND	24V		85V	tetrachloroethylene	ND
11V		23V	chloroform	ND	25V		86V	toluene	ND
16V		29V	1,1-dichloroethylene	ND	29V	316	87V	trichloroethylene	134 ug/l
26V	214	30V	1,2-trans-dichloroethylene	48	31V		88V	vinyl chloride	ND

Analytical Serv REPORT

LAB # 84-07-112

CEIVED: 07/20/84

Results by Sample

Continued From Above

MPLE ID 6C

FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

TES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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E 6
EIVED: 07/20/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-112

PLE ID 6C

FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/26/84 ANALYST RGS VERIFIED BY JSG
IC. FACTOR 1 INSTRUMENT b COMPOUNDS DETECTED 7

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	3.9
	1,1-Dichloroethene	ND
2	1,1-Dichloroethane	0.3
3	trans-1,2-Dichloroethene	2.9
4	Chloroform	0.7
	1,2-Dichloroethane	ND
5	1,1,1-Trichloroethane	106
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
6	Trichloroethene	4.9
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
7	Tetrachloroethylene *	0.7
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

08

RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-003
Continued From Above

SAMPLE ID 0

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram
All results reported in ug/L unless otherwise specified
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-003

Results by Sample

SAMPLE ID :

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/08/84 ANALYST MCL VERIFIED BY JSG

CONC FACTOR: INSTRUMENT b COMPOUNDS DETECTED 6

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	0.4
	1,1-Dichloroethene	ND
2	1,1-Dichloroethane	0.2
	trans-1,2-Dichloroethene	ND
3	Chloroform	1.6
4	1,2-Dichloroethane	0.3
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
5	Trichloroethene	3.1
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
6	Tetrachloroethylene #	0.2
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

8B

RECEIVED: 07/23/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-131
Continued From Above

SAMPLE ID 6C

FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 624. (Federal Register, 12/3/79).

RECEIVED: 07/23/84

Analytical Serv REPORT LAB # 84-07-131
Results by Sample

SAMPLE ID 6C

FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

DATA FILE 4CV07131V03 DATE INJECTED 07/23/84 ANALYST BWB VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 0

NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND
2V		3V	acrylonitrile	ND
3V		4V	benzene	ND
6V		6V	carbon tetrachloride	ND
7V		7V	chlorobenzene	ND
15V		10V	1,2-dichloroethane	ND
27V		11V	1,1,1-trichloroethane	ND
14V		13V	1,1-dichloroethane	ND
28V		14V	1,1,2-trichloroethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND
9V		16V	chloroethane	ND
4V		17V	bis (chloromethyl) ether	ND
10V		19V	2-chloroethylvinyl ether	ND
11V		23V	chloroform	ND
16V		29V	1,1-dichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND

NPDES	SCAN	EPA	COMPOUND	RESULT
17V		32V	1,2-dichloropropane	ND
18V		33V	cis-1,3-dichloropropylene	ND
18V		33V	trans-1,3-dichloropropylene	ND
19V		38V	ethylbenzene	ND
22V		44V	methylene chloride	ND
21V		45V	methyl chloride	ND
20V		46V	methyl bromide	ND
5V		47V	bromoform	ND
12V		48V	dichlorobromomethane	ND
30V		49V	trichlorofluoromethane	ND
13V		50V	dichlorodifluoromethane	ND
8V		51V	chlorodibromomethane	ND
24V		85V	tetrachloroethylene	ND
25V		86V	toluene	ND
29V		87V	trichloroethylene	ND
31V		88V	vinyl chloride	ND

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E 3 Analytical Serv ..EPORT LAB # 84-07-090
EIVED: 07/18/84 Results by Sample Continued From Above

IPLE ID 6D FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

'ES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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CEIVED: 07/18/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-090

MPLE ID 6D

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/24/84 ANALYST RGS VERIFIED BY JSG
NC. FACTOR INSTRUMENT 6 COMPOUNDS DETECTED 7

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
1	Methylene Chloride	2.0
2	Trichlorofluoromethane	1.8
	1,1-Dichloroethene	ND
3	1,1-Dichloroethane	1.7
4	trans-1,2-Dichloroethene	0.4
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
5	Trichloroethene	0.6
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
	Tetrachloroethylene *	ND
6	Chlorobenzene	20.5
	1,3-Dichlorobenzene	ND
7	1,2-Dichlorobenzene	8.4
	1,4-Dichlorobenzene	ND

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Analytical Serv REPORT

LAB # 84-08-003

RECEIVED: 08/01/84

Results by Sample

Continued From Above

SAMPLE ID (s) FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND - not detected at EPA detection limit method 601, (Federal Register, 12/3/79)
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-003
Results by Sample

SAMPLE ID 4P FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE b DATE INJECTED 08/08/84 ANALYST MGL VERIFIED BY JSG
CONC FACTOR INSTRUMENT b COMPOUNDS DETECTED 4

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	22.0
8	1,1-Dichloroethene	2.0
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2 Dichloropropane	ND
	trans-1,3 Dichloropropene	ND

SCAN	COMPOUND	RESULT
	Trichloroethene	ND
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
3	Chlorobenzene	21.8
	1,3-Dichlorobenzene	ND
4	1,2-Dichlorobenzene	11.0
	1,4-Dichlorobenzene	ND

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RECEIVED: 06/02/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-020
Continued From Above

SAMPLE ID 6D

FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601. (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/02/84

Analytical Serv REPORT LAB # 84-08-020
Results by Sample

SAMPLE ID 6D FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST MCL VERIFIED BY JSG
CONC FACTOR INSTRUMENT b COMPOUNDS DETECTED 5

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
1	1,1-Dichloroethane	1.8
	trans-1,2-Dichloroethene	ND
2	Chloroform	0.8
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
3	Trichloroethene	0.5
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
4	Chlorobenzene	34.5
	1,3-Dichlorobenzene	ND
5	1,2-Dichlorobenzene	10.3
	1,4-Dichlorobenzene	ND

RECEIVED: 07/18/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-093
Continued From Above

SAMPLE ID 6D

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/17/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN - scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND - not detected at EPA detection limit method 624. (Federal Register, 12/3/79).

RECEIVED: 07/18/84

Analytical Serv REPORT LAB # 84-07-093
Results by Sample

SAMPLE ID 6D

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/17/84 Category

DATA FILE 4CU07093V02 DATE INJECTED 07/25/84 ANALYST BWS VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 1

NPDES	SCAN	EPA	COMPOUND	RESULT	NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND	17V		32V	1,2-dichloropropane	ND
2V		3V	acrylonitrile	ND	18V		33V	cis-1,3-dichloropropylene	ND
3V		4V	benzene	ND	18V		33V	trans-1,3-dichloropropylene	ND
6V		6V	carbon tetrachloride	ND	19V		38V	ethylbenzene	ND
7V	481	7V	chlorobenzene	21	22V		44V	methylene chloride	ND
15V		10V	1,2-dichloroethane	ND	21V		45V	methyl chloride	ND
27V		11V	1,1,1-trichloroethane	ND	20V		46V	methyl bromide	ND
14V		13V	1,1-dichloroethane	ND	5V		47V	bromoform	ND
28V		14V	1,1,2-trichloroethane	ND	12V		48V	dichlorobromomethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND	30V		49V	trichlorofluoromethane	ND
9V		16V	chloroethane	ND	13V		50V	dichlorodifluoromethane	ND
4V		17V	bis (chloromethyl) ether	ND	8V		51V	chlorodibromomethane	ND
10V		19V	2-chloroethylvinyl ether	ND	24V		85V	tetrachloroethylene	ND
11V		23V	chloroform	ND	25V		86V	toluene	ND
16V		29V	1,1-dichloroethylene	ND	29V		87V	trichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND	31V		88V	vinyl chloride	ND

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RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-013
Continued From Above

SAMPLE ID 6D

FRACTION 01B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/31/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624. (Federal Register, 12/3/79).

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RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-013
Results by Sample

SAMPLE ID 6D

FRACTION 01B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/31/84 Category

DATA FILE 4CV08013V01 DATE INJECTED 08/02/84 ANALYST BWS VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT #4 COMPOUNDS DETECTED 1

NPDES	SCAN	EPA	COMPOUND	RESULT	NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND	17V		32V	1,2-dichloropropane	ND
2V		3V	acrylonitrile	ND	18V		33V	cis-1,3-dichloropropylene	ND
3V		4V	benzene	ND	18V		33V	trans-1,3-dichloropropylene	ND
6V		6V	carbon tetrachloride	ND	19V		38V	ethylbenzene	ND
7V	472	7V	chlorobenzene	30	22V		44V	methylene chloride	ND
15V		10V	1,2-dichloroethane	ND	21V		45V	methyl chloride	ND
27V		11V	1,1,1-trichloroethane	ND	20V		46V	methyl bromide	ND
14V		13V	1,1-dichloroethane	ND	5V		47V	bromoform	ND
28V		14V	1,1,2-trichloroethane	ND	12V		48V	dichlorobromomethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND	30V		49V	trichlorofluoromethane	ND
9V		16V	chloroethane	ND	13V		50V	dichlorodifluoromethane	ND
4V		17V	bis (chloromethyl) ether	ND	8V		51V	chlorodibromomethane	ND
10V		19V	2-chloroethylvinyl ether	ND	24V		85V	tetrachloroethylene	ND
11V		23V	chloroform	ND	25V		86V	toluene	ND
16V		29V	1,1-dichloroethylene	ND	29V		87V	trichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND	31V		88V	vinyl chloride	ND

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Analytical Serv REPORT

LAB # 84-08-003

RECEIVED 08/01/84

Results by Sample

Continued From Above

SAMPLE ID 8F

FRACTION Q4A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN -- scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND -- not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute

RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-003
Results by Sample

SAMPLE ID 01 FRACTION 04A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST MCL VERIFIED BY JSG
CONC FACTOR INSTRUMENT b COMPOUNDS DETECTED 0

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
	Trichloroethene	ND
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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[redacted]

RECEIVED: 08/16/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-167
Continued From Above

SAMPLE ID 6E

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601. (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/16/84

Analytical Serv REPORT LAB # 84-08-167
Results by Sample

SAMPLE ID 6E

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE A DATE INJECTED 08/23/84 ANALYST MCL VERIFIED BY JSG
CONC. FACTOR INSTRUMENT A COMPOUNDS DETECTED 0

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
	Trichloroethene	ND
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
	Tetrachloroethylene *	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-013
Continued From Above

SAMPLE ID 6E

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/30/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624. (Federal Register. 12/3/79).

RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-013

Results by Sample

SAMPLE ID 6E

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS

Date & Time Collected 07/30/84 Category

DATA FILE 4CU08013V02 DATE INJECTED 08/02/84 ANALYST BWS VERIFIED BY LAK

CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 1

NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND
2V		3V	acrylonitrile	ND
3V		4V	benzene	ND
6V		6V	carbon tetrachloride	ND
7V		7V	chlorobenzene	ND
15V		10V	1,2-dichloroethane	ND
27V		11V	1,1,1-trichloroethane	ND
14V		13V	1,1-dichloroethane	ND
28V		14V	1,1,2-trichloroethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND
9V		16V	chloroethane	ND
4V		17V	bis (chloromethyl) ether	ND
10V		19V	2-chloroethylvinyl ether	ND
11V		23V	chloroform	ND
16V		29V	1,1-dichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND
17V		32V	1,2-dichloropropane	ND
18V		33V	cis-1,3-dichloropropylene	ND
18V		33V	trans-1,3-dichloropropylene	ND
19V		38V	ethylbenzene	ND
22V		44V	methylene chloride	ND
21V		45V	methyl chloride	ND
20V		46V	methyl bromide	ND
5V		47V	bromoform	ND
12V		48V	dichlorobromomethane	ND
30V		49V	trichlorofluoromethane	ND
13V		50V	dichlorodifluoromethane	ND
8V		51V	chlorodibromomethane	ND
24V		85V	tetrachloroethylene	ND
25V	453	86V	toluene	61
29V		87V	trichloroethylene	ND
31V		88V	vinyl chloride	ND

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 Analytical Serv REPORT LAB # 84-08-003
RECEIVED: 08/01/84 Results by Sample Continued From Above

SAMPLE ID 6F FRACTION 05A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram
All results reported in ug/L unless otherwise specified
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
#Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-003
Results by Sample

SAMPLE ID 6F

FRACTION 05A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST MCL VERIFIED BY JSG
CONC FACTOR 1 INSTRUMENT 6 COMPOUNDS DETECTED 2

SCAN	COMPOUND	RESULT	SCAN	COMPOUND	RESULT
	Chloromethane	ND	2	Trichloroethene	0.1
	Bromomethane	ND		Dibromochloromethane *	ND
	Vinyl Chloride	ND		1,1,2-Trichloroethane *	ND
	Chloroethane	ND		cis-1,3-Dichloropropene *	ND
	Methylene Chloride	ND		2-Chloroethylvinyl Ether	ND
1	Trichlorofluoromethane	0.5		Bromoform	ND
	1,1-Dichloroethene	ND		1,1,2,2-Tetrachloroethane #	ND
	1,1-Dichloroethane	ND		Tetrachloroethylene #	ND
	trans-1,2-Dichloroethene	ND		Chlorobenzene	ND
	Chloroform	ND		1,3-Dichlorobenzene	ND
	1,2-Dichloroethane	ND		1,2-Dichlorobenzene	ND
	1,1,1-Trichloroethane	ND		1,4-Dichlorobenzene	ND
	Carbon Tetrachloride	ND			
	Bromodichloromethane	ND			
	1,2 Dichloropropane	ND			
	trans-1,3-Dichloropropene	ND			

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RECEIVED: 08/16/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-167
Continued From Above

SAMPLE ID 6F

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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RECEIVED: 08/16/84

Analytical Serv REPORT LAB # 84-08-167
Results by Sample

SAMPLE ID 6F FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE A DATE INJECTED 08/23/84 ANALYST MCL VERIFIED BY JSG
CONC. FACTOR INSTRUMENT A COMPOUNDS DETECTED 0

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
	Trichloroethene	ND
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
	Tetrachloroethylene *	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-013
Continued From Above

SAMPLE ID 6F

FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/30/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624, (Federal Register, 12/3/79).

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RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-013

Results by Sample

SAMPLE ID 6F

FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS

Date & Time Collected 07/30/84 Category

DATA FILE 4CU08013V03 DATE INJECTED 08/02/84 ANALYST BWB VERIFIED BY LAK

CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 0

NPDES	SCAN	EPA	COMPOUND	RESULT	NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND	17V		32V	1,2-dichloropropane	ND
2V		3V	acrylonitrile	ND	18V		33V	cis-1,3-dichloropropylene	ND
3V		4V	benzene	ND	18V		33V	trans-1,3-dichloropropylene	ND
6V		6V	carbon tetrachloride	ND	19V		38V	ethylbenzene	ND
7V		7V	chlorobenzene	ND	22V		44V	methylene chloride	ND
15V		10V	1,2-dichloroethane	ND	21V		45V	methyl chloride	ND
27V		11V	1,1,1-trichloroethane	ND	20V		46V	methyl bromide	ND
14V		13V	1,1-dichloroethane	ND	5V		47V	bromoform	ND
28V		14V	1,1,2-trichloroethane	ND	12V		48V	dichlorobromomethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND	30V		49V	trichlorofluoromethane	ND
9V		16V	chloroethane	ND	13V		50V	dichlorodifluoromethane	ND
4V		17V	bis (chloromethyl) ether	ND	8V		51V	chlorodibromomethane	ND
10V		19V	2-chloroethylvinyl ether	ND	24V		85V	tetrachloroethylene	ND
11V		23V	chloroform	ND	25V		86V	toluene	ND
16V		29V	1,1-dichloroethylene	ND	29V		87V	trichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND	31V		88V	vinyl chloride	ND

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Analytical Serv REPORT
Results by Sample

LAB # 84-07-090
Continued From Above

AMPLE ID 6G

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

IOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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GE 4
CEIVED: 07/18/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-090

MPLE ID 6G

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/25/84 ANALYST RGS VERIFIED BY JSG
INC. FACTOR INSTRUMENT b COMPOUNDS DETECTED 6

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
1	Chloroethane	1.1
2	Methylene Chloride	1.9
3	Trichlorofluoromethane	7.6
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
4	Chloroform	4.6
5	1,2-Dichloroethane	4.9
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
6	Trichloroethene	1.3
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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RECEIVED 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-003
Continued From Above

SAMPLE ID 06 FRACTION 06A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
#bromodichloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2 tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-003
Results by Sample

SAMPLE ID 06

FRACTION 06A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST MCL VERIFIED BY JSG
CONC. FACTOR INSTRUMENT 6 COMPOUNDS DETECTED 3

SCAN	COMPOUND	RESULT	SCAN	COMPOUND	RESULT
	Chloromethane	ND	3	Trichloroethene	0.9
	Bromomethane	ND		Dibromochloromethane *	ND
	Vinyl Chloride	ND		1,1,2-Trichloroethane *	ND
	Chloroethane	ND		cis-1,3-Dichloropropene *	ND
	Methylene Chloride	ND		2-Chloroethylvinyl Ether	ND
1	Trichlorofluoromethane	1.7		Bromoform	ND
	1,1-Dichloroethene	ND		1,1,2,2-Tetrachloroethane #	ND
	1,1-Dichloroethane	ND		Tetrachloroethylene #	ND
	trans-1,2-Dichloroethene	ND		Chlorobenzene	ND
	Chloroform	3.8		1,3-Dichlorobenzene	ND
	1,2-Dichloroethane	ND		1,2-Dichlorobenzene	ND
	1,1,1-Trichloroethane	ND		1,4-Dichlorobenzene	ND
	Carbon Tetrachloride	ND			
	Bromodichloromethane	ND			
	1,2-Dichloropropane	ND			
	trans-1,3-Dichloropropene	ND			

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RECEIVED: 08/02/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-020
Continued From Above

SAMPLE ID GG

FRACTION 04A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN -- scan number or retention time on chromatogram
all results reported in ug/l unless otherwise specified
ND -- not detected at EPA detection limit method 601, (Federal Register, 12/3/79)
#Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/02/84

Analytical Serv REPORT LAB # 84-08-020
Results by Sample

SAMPLE ID 6G

FRACTION 04A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE 6 DATE INJECTED 08/09/84 ANALYST MCL VERIFIED BY JSG
CONC. FACTOR INSTRUMENT 3 COMPOUNDS DETECTED 4

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
1	Chloroethane	0.6
2	Methylene Chloride	0.6
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
3	Chloroform	1.6
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND
4	Trichloroethene	0.6
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
	Tetrachloroethylene *	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-013
Continued From Above

SAMPLE ID 6G

FRACTION 04B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/30/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624. (Federal Register. 12/3/79).

RECEIVED: 07/18/84

Analytical Serv REPORT LAB # 84-07-093
Results by Sample

SAMPLE ID 6G, Bldg 3001 FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/16/84 Category

DATA FILE 4CU07093V03 DATE INJECTED 07/25/84 ANALYST BWS VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 3

NPDES	SCAN	EPA	COMPOUND	RESULT	NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND	17V		32V	1,2-dichloropropane	ND
2V		3V	acrylonitrile	ND	18V		33V	cis-1,3-dichloropropylene	ND
3V	336	4V	benzene	47	18V		33V	trans-1,3-dichloropropylene	ND
6V		6V	carbon tetrachloride	ND	19V		38V	ethylbenzene	ND
7V		7V	chlorobenzene	ND	22V	127	44V	methylene chloride	21
15V		10V	1,2-dichloroethane	ND	21V		45V	methyl chloride	ND
27V		11V	1,1,1-trichloroethane	ND	20V		46V	methyl bromide	ND
14V		13V	1,1-dichloroethane	ND	5V		47V	bromoform	ND
28V		14V	1,1,2-trichloroethane	ND	12V		48V	dichlorobromomethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND	30V		49V	trichlorofluoromethane	ND
9V		16V	chloroethane	ND	13V		50V	dichlorodifluoromethane	ND
4V		17V	bis (chloromethyl) ether	ND	8V		51V	chlorodibromomethane	ND
10V		19V	2-chloroethylvinyl ether	ND	24V		85V	tetrachloroethylene	ND
11V		23V	chloroform	ND	25V	455	86V	toluene	670
16V		29V	1,1-dichloroethylene	ND	29V		87V	trichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND	31V		88V	vinyl chloride	ND

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Reference #14
Record of Communication: Drew Puffer, USEPA to WM Little,
Radian Corp. 1/8/85

RECORD OF COMMUNICATION	☑ PHONE CALL ☐ DISCUSSION ☐ FIELD TRIP ☐ CONFERENCE ☐ OTHER (SPECIFY) (Record of item checked above)
TO: William Little, Radian Corp., Austin TX	FROM: Drew Puffer
	DATE: 1/8/85
	TIME: 1:50

SUBJECT: Tinker AFB IRP

SUMMARY OF COMMUNICATION

I called Mr. Little in reference to the Tinker AFB monitor well sampling that took place in the summer of 1984.

Mr. Little confirmed that field blanks had been taken during the sampling effort that included monitor wells 6A through 6G. Mr. Little also confirmed that those blanks did not register any contaminants

CONCLUSIONS, ACTION TAKEN OR REQUIRED

INFORMATION COPIES TO:

EPA Form 1320-6 (7-77) REPLACES EPA FORM [illegible] WHICH MAY BE USED UNTIL SUPPLY IS EXHAUSTED.

Reference #15
Analytical Results, Well 16. Transmitted by E.A. Jeffrey, USEPA to Cpt. D.R. Escoriaza, Tinker AFB on 30 Aug. 1982

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

30 AUG 1982

Captain Douglas R. Escoriaza
Bio-Sanitary Engineer
Bio-Medical Services Corp, USAF
Tinker Air Force Base
Oklahoma City, OK 73145

Dear Captain Escoriaza:

I am forwarding the analytical results of the VOC analyses performed on the six samples collected at various points at Tinker Air Force Base during April 1982. Small amounts of THM's were found at Well No. 7, and small amounts of cis/trans-1,2-dichloroethylene, trichloroethylene, and tetrachloroethylene were found in Well No. 16. The latter concentrations are very similar to those found in the initial sample collected in March 1981. I am wondering if Well No. 16 was also the location of the March 1981 sample. Can you confirm this?

These concentrations are low and are of no immediate health concern. Their mere presence in the water, however, should cause concern. If you can determine the source would you please let me know.

Sincerely yours,

Edgar A. Jeffrey, P.E.
State Program Manager
Public Water Supply Section

Enclosures

cc: Mike Harrell, w/enclosures

bcc: Official Files, 6WSP
Branch Reading Files, 6WS
Reading Files, 6WSP

Jeffrey 8/30/82

6WSP:JEFFREY:az:X1762:08/30/82

CONCURRENCES

SOL	6WSP							
SURNAME	GRAHAM							
DATE	8/26/82							

OFFICIAL FILE COPY

EPA Form 1320-1 (12-70)

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GRC WATER SUPPLY SURVEY RESAMPLE DATASHEET

SAMPLE SITE: TINKER AFB
WELL #16 - BLDG 862505
OKLAHOMA CITY OK
ATTN: MAJ. MCELWEY

SAMPLE NO: 2641-36 SAMPLING DATE: 04 19 82
PWS NO:

EPA Health Advisory

PARAMETERS	RESULTS (UG/L)	
CHLOROFORM	<0.2	
BROMODICHLOROMETHANE	<0.2	
DIBROMOCHLOROMETHANE	<0.5	
BROMOFORM	<1.0	
DICHLOROIODOMETHANE	<1.0	
VINYL CHLORIDE	<1.0	
1,1-DICHLOROETHYLENE	<0.2	
1,1-DICHLOROETHANE	<0.2	
CIS- AND/OR TRANS-1,2-DICHLOROETHYLENE	2.1 ✓	70 µg/l long term
1,2-DICHLOROETHANE	<0.5	
1,1,1-TRICHLOROETHANE	<0.2	
CARBON TETRACHLORIDE	<0.2	
1,2-DICHLOROPROPANE	<0.2	
TRICHLOROETHYLENE	4.2 ✓	80 µg/l long term
1,1,2-TRICHLOROETHANE	<0.5	
1,1,1,2-TETRACHLOROETHANE	<0.2	
TETRACHLOROETHYLENE	0.61 ✓	20 µg/l long term
1,1,2,2-TETRACHLOROETHANE	<0.5	
CHLOROBENZENE	<0.5	
1,2-DIBROMO-3-CHLOROPROPANE	<5.0	
BENZENE	<0.5	
TOLUENE	<0.5	
ETHYLBENZENE	<0.5	
BROMOBENZENE	<0.5	
ISOPROPYLBENZENE	<0.5	
M-XYLENE	<0.2	
STYRENE	<0.5	
O- + P-XYLENE	<0.2	
N-PROPYLBENZENE	<0.5	
O-CHLOROTOLUENE	<0.5	
P-CHLOROTOLUENE	<0.5	
M-DICHLOROBENZENE	<0.5	
O-DICHLOROBENZENE	<0.5	
P-DICHLOROBENZENE	<0.5	

< MINIMUM QUANTIFIABLE LIMITS

Reference #16
Letter: David W. McElway, Major, USAF to E.A. Jeffrey, USEPA
30 Sept. 1982

DEPARTMENT OF THE AIR FORCE
USAF HOSPITAL, TINKER (AFLC)
TINKER AIR FORCE BASE, OKLAHOMA 73145

30 SEP 1982

REPLY TO ATTN OF: SGB (Capt Cornell/7844)

SUBJECT: Tinker AFB Well Water-Halogenated Compound Contamination

TO: Edgar A. Jeffrey
Public Water Supply Section
U. S. Environmental Protection Agency, Region VI
1201 Elm
Dallas, Texas 75270

1. The analysis of well waters collected in March 1981 and April 1982 do not present significant problems to Tinker AFB. The 1981 sample was taken from the water works laboratory on base while it's companion 1982 sample was obtained from well number 16-located about 400 feet northwest. The 1982 well samples averaged about 30% less and had significantly less toulene and TOC than those taken from the laboratory in 1981 (see attached sheet).

2. Well number 7-which contained the trihalomethanes - is located 900 feet southeast from the pesticide storage and mixing area and is downgradient from the Oklahoma 507TAC Maintenance Operations.

3. We plan to sample well 7 and adjacent well 6 in addition to taking surface stream samples during the next months to insure that chlorinated hydrocarbon levels are not increasing significantly.

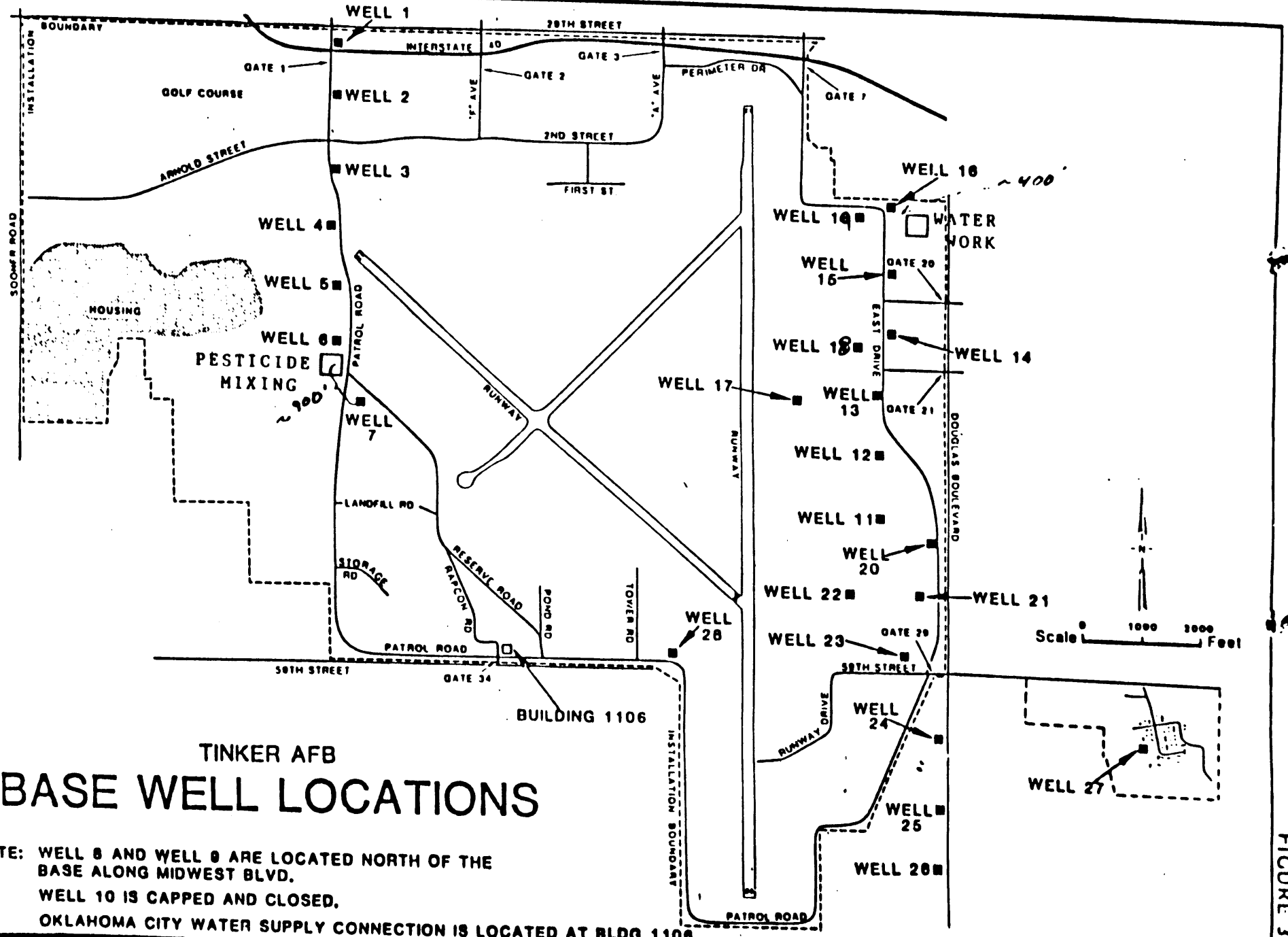
D.W. McElwey

DAVID W. McELWEY, MAJOR, USAF, BSC
Chief, Bioenvironmental Engineering Division

1 Atch: Base Well Locations
Copy to: 2854CES/DEEX

RECEIVED
OCT 04 1982
EPA GAWS
REGION VI

AFLC - Lifeline of the Aerospace Team



TINKER AFB

BASE WELL LOCATIONS

NOTE: WELL 8 AND WELL 9 ARE LOCATED NORTH OF THE BASE ALONG MIDWEST BLVD.
WELL 10 IS CAPPED AND CLOSED.
OKLAHOMA CITY WATER SUPPLY CONNECTION IS LOCATED AT BLDG 1106.

SOURCE: TINKER AFB DOCUMENTS

FIGURE 3.1

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Reference #17
Analytical Results from Ground Water Supply Study. Transmitted by Ed. Jeffrey, USEPA, to Mike Harrell. 3/2/82

Date 3/282

ROUTING AND TRANSMITTAL SLIP

TO: (Name, office symbol, room number, building, Agency/Post)	Initials	Date
Mike Harrell		
2.		
3.		
4.		
5.		

	Action		File		Note and Return
	Approval		For Clearance		Per Conversation
	As Requested		For Correction		Prepare Reply
	Circulate		For Your Information		See Me
	Comment		Investigate		Signature
	Coordination		Justify		

REMARKS

I am enclosing analytical results of samples collected during the Ground Water Supply Study conducted by EPA during the spring and summer of 1981. Only Tinker AFB had results greater than detectable limits (except for trace of toluene in Woodward). Per our phone conversation, I have contacted Capt. Excoriaza at Tinker to arrange for resamplin there. Enclosed is a copy of guidance prepared by Headquarters for responding to inquires about dected con-
rations. If you have any questions call me. +e

Tinker, El Reno, USDA SW LvStck, Vance, Moore, Perkins, Roger Mills RWS, Altus, Woodward

DO NOT use this form as a RECORD of approvals, concurrences, disposals, clearances, and similar actions

FROM: (Name, org. symbol, Agency/Post)	Room No.—Bldg.
Ed Jeffrey EJ	Phone No.

5041-102

OPTIONAL FORM 41 (Rev. 7-76)
Prescribed by GSA
FPMR (41 CFR) 101-11.206

* GPO : 1980 O - 311-116 (34)

GROUND WATER SUP
SAMPLE SITE: WOODWARD WATER
WOODWARD
ATTN:
SAMPLE NO: 0226-36-04
PWS NO: 2007701
POPULATION SERVED: 999
TOTAL PRODUCTION (MGD): 991
POSITIVE PARAMETERS

TOLUENE

GROUND WATER SUP
SAMPLE SITE: TINKER AFB
OKLAHOMA CITY
ATTN: DAVID
SAMPLE NO: 0601-36-04
PWS NO:
POPULATION SERVED: 18000.
TOTAL PRODUCTION (MGD): 5.1
POSITIVE PARAMETERS

CIS- AND/OR TRANS-1,2-DICHLOR
TRICHLOROETHYLENE
TETRACHLOROETHYLENE
TOLUENE

RECEIVED

MAR 01 1982

EPA 6AWS
REGION VI

GROUND WATER SUPPLY SURVEY DATASHEET

SAMPLE SITE: WOODWARD WATER

WOODWARD OK
ATTN:

SAMPLE NO: 0226-36-04 SAMPLING DATE: 07 19 81
PWS NO: 2007701
POPULATION SERVED: $$$ NUMBER OF WELLS: $$$
TOTAL PRODUCTION (MGD): $$$ NO. OF WELLS SAMPLED: $$$

POSITIVE PARAMETERS	RESULTS (UG/L)
TOLUENE	2.40

GROUND WATER SUPPLY SURVEY DATASHEET

SAMPLE SITE: TINKER AFB

OKLAHOMA CITY OK 73145
ATTN: DAVID BURRIS

SAMPLE NO: 0641-36-04 SAMPLING DATE: 03 18 81
PWS NO:
POPULATION SERVED: 18000. NUMBER OF WELLS: 27.
TOTAL PRODUCTION (MGD): 5.1 NO. OF WELLS SAMPLED: 1.

POSITIVE PARAMETERS	RESULTS (UG/L)
CIS- AND/OR TRANS-1,2-DICHLOROETHYLENE	2.70
TRICHLOROETHYLENE	5.60
TETRACHLOROETHYLENE	1.10
TOLUENE	1.50

10^{-6} 10^{-6}

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GROUND WATER SUPPLY SURVEY DATASHEET

SAMPLE SITE: TINKER AFB

OKLAHOMA CITY OK 73145
ATTN: DAVID BURRIS

SAMPLE NO: 0641-36-04 SAMPLING DATE: 03 18 81
PWS NO:
POPULATION SERVED: 18000. NUMBER OF WELLS: 27.
TOTAL PRODUCTION (MGD): 5.1 NO. OF WELLS SAMPLED: 1.

PARAMETERS	RESULTS (UG/L)
CHLOROFORM	<0.2
BROMODICHLOROMETHANE	<0.2
DIBROMOCHLOROMETHANE	<0.5
BROMOFORM	<1.0
DICHLOROIODOMETHANE	<1.0
VINYL CHLORIDE	<1.0
1,1-DICHLOROETHYLENE	<0.2
1,1-DICHLOROETHANE	<0.2
CIS- AND/OR TRANS-1,2-DICHLOROETHYLENE	2.7
1,2-DICHLOROETHANE	<0.5
1,1,1-TRICHLOROETHANE	<0.2
CARBON TETRACHLORIDE	<0.2
1,2-DICHLOROPROPANE	<0.2
TRICHLOROETHYLENE	5.6
1,1,2-TRICHLOROETHANE	<0.5
1,1,1,2-TETRACHLOROETHANE	<0.2
TETRACHLOROETHYLENE	1.1
1,1,2,2-TETRACHLOROETHANE	<0.5
CHLOROBENZENE	<0.5
1,2-DIBROMO-3-CHLOROPROPANE	<5.0
BENZENE	<0.5
TOLUENE	1.5
ETHYLBENZENE	<0.5
BROMOBENZENE	<0.5
ISOPROPYLBENZENE	<0.5
M-XYLENE	<0.2
STYRENE	<0.5
O- + P-XYLENE	<0.2
N-PROPYLBENZENE	<0.5
O-CHLOROTOLUENE	<0.5
P-CHLOROTOLUENE	<0.5
M-DICHLOROBENZENE	<0.5
O-DICHLOROBENZENE	<0.5
P-DICHLOROBENZENE	<0.5
TOC@	1.1
FREE CHLORINE@	<0.1
TOTAL CHLORINE@	<0.1

< MINIMUM QUANTIFIABLE LIMITS
@ THESE VALUES ARE IN MG/L

Reference #18
Groundwater Supply Survey, by J.J. Westrick et al., Journal AWWA, pages 52-59, May 1964

The Groundwater Supply Survey

James J. Westrick, J. Wayne Mello, and Robert F. Thomas

The results of the US Environmental Protection Agency, Office of Drinking Water, sampling and analysis of volatile organic compounds (VOCs) in finished water supplies that use groundwater sources are discussed. Concentrations of 29 VOCs in addition to five trihalomethanes and total organic carbon from 945 water supplies were measured. The five most frequently found compounds other than trihalomethanes were trichloroethylene, 1,1,1-trichloroethane, tetrachloroethylene, cis- and/or trans-1,2-dichloroethylene, and 1,1-dichloroethane. Approximately half of the samples were taken from a random list of water systems, which were subdivided into two sets of systems—those serving fewer than 10 000 persons and those serving more than 10 000 persons. The nonrandom samples were taken from systems selected by the states, using groundwater sources that were likely to show VOCs in drinking water. Large systems in the random sample had a significantly higher frequency of occurrence of VOC contamination than small systems and were also more likely to have higher levels of contamination.

Volatile organic compounds (VOCs) are a general category of synthetic organic chemicals that include low-molecular-weight, volatile aliphatic and aromatic hydrocarbons, many of which are halogenated. Their presence in groundwater supplies has been reported with increasing frequency. To supplement existing data on the occurrence of VOCs in drinking water for purposes of developing regulatory alternatives,[1] the US Environmental Protection Agency (USEPA), Office of Drinking Water (ODW), Technical Support Division (TSD), Cincinnati, Ohio, conducted a sampling and analysis program in 1981 and 1982. The objectives were: (1) to provide additional data for estimating the nationwide occurrence of VOCs in drinking water supplied from underground sources, and (2) to collect information about the physical characteristics of the well fields and the surrounding areas to develop a predictive capability for locating contaminated groundwater. Only the occurrence data are discussed here.

The survey consisted of two parts. Half of the sampling and analytical program developed data from a random sample of groundwater supplies obtained from the inventory of public water systems maintained in the Federal Reporting Data System (FRDS), from which 500 supplies were selected. Two subsets were developed: 300 of the systems serve fewer than 10 000 persons and 200 of the systems serve more than 10 000 persons. A second randomly selected two-part list provided replacement sampling sites for cases in which the supplies on the primary list of 500 were inappropriate or nonexistent. This occurred if, for example, a utility had recently begun to purchase its water from another utility that uses a surface water source.

Prior data on the occurrence of VOCs were gathered from samples collected from groundwater systems during the Community Water Supply Survey (CWSS) of 1978.[2] These data were used to estimate the necessary sizes of the samples. During the 1978 survey, the frequency of occurrence of the 10 VOCs for which analyses were conducted among the 300 groundwater systems serving fewer than 10 000 persons was 12 percent of the systems. Of the 29 groundwater systems that serve more than 10 000 persons, 45 percent contained at least one VOC. Using these occurrence frequencies as estimates of what might be found in the new survey, it was determined that sampling 300 small systems and 200 large systems would provide 95 percent confidence limits of ±30 percent and ±15 percent for the estimates of frequencies of occurrence for the small systems and large systems, respectively.

The second part of the survey was used to encourage state agencies to try to identify problem supplies. The purpose of this portion of the survey was not only to expand state involvement but also to provide ODW with some information on the frequency and extent of serious problems, based on the state agency's knowledge of local conditions. Each state was assigned a number of sampling sites roughly proportional to its fraction of the total number of groundwater systems nationwide; this was designated the nonrandom sample. The target number of nonrandom sites was also 500. The state agencies were encouraged to select supplies that might be contaminated by VOCs because of the proximity of the well field to industries, landfills, or other potential sources of contamination. The state agencies were also encouraged to choose water supplies for which no VOC data were available in an effort to discover previously unknown instances of contamination.

General procedures

To obtain information from a maximum number of systems that use groundwater sources, one sample of finished water from each utility was collected at a point near the entrance to the distribution system. The VOC concentrations in water supplied from a single well that is not pumped continuously can vary depending on the pumping rate, the schedule, and the hydrodynamics of the plume of contamination. If multiple wells supply a system at a single entry point and some wells are contaminated whereas others are not, the VOC concentrations in the sample at the entry point could vary greatly, depending on which wells were in operation at the time of sampling. In systems with more than one entry point, a single sample would obviously represent only those wells contributing to that entry point. With these limitations in mind, the sampling of finished water taken at or near a point of entry would provide a reasonable compromise between information obtained from a sample taken from a single well and that from multiple samples taken throughout the system.

State drinking water agencies played a major role in the planning and execution of this survey. Each state with primary public water system enforcement responsibility (primacy) was contacted through the regional USEPA drinking water offices. Most of the states indicated a willingness to assist in the project. State involvement consisted of reviewing the primary random list for errors or for inappropriate or nonexistent systems, filling in missing information on the randomly selected systems, selecting systems for inclusion in the nonrandom portion of the survey, and providing scheduling information to the TSD project engineer. In most cases state personnel traveled to the sampling sites, collected the samples and site information, and shipped the samples on ice to the TSD laboratory in Cincinnati, Ohio, using sampling supplies provided by TSD. In nonprimacy states and states that were unable to assist in the planning or the sampling because of budgetary or

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other constraints, regional USEPA personnel provided the necessary assistance. Personnel from the TSD collected some samples that were obtainable within reasonable driving distance from Cincinnati or if it was not possible for either state or regional USEPA personnel to travel to the sampling locations.

Logistics

A sampling kit was prepared at TSD for each sampling location. Amber bottles of 60 mL and 250-mL capacity were dosed with a preservative (10 mg mercuric chloride/L), capped with PTFE fluorocarbon-faced septa and screw caps, affixed with preprinted labels that had been stamped with the sample identification numbers, and secured in expanded polystyrene boxes. A shipping blank (a 250-mL bottle containing organic-free water and preservative) was also included with the sampling kit. The shipping blanks were to remain with the sampling kit through all stages of transportation and storage so that the possibility of contamination from the surroundings could be investigated by analyzing the shipping blank.

Samples were received at TSD the day after they were collected. They were unpacked and logged in, and any unusual circumstances were noted. The sample bottles were then placed in storage in a cold room, free of organic vapor contamination, until they were repacked for shipment to the chemical analysis contract laboratory.* Since replicate samples were collected at each site, half the bottles were shipped to the contract laboratory and half were held in cold storage at TSD. This was necessary for quality assurance analysis of duplicates by TSD chemists or for quick-response, in-house verification of the contract laboratory's results.

When the samples were shipped to the contract laboratory, the information was entered into the TSD data system for tracking purposes. Primary analysis of the samples was completed by the contractor within 30 days of collection. The contract laboratory had access to the TSD data system, so upon completion of the analyses for a sample, the data were entered at the contractor's terminal and retrieved by the TSD project engineer in Cincinnati. The results for each sample were examined by the TSD project officer and verified by agreement between the project officer and the contract laboratory project leader after review of quality assurance information. The verified data were then entered into a confirmed data file. Reports of verified data for each USEPA region were periodically distributed to the appropriate USEPA regional office. The regional office then distributed two copies of the data to each state, one of which was forwarded by the state to the utility.

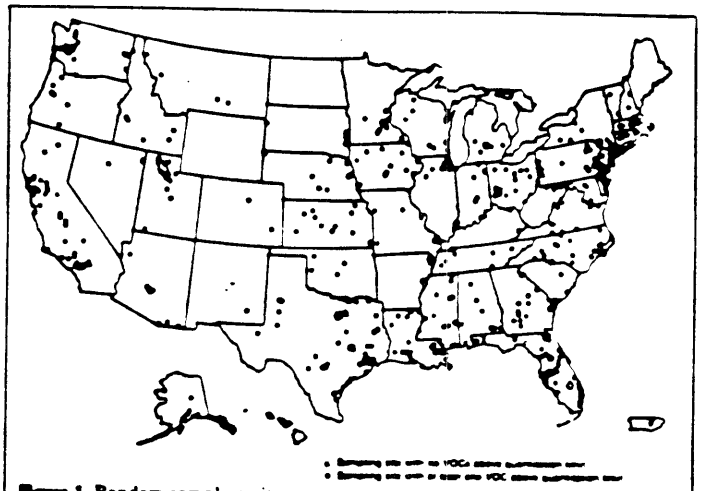

Figure 1. Random sampling sites

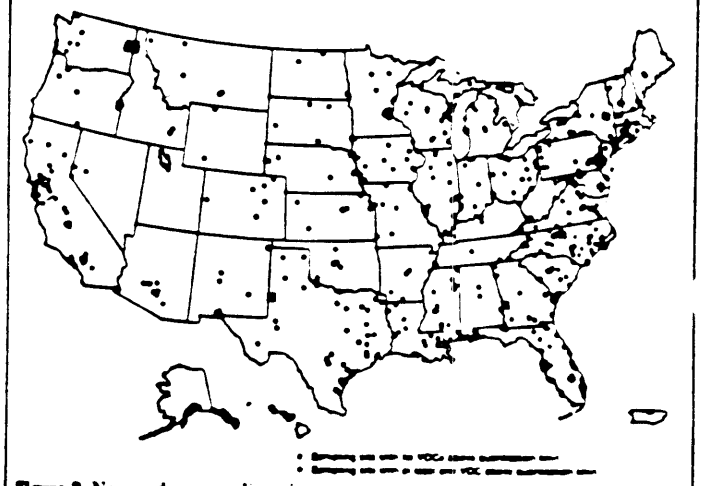

Figure 2. Nonrandom sampling sites

Analytical considerations

A total of 34 parameters were selected for analysis by purge-and-trap gas chromatographic methods (Table 1). However, the emphasis in this article is on the 29 VOCs other than the five trihalomethanes (THMs)—chloroform, bromodichloromethane, dibromochloromethane, dichloroiodomethane, and bromoform. The samples were not dosed with a reducing agent, so the THM formation reaction continued until the time of analysis or until the depletion of either residual chlorine or precursor material.

The two isomers of 1,2-dichloroethylene could not be separately determined by the analysis and thus are considered one parameter. The same is true for ortho- and paraxylenes. Methylene chloride originally was to be determined, but this compound is a widely used laboratory solvent and appears frequently as a laboratory contaminant. Because it was found in all the analyzed shipping blanks, it was impossible to ascertain whether the methylene chloride was originally present in a sample or had come from the surrounding atmosphere. Therefore, results for methylene chloride could not be validated.

The purge-and-trap gas chromatography (GC) analyses were conducted according to USEPA methods 502.1[4] and 503.1[5] with a significant modification. The nondestructive photoionization detector for analysis of aromatics and the

*[illegible] International, Inc., Menlo Park, Calif.

electrolytic conductivity detector for the analysis of halocarbons were coupled in series, allowing analysis for the complete list of 34 compounds with one sample purge. A comparability study conducted prior to the survey showed that serial analysis gave results equivalent to separate analyses for the two types of compounds. This technique proved beneficial in terms of the time and cost required for analysis. An additional benefit resulted from the acquisition of further information by using the two detectors in series. The photoionization detector can assist in identifying and quantifying compounds that coelute from the primary GC column or that have poor responses with the detector.

Quality assurance

When the contract for analytical services was written, a detailed quality assurance protocol was included for monitoring and maintaining the quality of data. This protocol was followed throughout the survey, and the validating data were continually scrutinized by the TSD project officer. Table 2 lists the quality assurances used.

USEPA reference samples. The precision and accuracy of analyses of the halocarbon and aromatic reference samples, which were analyzed weekly, met the quality assurance specifications. This was true for both the primary and confirmatory analytical schemes. The USEPA reference samples contained known concentrations of compounds, including the four common trihalomethanes and nine frequently found VOCs. The precision measure used was the coefficient of variation, the standard deviation of approximately 50 analyses divided by the mean of those values. The precision of the primary analysis of reference samples at levels below 5 μg/L averaged ±13 percent with a range of ±8 percent for tetrachloroethylene to ±22 percent for 1,1,1-trichloroethane. For reference samples containing levels of more than 5 μg/L, the precision ranged from ±6 percent for trichloroethylene to ±20 percent for 1,1,1-trichloroethane. There was an average precision of ±11 percent. Accuracy is indicated by the percent error, that is, the difference between the mean of the measured values and the expected (true) value divided by the expected value. This parameter ranged from 0 percent for tetrachloroethylene at 5.9 μg/L to −19 percent for dibromochloromethane at 2.1 μg/L, with averages of −9 percent below 5 μg/L and −4 percent above 5 μg/L. Negative error indicates that the mean of the measured values was less than the expected value.

Duplicate analyses. As another gauge of precision, the contract called for duplicate analyses to be performed on a minimum of 10 percent of the samples. The duplicates were to agree within 40 percent for compounds present at concentrations of less than 5 μg/L and within 20 percent at concentrations in excess of 5 μg/L. The precision measure used is the percent difference, i.e., 100 times the absolute difference in the duplicate values divided by the mean of the two values. Data were gathered on 16 individual compounds that were present collectively in the duplicate analyses. A total of 84 quantifiable results in concentrations of less than 5 μg/L were duplicated. All but five met the precision criterion. The average percent difference for the quantifiable low-level duplicate results was 17 percent. Eighteen quantifiable pairs of duplicate results in concentrations in excess of 5 μg/L were reported, with four of the 18 falling outside the precision limits. The average precision of the 18 pairs of samples with higher concentrations was 13 percent.

Confirmatory analyses. All samples found or suspected to contain VOCs other than THMs were reanalyzed by using different chromatographic columns that elute the compounds in different orders. In addition, samples containing chloroform at concentrations in excess of 40 μg/L were reanalyzed by using the confirmatory column since chloroform at this level of concentration could mask small quantities of 1,2-dichloroethane. Approximately 33 percent of all samples were reanalyzed by second column chromatography for halocarbons and 6 percent for aromatics. Precision and accuracy of the analyses of the 19 USEPA reference samples for halocarbons and 11 USEPA reference samples for aromatics were documented. All accuracy values were within the contract limits for the primary analyses, and the precision values for all but two of the compounds fell within the error limits of the primary analysis. In addition, approximately 5 percent of all the samples were reanalyzed by gas chromatography-mass spectrometry for additional confirmation and tentative identification of unknown peaks.

Blind samples. Five blind samples were prepared by TSD in the initial phase of the survey to ascertain the contractor's ability to identify particular compounds qualitatively and to measure them quantitatively. The blinds consisted of five different mixtures of compounds, spiked into organic-free distilled water. These were periodically sent to the contractor early in the survey period disguised as survey samples. The mixtures were designed to pose selected anomalies in the analytical system, such as interferences or compounds with similar gas chromatographic retention times. Prior to shipment, the blinds were analyzed by TSD, and these results were compared with those subsequently reported by the contractor. In every case, the contractor correctly identified the spiked compounds. Although no quantitative criteria were established for the blind samples, the percent differences between the contractor's results and TSD-determined concentrations were within the error limits for duplicates for 27 of 32 pairs of values.

TSD analysis of duplicate samples. Replicate samples were collected in separate bottles and stored at TSD so they could be analyzed as an additional check on the contractor's laboratory results. The check samples to be analyzed by TSD were chosen from those that the contractor had reported to contain one or more of the VOCs. The percent differences between the contractor's results and those of TSD were within the error limits for 48 of the 64 pairs of values in excess of the quantitation limits. The error limits used are those established for a single laboratory conducting duplicate analyses of the same sample. Large percent differences were expected for this comparison since the analyses were done on duplicate samples and analyzed by independent systems. Also, the duplicate samples often contained several compounds at widely varying concentrations, from less than 1 μg/L to more than 100 μg/L.

The quality assurance program was a critical part of the analysis. It consumed a significant portion of the analytical resources and required considerable time and effort from TSD personnel. Careful attention to the monitoring, control, and documentation of the quality of the data resulted in a high degree of confidence that the identification and quantitation of compounds were accurate.

An in-depth description of the analytical quality assurance program for this survey can be found elsewhere.[6,7]

Results

The distribution of all samples is shown in Table 3 and Figures 1 and 2. The final number of random systems was 280 from systems serving fewer than 10 000 persons and 186 from systems serving more than 10 000 persons. The final tally for state-selected sites was 479. The number of random-sample sites in each state was roughly proportional to the number of groundwater systems in that state. The number of nonrandom samples allocated to a state was also based approximately on its number of groundwater systems. Figures 1 and 2 show all sampling locations.

The quantitation limits are not the same for all compounds. In most cases, the quantitation limit is either 0.2 μg/L or 0.5 μg/L. This difference in quantitation limits can confuse the interpretation of the data somewhat, so the results of the survey should be viewed with the differing quantitation limits in mind. Unless otherwise stated, an "occur-

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rence" is any specific organic parameter that was found at, or in excess of, the quantitation limit.

Random sample occurrences. Tables 4 and 5 summarize occurrences from the random sample for each of the 34 parameters. Table 4 contains data from the random sample of systems serving fewer than 10 000 persons, and Table 5 contains the results for systems serving more than 10 000 persons. These tables list the quantitation limit, the frequency of occurrence, the median concentration of the positive values of each compound, and the highest concentration for each parameter.

Because the two subsets of the random sample were selected independently and because a much higher percentage of large systems than small systems were included (15 percent of roughly 1200 systems serving more than 10 000 and 0.6 percent of nearly 48 000 systems serving fewer than 10 000 persons), the data from the large systems and the small systems were not combined. The normal curve approximation to the binomial distribution for large samples was used to conduct tests of the significance of the difference in frequency of occurrence of compounds in the two subsets of the random sample.[3] The large systems' frequency of occurrence was greater than the small systems' frequency of occurrence for trichloroethylene, cis and/or trans-1,2-dichloroethylene and tetrachloroethylene at the 0.01 significance level and for 1,2-dichloropropane, carbon tetrachloride, and 1,1,1-trichloroethane at the 0.05 significance level. No other significant differences in the occurrence of specific parameters could be discerned between the samples from large systems and those from small systems.

Though the data indicate that the frequency of occurrence of several of the compounds is higher among the larger communities, a similar inference cannot be drawn regarding the severity of contamination from a casual observation of Tables 3 and 4. The highest concentrations of 1,2-dichloropropane, trichloroethylene, and benzene were found in samples from the larger communities, whereas samples from small systems contained the highest levels of 1,1,1-trichloroethane, carbon tetrachloride, and tetrachloroethylene.

Trihalomethanes occurred more frequently in the samples from larger systems, but this could be because a higher percentage of large systems chlorinate their water supplies (85 percent of the large systems versus 56 percent of the smaller systems). The THM concentrations were generally low, although some groundwaters can produce high concentrations of THMs. Again, the different quantitation limits must be considered when the frequency of occurrences and the median of the positive values for THMs are evaluated. Since the samples were normally analyzed after one to four weeks of low-temperature storage, the THM concentrations reported are undoubtedly higher than they would have been had the THM formation reaction been stopped by a reducing agent at the time of sampling. Therefore, the concentrations reported may not be representative of concentrations in the distribution systems. However, the data provide an indication of the tendency for THMs to form in groundwater supplies.

There is no evidence in the literature that chlorination of drinking water

TABLE 1
Specific organic parameters

Contaminant	
Vinyl chloride	1,1,2 Trichloroethane
1,1-Dichloroethylene	1,1,1,2 Tetrachloroethane
1,1-Dichloroethane	1,1,2,2 Tetrachloroethane
cis and/or trans 1,2 Dichloroethylene	Chlorobenzene
1,2-Dichloroethane	1,2-Dibromo-3-chloropropane
1,1,1 Trichloroethane	n-Propylbenzene
Carbon tetrachloride	o-Chlorotoluene
1,2-Dichloropropane	p-Chlorotoluene
Trichloroethylene	m Dichlorobenzene
Tetrachloroethylene	o-Dichlorobenzene
Benzene	Styrene
Toluene	Isopropylbenzene
Ethylbenzene	Chloroform
Bromobenzene	Bromodichloromethane
m Xylene	Dibromochloromethane
o + p-Xylene	Dichlorodibromethane
p-Dichlorobenzene	Bromoform

TABLE 2
Quality assurance protocol for the analysis of VOCs

Quality Assurance Analysis	Frequency or Amount	Specified Limits			Source of Sample
		Parameter	<5 µg/L percent	>5 µg/L percent	
USEPA reference samples	1 per week for each instrument	Precision Accuracy	±40 ±40	±20 ±20	Environmental Monitoring Support Laboratory, Cincinnati
Duplicate analyses	10 percent of samples	Agreement	40	20	Survey samples
Confirmatory analyses	100 percent of positives	Qualitative agreement			Survey samples
Blind samples	Variable	None specified			TSD
TSD analyses of duplicate samples	10 percent of positives	None specified			Survey samples

TABLE 3
Number of supplies sampled by state

State	Random	Nonrandom	State	Random	Nonrandom
Alabama	7	5	Nebraska	8	6
Alaska	4	4	Nevada	2	3
Arizona	8	9	New Hampshire	2	4
Arkansas	3	4	New Jersey	17	5
California	34	20	New Mexico	1	6
Colorado	2	6	New York	22	25
Connecticut	8	7	North Carolina	13	31
Delaware	1	1	North Dakota	0	3
Florida	44	31	Ohio	14	15
Georgia	14	13	Oklahoma	4	5
Hawaii	0	2	Oregon	7	7
Idaho	6	8	Pennsylvania	16	26
Illinois	15	12	Rhode Island	1	2
Indiana	8	8	South Carolina	5	11
Iowa	12	13	South Dakota	4	4
Kansas	11	6	Tennessee	6	4
Kentucky	4	3	Texas	41	23
Louisiana	14	10	Utah	8	2
Maine	0	2	Vermont	2	3
Maryland	4	6	Virginia	9	18
Massachusetts	11	4	Washington	19	10
Michigan	8	12	West Virginia	4	5
Minnesota	10	9	Wisconsin	7	13
Mississippi	14	14	Wyoming	0	2
Missouri	6	10	Puerto Rico	2	2
Montana	4	5			

TABLE 4

Summary of occurrences from 280 random sample sites serving fewer than 10 000 persons

Parameter	Quantitation Limit µg/L	Occurrences Number	Occurrences Percent	Median of Positives µg/L	Maximum Value µg/L
Vinyl chloride	1.0	0	0		
1,1-Dichloroethylene	0.2	4	1.4	1.2	6.3
1,1-Dichloroethane	0.2	10	3.6	0.51	3.2
cis and/or trans 1,2-Dichloroethylene	0.2	3	1.1	0.23	1.7
1,2-Dichloroethane	0.5	0	0		
1,1,1-Trichloroethane	0.2	12	4.3	0.32	18
Carbon tetrachloride	0.2	5	1.8	0.37	16
1,2-Dichloropropane	0.2	1	0.4	0.75	0.75
Trichloroethylene	0.2	9	3.2	0.88	40
Tetrachloroethylene	0.2	13	4.6	0.35	23
Benzene	0.5	1	0.4	0.61	0.61
Toluene	0.5	4	1.4	0.82	0.85
Ethylbenzene	0.5	2	0.7	0.94	1.1
Bromobenzene	0.5	3	1.1	1.9	5.8
m-Xylene	0.2	6	2.1	0.32	1.5
o + p-Xylene	0.2	6	2.1	0.34	0.59
p-Dichlorobenzene	0.5	2	0.7	0.80	0.88
1,1,2-Trichloroethane	0.5	0	0		
1,1,1,2-Tetrachloroethane	0.2	0	0		
1,1,2,2-Tetrachloroethane	0.5	0	0		
Chlorobenzene	0.5	0	0		
1,2-Dibromo-3-chloropropane	5.0	1	0.4	5.5	5.5
n-Propylbenzene	0.5	0	0		
o-Chlorotoluene	0.5	0	0		
p-Chlorotoluene	0.5	0	0		
m-Dichlorobenzene	0.5	0	0		
o-Dichlorobenzene	0.5	0	0		
Styrene	0.5	0	0		
Isopropylbenzene	0.5	0	0		
Chloroform	0.2	104	37.1	1.4	140
Bromodichloromethane	0.2	100	35.1	1.4	80
Dibromochloromethane	0.5	87	31.1	2.1	52
Dichloroiodomethane	1.0	2	0.7	2.8	4.1
Bromoform	1.0	44	15.7	2.4	54

TABLE 5

Summary of occurrences from 186 random sample sites serving more than 10 000 persons

Parameter	Quantitation Limit µg/L	Occurrences Number	Occurrences Percent	Median of Positives µg/L	Maximum Value µg/L
Vinyl chloride	1.0	1	0.5	1.1	1.1
1,1-Dichloroethylene	0.2	5	2.7	0.28	2.2
1,1-Dichloroethane	0.2	8	4.3	0.54	1.2
cis and/or trans 1,2-Dichloroethylene	0.2	13	7.0	1.1	2.0
1,2-Dichloroethane	0.5	3	1.6	0.57	0.95
1,1,1-Trichloroethane	0.2	15	8.1	1.0	3.1
Carbon tetrachloride	0.2	10	5.4	0.32	2.8
1,2-Dichloropropane	0.2	5	2.7	0.96	21
Trichloroethylene	0.2	21	11.3	1.0	78
Tetrachloroethylene	0.2	21	11.3	0.52	5.9
Benzene	0.5	2	1.1	0.0	15
Toluene	0.5	2	1.1	2.6	2.9
Ethylbenzene	0.5	1	0.5	0.74	0.74
Bromobenzene	0.5	1	0.5	1.7	1.7
m-Xylene	0.2	2	1.1	0.46	0.61
o + p-Xylene	0.2	2	1.1	0.59	0.91
p-Dichlorobenzene	0.5	3	1.6	0.86	1.3
1,1,2-Trichloroethane	0.5	0	0		
1,1,1,2-Tetrachloroethane	0.2	0	0		
1,1,2,2-Tetrachloroethane	0.5	0	0		
Chlorobenzene	0.5	0	0		
1,2-Dibromo-3-chloropropane	5.0	0	0		
n-Propylbenzene	0.5	0	0		
o-Chlorotoluene	0.5	0	0		
p-Chlorotoluene	0.5	0	0		
m-Dichlorobenzene	0.5	0	0		
o-Dichlorobenzene	0.5	0	0		
Styrene	0.5	0	0		
Isopropylbenzene	0.5	0	0		
Chloroform	0.2	105	57.0	1.6	380
Bromodichloromethane	0.2	101	54.3	1.6	71
Dibromochloromethane	0.5	96	51.6	2.9	89
Dichloroiodomethane	1.0	3	1.6	1.8	4.1
Bromoform	1.0	57	30.6	3.8	50

causes the formation of any of the VOCs other than THMs. There have been reports that commercial chlorine can contain traces of carbon tetrachloride thereby contaminating chlorinated drinking water. Therefore, the carbon tetrachloride occurrence data should be qualified by the possibility that the cause of some occurrences of carbon tetrachloride could be contaminated chlorine.

The data from the random sample of systems serving fewer than 10 000 persons were examined for any other possible effects of chlorination. There was no significant difference in the frequency of occurrences of any VOCs between small systems that chlorinate and those that do not. The larger systems that do not chlorinate are too few in number to provide a valid comparison with larger systems that do chlorinate.

The number and percentage of contaminated supplies in each part of the random sample are listed in Table 6. Of 280 small systems, 47 contained one or more of the 29 VOCs included in the analysis. Of those 47 supplies, 19 had multiple contaminants above the quantitation limit. Of the 186 larger systems, 52 contained at least one contaminant. Of those, 25 supplies contained more than one VOC.

Water samples from 16.8 percent of the systems serving fewer than 10 000 persons and 28 percent of the larger systems' supplies contained at least one VOC. Confidence limits, based on the binomial distribution,[3] were constructed around the point estimates (16.8 and 28 percent) of the probability of VOC occurrences in systems in the two size categories. The confidence interval is simply a function of the observed frequency and the sample size and does not account for uncertainty owing to analytical variability or variation in water quality. The frequency of occurrence in all systems serving fewer than 10 000 persons can be estimated with 95 percent confidence to lie in the range of 12.9–21.7 percent. The large systems' frequency of occurrence can be estimated with 95 percent confidence to lie in the range of 22.1–35 percent. The frequency of occurrence for the large systems was greater than that for the small systems at the 0.01 significance level.

Table 7 shows the supplies by population category with summed VOC concentrations in various ranges of concentrations. For example, there were 88 supplies in the population category of 101–500 persons. Of those 88 supplies, 77 contained no VOC above the quantitation limit, 9 contained one or more of the contaminants with sums of concentrations less than 5.0 µg/L, and 2 had a summed VOC concentration in the range of 11–50 µg/L.

The number and percentage of supplies containing various levels of summed

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VOC concentrations are shown in Table 8. The point estimate of the probability that a system serving more than 10 000 persons contains a summed VOC concentration greater than 5.0 μg/L was 6.5 percent (12 of 186), with a 95 percent confidence interval of 3.8–11 percent. Eight of 280 small systems (2.9 percent) contained a summed VOC concentration greater than 5.0 μg/L, resulting in a 95 percent confidence interval for the estimate of 1.5–5.6 percent. The frequency of occurrence of summed VOC concentrations greater than 5.0 μg/L was higher in large systems than in small systems at the 0.05 significance level.

Nonrandom sample occurrences. The nonrandom sample data are given in Tables 9 through 13. Obviously, higher frequencies and concentrations were found in this sample set than in the random sample. Nearly 25 percent of the large systems and 7 percent of the small systems selected were contaminated with trichloroethylene. Other compounds that appeared frequently included cis- and/or trans-1,2-dichloroethylene, 1,1,1-trichloroethane, tetrachloroethylene, and 1,1-dichloroethane. Of the 131 systems found to be contaminated with VOCs, more than half showed the presence of multiple contaminants, the water from one smaller community contained eight VOCs. Trichloroethylene, tetrachloroethylene, and cis- and/or trans-1,2-dichloroethylene were found 18, 11, and 10 times, respectively, in concentrations greater than 5.0 μg/L. Trichloroethylene occurred three times in concentrations greater than 50 μg/L and tetrachloroethylene and cis- and/or trans-1,2-dichloroethylene once each in concentrations greater than 50 μg/L. All xylene occurrences were in supplies serving fewer than 10 000 persons; in fact, only six occurrences of aromatic compounds were found in the larger supplies. Although 1,1,1-trichloroethane was the second most frequently found compound, it was found only four times in concentrations greater than 5.0 μg/L. Of the larger supplies selected, 37 percent had at least one measurable VOC and 18 percent had a summed VOC concentration greater than 5.0 μg/L. Of the smaller systems, 22 percent showed some contamination. The summed VOC concentration exceeded 5.0 μg/L in 5 percent of the samples.

Resampling of contaminated supplies

Approximately 100 contaminated supplies were resampled. The states were asked to resample the finished water and were also given the opportunity to collect several raw water samples of their choosing. In many cases, the original sample point was not resampled or the sampling points were not described well enough to enable comparison of the original sample with the resample.

TABLE 6

Summary of random sample multiple occurrences of contaminants

Number of Contaminants	Population Category: ≤10 000 Persons, Number	≤10 000 Persons, Percent	>10 000 Persons, Number	>10 000 Persons, Percent
0	233	83.2	134	72.1
1	28	10.0	27	14.5
2	10	3.5	8	4.3
3	6	2.1	6	3.2
4	1	0.4	5	2.7
5	1	0.4	3	1.6
6	0	0	2	1.1
7	1	0.4	1	0.5
Total	280		186	

TABLE 7

Summed concentrations of VOCs in random samples*

Population	Number of Supplies With Summed Concentrations of VOCs: Below Quantitation Limit	Quantitation Limit: 5.0 μg/L	5.1–10 μg/L	11–50 μg/L	51–100 μg/L	>100 μg/L
<100	70	9	0	1	0	0
101–500	77	9	0	2	0	0
501–1000	34	2	2	0	0	0
1001–2500	26	4	0	1	0	0
2501–5000	26	8	1	0	1	0
5001–10 000	10	7	0	0	0	0
10 001–100 000	123	38	5	6	1	0
>100 000	11	2	0	0	0	0

*Summed concentrations = summation of all VOCs exclusive of THMs.

TABLE 8

Summed concentrations in random samples

Summed Concentrations of VOCs—μg/L	Supplies with Summed Concentrations of VOCs Greater Than Value Shown: ≤10 000 Persons, Number	≤10 000 Persons, Percent	>10 000 Persons, Number	>10 000 Persons, Percent
>Quantitation limit	47	16.8	52	28.0
>1.0	20	7.1	26	14.0
>5.0	8	2.9	12	6.5
>10	5	1.8	7	3.8
>50	1	0.4	1	0.5
>100	0	0	0	0

An example of data from resampled finished water illustrates some aspects of the groundwater VOC data. Table 14 shows the concentrations of VOCs in two samples of finished water, collected nine months apart, from a single well owned by a small town (city A).

These two samples show much the same pattern of contamination, with a possible slight decrease in concentrations in the second sample. Trichloroethylene, which was counted as an occurrence in the original sample, was not found above the quantification limit in the resample. When the original sample and the resample were from a single well, both usually contained nearly identical patterns of contamination. This increases confidence that the original results were accurate and reinforces the belief that levels of groundwater contamination usually change slowly.

The occurrence of a compound at or near the quantitation limit was often not repeated in the resample. For example, in the 37 supplies resampled from the original point, 25 occurrences in the original sample did not recur in the resample. (Many of the supplies resampled had multiple occurrences.) There were also 16 instances, however, in which a compound that was not found in the original sample was quantified in the resampled finished water. This nonrepeatability occasionally occurred in well samples, such as those shown in Table 14, with low levels of contaminants. This situation could result from either normal analytical variability or from actual changes in concentration at the well. This phenomenon was more common in larger systems in which the finished water was a blend of water from multiple wells with various levels of contamination. In these cases, changes in the concentrations of contaminants could result from changes in the relative contributions of the various wells as

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TABLE 9

Summary of occurrences from 321 nonrandom sample sites serving fewer than 10 000 persons

Parameter	Quantitation Limit µg/L	Occurrence Number	Occurrence Percent	Median of Positives µg/L	Maximum Value µg/L
Vinyl chloride	1.0	0	0		
1,1-Dichloroethylene	0.2	5	1.6	0.35	3.0
1,1-Dichloroethane	0.2	6	1.9	0.62	1.2
cis and/or trans 1,2-Dichloroethylene	0.2	11	3.4	1.3	17
1,2-Dichloroethane	0.5	3	0.9	2.9	3.4
1,1,1-Trichloroethane	0.2	25	7.8	1.2	8.2
Carbon tetrachloride	0.2	9	2.8	0.44	15
1,2-Dichloropropane	0.2	3	0.9	1.2	1.4
Trichloroethylene	0.2	23	7.2	1.2	29
Tetrachloroethylene	0.2	27	8.4	0.79	21
Benzene	0.5	5	1.6	1.6	12
Toluene	0.5	4	1.2	0.67	0.79
Ethylbenzene	0.5	3	0.9	0.87	0.95
Bromobenzene	0.5	2	0.6	0.97	1.2
m-Xylene	0.2	8	2.5	0.38	0.83
o + p-Xylene	0.2	10	3.1	0.44	2.5
p-Dichlorobenzene	0.5	4	1.2	0.74	0.90
1,1,2 Trichloroethane	0.5	0	0		
1,1,1,2 Tetrachloroethane	0.2	0	0		
1,1,2,2 Tetrachloroethane	0.5	0	0		
Chlorobenzene	0.5	1	0.3	2.7	2.7
1,2-Dibromo-3-chloropropane	5.0	0	0		
n-Propylbenzene	0.5	1	0.3	0.98	0.98
o-Chlorotoluene	0.5	0	0		
p-Chlorotoluene	0.5	0	0		
m-Dichlorobenzene	0.5	0	0		
o-Dichlorobenzene	0.5	1	0.3	2.2	2.2
Styrene	0.5	0	0		
Isopropylbenzene	0.5	0	0		
Chloroform	0.2	155	48.3	1.6	180
Bromodichloromethane	0.2	144	44.9	2.0	49
Dibromochloromethane	0.5	135	42.1	3.5	63
Dichlorodibromomethane	1.0	5	1.6	1.4	4.2
Bromoform	1.0	88	27.4	3.7	110

TABLE 10

Summary of occurrences from 158 nonrandom sample sites serving more than 10 000 persons

Parameter	Quantitation Limit µg/L	Occurrence Number	Occurrence Percent	Median of Positives µg/L	Maximum Value µg/L
Vinyl chloride	1.0	6	3.8	2.7	8.4
1,1-Dichloroethylene	0.2	10	6.3	0.34	0.64
1,1-Dichloroethane	0.2	17	10.8	0.87	4.2
cis and/or trans 1,2-Dichloroethylene	0.2	27	17.1	2.7	130
1,2-Dichloroethane	0.5	4	2.5	1.8	9.8
1,1,1-Trichloroethane	0.2	26	16.5	0.93	21
Carbon tetrachloride	0.2	6	3.8	0.70	9.4
1,2-Dichloropropane	0.2	4	2.5	0.70	18
Trichloroethylene	0.2	38	24.1	1.5	130
Tetrachloroethylene	0.2	18	11.4	0.66	69
Benzene	0.5	3	1.9	2.7	12
Toluene	0.5	1	0.6	1.5	1.5
Ethylbenzene	0.5	0	0		
Bromobenzene	0.5	0	0		
m-Xylene	0.2	0	0		
o + p-Xylene	0.2	0	0		
p-Dichlorobenzene	0.5	0	0		
1,1,2 Trichloroethane	0.5	0	0		
1,1,1,2 Tetrachloroethane	0.2	0	0		
1,1,2,2 Tetrachloroethane	0.5	0	0		
Chlorobenzene	0.5	0	0		
1,2-Dibromo-3-chloropropane	5.0	0	0		
n-Propylbenzene	0.5	0	0		
o-Chlorotoluene	0.5	1	0.6	2.4	2.4
p-Chlorotoluene	0.5	0	0		
m-Dichlorobenzene	0.5	0	0		
o-Dichlorobenzene	0.5	1	0.6	2.7	2.7
Styrene	0.5	0	0		
Isopropylbenzene	0.5	0	0		
Chloroform	0.2	100	63.3	2.1	430
Bromodichloromethane	0.2	100	63.3	2.2	110
Dibromochloromethane	0.5	87	55.1	4.6	51
Dichlorodibromomethane	1.0	8	5.1	1.2	4.1
Bromoform	1.0	60	38.0	5.1	68

determined by their pumping rate. Temporal changes in concentration could also result from a relatively rapid movement of the plume of contamination, which could occur during recharge and withdrawal in a highly permeable aquifer.

The data from resampling of finished water from individual wells reinforced confidence that the identification and quantitation of compounds in the samples were accurate. The data from large multiple-well systems show that concentrations of compounds in a finished water can vary considerably over time. Therefore, sampling a large number of supplies, as in this survey, provides an accurate representation of the percentage of systems with water containing VOCs and an indication of the magnitude of the levels of concentrations.

The variability of the quality of finished water from groundwater supplies is site-specific and not amenable to definition by a national survey such as this. In the face of this variability, the sampling approach was a compromise between providing broad national coverage and obtaining representative samples at each site.

Conclusion

The groundwater supply survey was undertaken primarily to strengthen the body of data on the occurrence of VOCs in groundwater supplies. Careful attention was paid to quality assurance so that a reliable representation of the occurrence of VOCs in US groundwater supplies would result. The frequencies of occurrence of 29 volatile compounds were documented in samples collected from 466 randomly selected communities and from 479 communities selected by the state agencies. The three most frequently detected compounds were trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane. The percentages of supplies containing at least one VOC above the quantitation limit in the subsets of the survey were: random sample of systems serving fewer than 10 000 persons, 16.8 percent; random sample of systems serving more than 10 000 persons, 28 percent; nonrandom sample of systems serving fewer than 10 000 persons, 22.4 percent; and nonrandom sample of systems serving more than 10 000 persons, 37.3 percent. The percentages of supplies containing summed VOC concentrations in finished water greater than 5 µg/L were: random sample of systems serving fewer than 10 000 persons, 2.9 percent; random sample of systems serving more than 10 000 persons, 6.5 percent; nonrandom sample of systems serving fewer than 10 000 persons, 4.7 percent; and nonrandom sample of systems serving more than 10 000 persons, 17.7 percent.

Simple statistical tests, based on ran-

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TABLE 11

Summary of nonrandom sample multiple occurrences of contaminants

Number of Contaminants	Population Category: ≤10 000 Persons, Number	≤10 000 Persons, Percent	>10 000 Persons, Number	>10 000 Persons, Percent
0	249	77.6	99	62.7
1	35	10.9	19	12.0
2	15	4.7	14	8.9
3	11	3.4	7	4.4
4	7	2.2	7	4.4
5	2	0.6	7	4.4
6	0	0	4	2.6
7	1	0.3	1	0.6
8	1	0.3	0	0
Total	321		158	

TABLE 12

Summed concentrations of VOCs in nonrandom samples*

Population	Number of Supplies With Summed Concentrations of VOCs: Below Quantitation Limit	Quantitation Limit: 5.0 µg/L	5.1-10 µg/L	11-50 µg/L	51-100 µg/L	>100 µg/L
<100	24	10	1	0	0	0
101-500	38	4	0	1	0	0
501-1000	27	5	0	2	0	0
1001-2500	62	8	0	1	0	0
2501-5000	43	18	0	2	0	0
5001-10 000	55	12	4	4	0	0
10 001-100 000	85	29	6	13	3	2
>100 000	14	2	0	3	0	1

*Summed concentrations = summation of all VOCs exclusive of THMs

TABLE 13

Summed concentration levels in nonrandom samples

Summed Concentrations of VOCs—µg/L	Supplies with Summed Concentrations of VOCs Greater Than Value Shown: Population Category ≤10 000 Persons, Number	≤10 000 Persons, Percent	>10 000 Persons, Number	>10 000 Persons, Percent
>Quantitation limit	72	22.4	59	37.3
>1.0	41	12.8	43	27.2
>5.0	15	4.7	28	17.7
>10	10	3.1	22	13.9
>50	0	0	6	3.8
>100	0	0	3	1.9

TABLE 14

VOCs found in original sample and resample in city A

Parameter	June 1981 µg/L	March 1982 µg/L
1,1-Dichloroethane	0.62	0.51
1,1,1-Trichloroethane	1.9	1.4
Trichloroethylene	0.21	<0.2
Tetrachloroethylene	1.3	0.94

dom sampling showed significant differences in the frequency of occurrences of VOCs in the larger and smaller community subsets. The results of the random sample were also used to construct statistical confidence limits of estimates of the probabilities of occurrence.

The nonrandom portion of the sample provided additional data on the high side of the occurrence curve, since the sites were selected in hopes of finding a greater frequency of higher levels of contamination. For example, six of the eight suppliers with summed VOC concentrations greater than 50 µg/L were from the nonrandom sample, including all three of the supplies with summed VOC concentrations greater than 100 µg/L.

Resampling of contaminated supplies strengthened confidence in the quality of the analytical data. It also showed that finished water quality, with respect to VOCs, can vary over time, especially in systems supplied by multiple wells.

Additional analysis of the data generated by this survey will appear in documents prepared by the USEPA in support of VOC regulatory recommendations.

Acknowledgments

The authors acknowledge those who assisted in this sampling and analysis program: the SRI International analysis team, led by Barbara Kingsley; members of the Office of Drinking Water in Washington, D.C., and Cincinnati, Ohio, who participated in the planning and execution of the project and in the preparation and review of this document, including Victor J. Kimm, Lowell A. Van Den Berg, Joseph A. Cotruvo, Arnold M. Kuzmack, Herbert J. Brass, Craig Vogt, David Schnare, Eric Bissonette, Richard Johnston, Waymon Wallace, Jane Gruber, Audrey Kroner, Dale Ruhter, and William Coniglio; the USEPA regional water supply personnel who coordinated and monitored the survey, and, in some cases, carried out the activities in their regions; and the personnel of the state drinking water agencies.

References

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7. Kingsley, B.A. Quality Assurance in a Contract Laboratory. Proc. AWWA WQTC, Nashville, Tenn. (Dec. 1982).

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Reference #19
Oklahoma Water Quality Standards - 1982. Publication 111.
Oklahoma Water Resources Board

OKLAHOMA'S

Water Quality Standards

1982

PUBLICATION 111

OKLAHOMA WATER RESOURCES BOARD
P.O. BOX 53585, 1000 NE 10th, 12TH FL
OKLAHOMA CITY, OKLAHOMA 73152

3 - Class I irrigation
4 - Class II irrigation with class I irrigation as a goal if natural conditions permit
5 - Class III irrigation with class I irrigation as a goal if natural conditions permit

STREAM ORDER 1 2 3 4 5 6	STREAM SEGMENT	PUBLIC & PRIVATE WATER SUPPLY	EMERGENCY WATER SUPPLY	FISH & WILDLIFE PROPAGATION	AGRICULTURE	HYDROELECTRIC POWER	W & I COOLING WATER	PRIMARY RECREATION	SECONDARY RECREATION	NAVIGATION	AESTHETICS	SMALLMOUTH BASS	TROUT FISHERIES	LIMITATIONS	REMARKS
Okemah Lake and Watershed	520700	●	1	●		●	●	●		●				a	
Salt Creek	520700	●	1	●		●	●	●		●					
Camp Creek below Stroud Lake	520700	●	1	●		●	●	●		●					
Stroud Lake and Watershed	520700	●	1	●		●	●	●		●				a	
Dry Creek	520700	●	1	●		●	●	●		●					
Deer Creek	520700	●	1	●		●	●	●		●					
Robinson Creek	520700	●	1	●		●	●	●		●					
Quapaw Creek	520700	●	1	●		●	●	●		●					
Meeker Lake and Watershed	520700	●	1	●		●	●	●		●				a	
Bellcow Creek	520700	●	1	●		●	●	●		●					
Chandler Lake and Watershed	520700	●	1	●		●	●	●		●				a	
Kickapoo Creek	520700	●	1	●		●	●	●		●					
East Captain Creek	520700	●	1	●		●	●	●		●					
Bear Creek	520700	●	1	●		●	●	●		●					
DEEP FORK OF CANADIAN RIVER from Bear Creek to Coffee Creek	520710	●	●	●		●	●	●		●					△
Coffee Creek	520710	●	●	●		●	●	●		●					△
DEEP FORK OF CANADIAN RIVER above Coffee Creek and watershed	520710	●	1	●		●	●	●		●				a	

W.Q. Basin No. 5, Sheet 3

BENEFICIAL USE CODES
- ● - Indicates designated beneficial use
- O - Indicates a goal for the continuous attainment of the beneficial use (beneficial use applies when dilution capacity is sufficient)
- 1 - Primary warm water fishery
- 2 - Secondary warm water fishery with primary warm water fishery as a goal
- 3 - Class I irrigation
- 4 - Class II irrigation with class I irrigation as a goal if natural conditions permit
- 5 - Class III irrigation with class I irrigation as a goal if natural conditions permit

STREAM ORDER 1 2 3 4 5 6	STREAM SEGMENT	PUBLIC & PRIVATE WATER SUPPLY	EMERGENCY WATER SUPPLY	FISH & WILDLIFE PROPAGATION	AGRICULTURE	HYDROELECTRIC POWER	W & I COOLING WATER	PRIMARY RECREATION	SECONDARY RECREATION	NAVIGATION	AESTHETICS	SMALLMOUTH BASS	TROUT FISHERIES	LIMITATIONS	REMARKS
Bad Creek	520500	●	1	●		●	●	●		●					
Weleetka Lake and Watershed	520500	●	1	●		●	●	●		●				a	
Wewoka Creek	520500	O	2	●		●	O	●		●					
Fish Creek	520500	●	1	●		●	●	●		●					
Grief Creek	520500	●	1	●		●	●	●		●					
Little Wewoka Creek	520500	●	1	●		●	●	●		●					
Wewoka Lake and Watershed	520500	●	1	●		●	●	●		●				a	
Turkey Creek	520510	●	1	●		●	●	●		●					
Tecumseh Lake and Watershed	520510	●	1	●		●	●	●		●				a	
Shawnee Twin Lakes and Watershed	520510	●	1	●		●	●	●		●				a	
North Deer Creek	520510	●	1	●		●	●	●		●					
NORTH CANADIAN RIVER from Lincoln County Line to Portland Street Bridge, Oklahoma City	520520	O	2	4		●	O	●		●					
Choctaw Creek	520520	O	2	●		●	O	●		●					
Crutcho Creek	520520	O	2	●		●	O	●		●					
Crooked Oak Creek	520520		●	●		●		●		●					△
NORTH CANADIAN RIVER from Portland Street Bridge to Lake Overholser Dam	520520	●	1	4		●	●	●		●					
Mustang Creek	520520	O	1	●		●	O	●		●					

Reference #20
Record of Communication: Drew Puffer, USEPA to Capt. Cornell, Tinker AFB. 11/5/84

RECORD OF COMMUNICATION

☒ PHONE CALL ☐ DISCUSSION ☐ FIELD TRIP ☐ CONFERENCE
☐ OTHER (SPECIFY)
(Record of item checked above)

Captain Cornell Tinker AFB	FROM Drew Puffer	DATE 11/5/84 TIME 12:30

SUBJECT
Tinker AFB IRP

SUMMARY OF COMMUNICATION

I called Captain Cornell to find out why some areas of concern to EPA had been omitted from the Phase II B workplan, and why other areas did not recieve investigations that were thorough enough to define problems in those areas. Capt. Cornell stated that planning and budgeting are often completed before new information comes into play that might change the workplan. Once work is budgeted, it is costly to revise the plan & budget. This explains why only one monitoring well has been set up at Landfill #6 and the lack of volatile organic sampling by Tinker for all samples. Capt. Cornell says that these plan and budget constraints are the reason more investigation has not been done for Bldg. #3001. Currently there are six monitoring wells to east of Bldg #3001, two of which show TCE (≅ 100 PPB); the two contaminated wells are along East Drive, and are the Northern and middle wells along that drive.

Regarding well #18, which is a contaminated base well, a T.V. scan

CONCLUSIONS, ACTION TAKEN OR REQUIRED

of the casing was performed; the scan showed a significant split in the casing @ 140' with liquid pouring into the well from that split. Smaller cracks in the casing were also found. Capt. Cornell said Tinker is scheduling a meeting for early December to allow EPA and the State of Oklahoma to comment on the Phase II B and up coming work. Tinker will also share

INFORMATION COPIES
TO Wright, Nott

EPA Form 1320-4 (7-73) REPLACES EPA NO FORM 1320-4 WHICH MAY BE USED UNTIL SUPPLY IS EXHAUSTED.

unpublished data with us at that time.

Note: The Phase II B Draft recieved by EPA is a working draft. The final

Reference #21
Record of Communication: Kelly Nash, USEPA to T. Perdue, USEPA
1/30/85, with attachment of Midwest City well locations

RECORD OF COMMUNICATION

☐ PHONE CALL ☑ DISCUSSION ☐ FIELD TRIP ☐ CONFERENCE
☐ OTHER (SPECIFY)

(Record of item checked above)

Tim Perdue Superfund Compliance (6AW-SC)	FROM: Kelly Nash ofc. of Groundwater 6W	DATE 1/30/85 TIME 3:45 pm

SUBJECT
Tinker AFB Ranking Info. - Midwest City Well Locations

SUMMARY OF COMMUNICATION

In order to obtain information on groundwater uses near TAFB for MITRE ranking I contacted Ed Jeffrey, Reg. Public Water Supply Sect. (6W-PS) who is the Project Officer for the Okla. PWS program. Mr. Jeffrey showed me an inventory from the Oklahoma State Department of Health which gave the number of users, no. of wells and a general location of the wellfield which indicated that some of the wells may have been within 3 miles of the site. Mr. Jeffrey contacted Bob Crow, PWS engineer with OSDH, who was able to supply locations for 36 wells which were known to be active. Using a USGS 7½' quad. map I was able to find 16 wells w/in 3mi. - these were circled.

CONCLUSIONS, ACTION TAKEN OR REQUIRED

Please let me know if you need more information (x2768)

INFORMATION COPIES TO: Perdue (6AW-SC)

EPA Form 1300-6 (7-72) REPLACES EPA HQ FORM 8300-3 WHICH MAY BE USED UNTIL SUPPLY IS EXHAUSTED.

MIDWEST CITY OKLAHOMA - PWS WELL LOCATIONS

info from Bob Crow
OSDH 405-271-7379

Well #	Location			
1	S 1/2	Sec 10	11N	2W
1	S 1/2	10	11N	2W
2				
3	–	10	11N	2W
4	–	10	11N	2W
6	SE 1/4	4	11N	2W
8	NE 1/4	10	11N	2W
9	SE 1/4	3	11N	2W
10	SE 1/4	3	"	"
11	–	3	"	"
12	–	34	"	"
13	–	2	"	"
14	NE 1/4	3	"	"
15				
16	SW 1/4	34	12N	2W
17	SE 1/4	34	11N	2W
18	NW 1/4	34	12N	2W
19	SW 1/4	34	"	"
20	SE 1/4	34	"	"
21	–	11	11N	2W
22	SE 1/4	33	12N	2W
23	–	2	11N	2W
24	NE 1/4	34	12N	2W
25	NW 1/4	4	11N	2W
26	NW 1/4	4	11N	2W
27	SW 1/4	25	"	"
28	SW 1/4	1	"	"
32				
33				
34				
35	NE 1/4	12	11N	2W
37	NW 1/4	35	12N	2W
38	NW 1/4	35	12N	2W
39	NW 1/4	35	12N	"
40	SW 1/4	31	12N	1W
41				
42	NE 1/4	36	12N	2W
44	NW 1/4	22	12N	2W
48	SW 1/4	33	12N	1W
49	NW 1/4	2	11N	2W
50	NE 1/4	2	11N	2W
51	SW 1/4	26	12N	2W
52				

Lot 17 Blk 1

Circled wells are w/in 3 mi. of Tinker Well #16 KW

16 of 43 active wells (at least)

Lot 1 Blk 5

Wells are blended into system. No way of getting # customers/well

Lot 16 Blk 9
1 1
22 1

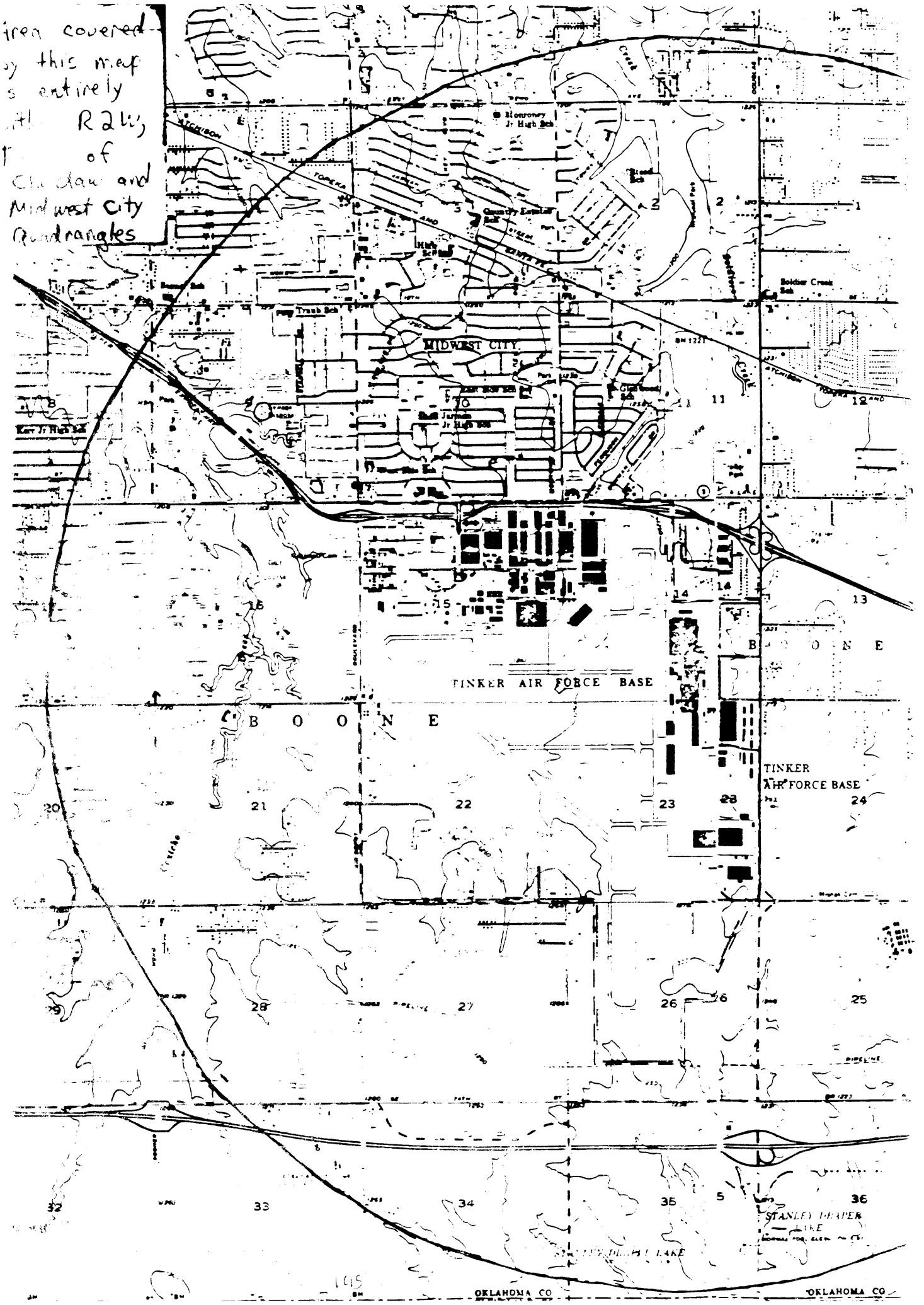
1 1

1 1

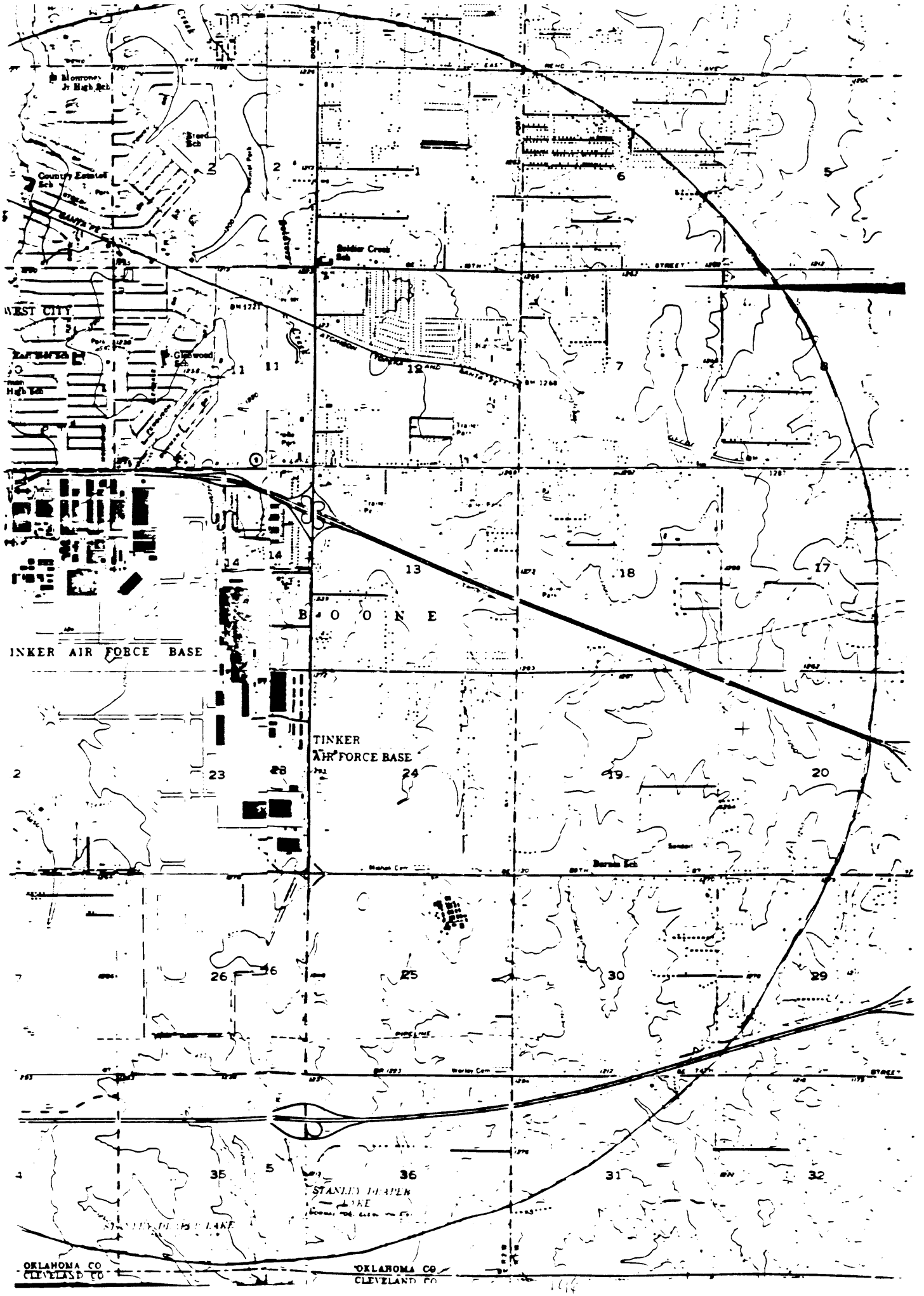
4/24/84 36 wells w legals
7 wells w/ legals to be obtained
43 Active

Reference #22

USGS top quad maps: Choctaw and Midwest City, both photorevised to 1975



Area covered by this map is entirely with R2W, T of Chickasaw and Midwest City Quadrangles
MIDWEST CITY
TINKER AIR FORCE BASE
B O O N E
TINKER AIR FORCE BASE
STANLEY DRAPER LAKE
OKLAHOMA CO
OKLAHOMA CO


WEST CITY
B O O N E
TINKER AIR FORCE BASE
TINKER
AIR FORCE BASE
STANLEY DRAPER
LAKE
OKLAHOMA CO
CLEVELAND CO
OKLAHOMA CO
CLEVELAND CO

Doc #: 110684~~001~~ 431 Category: 1.1

Title: Bldg 3001 & Soldier Creek Drainage Are, Tinker Air Force Base...NPL Scoring Package

Facility name: Bldg 3001 and Soldier Creek Drainage Area, Tinker AFB

Location: Oklahoma City, Oklahoma

EPA Region: 6

Person(s) in charge of the facility: Richard A. Burpee
Major General, USAF Command
Oklahoma City Air Logistics Ctr.
Tinker AFB, OK 73145

Name of Reviewer: A. J. Puffer Date: 11/6/84

General description of the facility:

(For example: landfill, surface impoundment, pile, container; types of hazardous substances; location of the facility, contamination route of major concern; types of information needed for rating, agency action, etc.)

Maintenance and repair building for a aircraft, which uses solvents for paint removal and cleaning and also generates plating wastes. The building is located in the recharge zone and is the source of contamination of base wells #18 and #19, and possibly other base wells. This building is also a source of contamination for the Soldier Creek and its tributaries.

Scores: S_M = ~~42.26~~ 42.24 S_{gw} = ~~42.26~~ 73.08 S_{sw} = 0 S_a = 0)

S_{FE} = 0

S_{DC} = 0

FIGURE 1
HRS COVER SHEET

QA —
R. Clemmy Johnson
1/31/85

A-1

Ground Water Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Observed Release	0 (45)	1	45	45	3.1
If observed release is given a score of 45, proceed to line 4. If observed release is given a score of 0, proceed to line 2.					
2 Route Characteristics					3.2
Depth to Aquifer of Concern	0 1 2 3	2		6	
Net Precipitation	0 1 2 3	1		3	
Permeability of the Unsaturated Zone	0 1 2 3	1		3	
Physical State	0 1 2 3	1		3	
	Total Route Characteristics Score			15	
3 Containment	0 1 2 3	1		3	3.3
4 Waste Characteristics					3.4
Toxicity/Persistence	0 3 6 9 12 15 (18)	1	18	18	
Hazardous Waste Quantity	0 (1) 2 3 4 5 6 7 8	1	1	8	
	Total Waste Characteristics Score		19	26	
5 Targets					3.5
Ground Water Use	0 1 2 (3)	3	9	9	
Distance to Nearest Well/Population Served	0 4 6 8 10 / 12 16 18 20 / 24 30 32 35 (40)	1	40	40	
	Total Targets Score		49	49	
6 If line 1 is 45, multiply 1 x 4 x 5 / If line 1 is 0, multiply 2 x 3 x 4 x 5			41,895	57,330	
7 Divide line 6 by 57,330 and multiply by 100		S_{gw} = 73.08			

FIGURE 2
GROUND WATER ROUTE WORK SHEET

RCJ 1/31/85

Surface Water Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Observed Release	0 45	1	0	45	4.1
If observed release is given a value of 45, proceed to line 4. If observed release is given a value of 0, proceed to line 2					
2 Route Characteristics					4.2
Facility Slope and Intervening Terrain	0 1 2 3	1		3	
1-yr. 24-hr. Rainfall	0 1 2 3	1		3	
Distance to Nearest Surface Water	0 1 2 3	2		6	
Physical State	0 1 2 3	1		3	
Total Route Characteristics Score				15	
3 Containment	0 1 2 3	1		3	4.3
4 Waste Characteristics					4.4
Toxicity/Persistence	0 3 6 9 12 15 18	1		18	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
Total Waste Characteristics Score				26	
5 Targets					4.5
Surface Water Use	0 1 2 3	3		9	
Distance to a Sensitive Environment	0 1 2 3	2		6	
Population Served/Distance to Water Intake Downstream	0 4 6 8 10 12 16 18 20 24 30 32 35 40	1		40	
NO TARGETS IDENTIFIED					
Total Targets Score			0	55	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5				64,350	
7 Divide line 6 by 64,350 and multiply by 100		S_{sw} = 0			

FIGURE 7
SURFACE WATER ROUTE WORK SHEET

RJ 1/31/85

Air Route Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max. Score	Ref. (Section)
1 Observed Release NONE	0 45	1		45	5.1
Date and Location:					
Sampling Protocol:					
If line 1 is 0, the S_a = 0. Enter on line 5. If line 1 is 45, then proceed to line 2.					
2 Waste Characteristics					5.2
Reactivity and Incompatibility	0 1 2 3	1		3	
Toxicity	0 1 2 3	3		9	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
	Total Waste Characteristics Score			20	
3 Targets					5.3
Population Within 4-Mile Radius	0 9 12 15 18 21 24 27 30	1		30	
Distance to Sensitive Environment	0 1 2 3	2		6	
Land Use	0 1 2 3	1		3	
	Total Targets Score			39	
4 Multiply 1 x 2 x 3				35,100	
5 Divide line 4 by 35,100 and multiply by 100		S_a = 0			

FIGURE 9
AIR ROUTE WORK SHEET

RCA
1/31/85

	S	S^2
Groundwater Route Score (S_{gw})	73.08	5,340.24
Surface Water Route Score (S_{sw})	0	0
Air Route Score (S_a)	0	0
$S_{gw}^2 + S_{sw}^2 + S_a^2$		5,340.24
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2}$		73.08
$\sqrt{S_{gw}^2 + S_{sw}^2 + S_a^2} / 1.73 = S_M =$		42.24

FIGURE 10
WORKSHEET FOR COMPUTING S_M

KCA
1/31/85

Fire and Explosion Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max Score	Ref. (Section)
1 Containment	1 3	1		3	7.1
2 Waste Characteristics					7.2
Direct Evidence	3	1		3	
Ignitability	0 1 2 3	1		3	
Reactivity	0 1 2 3	1		3	
Incompatibility	0 1 2 3	1		3	
Hazardous Waste Quantity	0 1 2 3 4 5 6 7 8	1		8	
Total Waste Characteristics Score				20	
3 Targets					7.3
Distance to Nearest Population	0 1 2 3 4 5	1		5	
Distance to Nearest Building	0 1 2 3	1		3	
Distance to Sensitive Environment	0 1 2 3	1		3	
Land Use	0 1 2 3	1		3	
Population Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Buildings Within 2-Mile Radius	0 1 2 3 4 5	1		5	
Total Targets Score				24	
4 Multiply 1 x 2 x 3				1,440	
5 Divide line 4 by 1,440 and multiply by 100		S_{FE} = 0			

FIGURE 11
FIRE AND EXPLOSION WORK SHEET

RCB 1/31/85

Direct Contact Work Sheet					
Rating Factor	Assigned Value (Circle One)	Multi-plier	Score	Max Score	Ref. (Section)
1 Observed Incident	0 45	1	0	45	8.1
If line 1 is 45, proceed to line 4 If line 1 is 0, proceed to line 2					
2 Accessibility	0 1 2 3	1	0	3	8.2
3 Containment	0 15	1		15	8.3
4 Waste Characteristics Toxicity	0 1 2 3	5		15	8.4
5 Targets					8.5
Population Within a 1-Mile Radius	0 1 2 3 4 5	4		20	
Distance to a Critical Habitat	0 1 2 3	4		12	
Total Targets Score				32	
6 If line 1 is 45, multiply 1 x 4 x 5 If line 1 is 0, multiply 2 x 3 x 4 x 5				21,600	
7 Divide line 6 by 21,600 and multiply by 100	S_{DC} = 0				

FIGURE 12
DIRECT CONTACT WORK SHEET

RCA 1/31/85

DOCUMENTATION RECORDS
FOR
HAZARD RANKING SYSTEM

INSTRUCTIONS: The purpose of these records is to provide a convenient way to prepare an auditable record of the data and documentation used to apply the Hazard Ranking System to a given facility. As briefly as possible summarize the information you used to assign the score for each factor (e.g., "Waste quantity = 4,230 drums plus 800 cubic yards of sludges"). The source of information should be provided for each entry and should be a bibliographic-type reference that will make the document used for a given data point easier to find. Include the location of the document and consider appending a copy of the relevant page(s) for ease in review.

FACILITY NAME: Building 3001 and Soldier Creek Drainage Area, Tinker AFB

LOCATION: Oklahoma City, Oklahoma

QA —
R. Channing Johnson
1/31/85

GROUND WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected (5 maximum):

Trichloroethylene	1750ppb	
Tetrachloroethylene	30.1ppb	(Ref. 4, Table 4-13 and Appendix H
1,2 Dichloroethane	25.8ppb	for well 18)
Chlorobenzene	7.9ppb	

Rationale for attributing the contaminants to the facility:
These materials are used on site and have been released to the environment (Ref. 4, above, and Ref. 5) Well 18 within building is contaminated below 140' (Ref. 20). Pattern of contamination of monitoring wells shows contamination centered on building 3001. Lack of trichloroethylene and tetrachloroethylene in wells 8 and 9 to north indicates contamination is not attributable to municipal industrial parks (Ref. 4, 8 and 12).

* * *

2 ROUTE CHARACTERISTICS

Depth to Aquifer of Concern

Name description of aquifers(s) of concern:
Garber-Wellington Sandstone (Ref. 3, pages 3-7 to 3-18)
Tinker AFB is located in the recharge zone of this aquifer. The water bearing portion of this aquifer are lenses of sandstone which are irregularly interbedded with sandy to silty shales (Ref. 11).

Depth(s) from the ground surface to the highest seasonal level of the saturated zone (water table(s)) of the aquifer of concern:

Depth from the ground surface to the lowest point of waste ~~xxxxxxxx~~ contamination:
~~xxxxxxx~~

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1/31/85

Net Precipitation

Mean annual or seasonal precipitation (list months for seasonal):

Mean annual lake or seasonal evaporation (list months for seasonal):

Net precipitation (subtract the above figures):

Permeability of Unsaturated Zone

Soil type in unsaturated zone:

Permeability associated with soil type:

Physical State

Physical state of substances at time of disposal (or at present time for generated gases):

* * *

Rcf
1/31/85

3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Method with highest score:

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated:	Toxicity	Persistence
Tetrachlorethylene	2	2 (Ref. 4, Table 4-13)
Trichloroethylene	2	2 "
1,1Dichloroethene	3	2 "
Chloroform	3	3 (Monitor Wells (Ref. 13)
Chromium	3	3 (Ref. 7, page 7 and Table I)

Compound with highest score:

Chloroform and Chromium - 18

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

Unknown: Value of 1 assigned because the observed release indicates a quantity greater than zero.

Basis of estimating and/or computing waste quantity:

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1/31/85

* * *

5 TARGETS

Ground Water Use

Use(s) of aquifer(s) of concern within a 3-mile radius of the facility:

Drinking water - Garber-Wellington (Ref. 6) serves Midwest City. There is no alternate supply with minimal hookup requirements from alternate unthreatened source (Ref. 21).

Distance to Nearest Well

Location of nearest well drawing from aquifer of concern or occupied building not served by a public water supply:

Onsite water supply wells for Tinker AFB

Distance to above well or building:

Well 18; 0 Feet - well is inside the building and is contaminated (Ref. 4, Fig. 1-1 for location; Ref. 4, Table 4-13 for contamination)

Population Served by Ground Water Wells Within a 3-Mile Radius

Identified water-supply well(s) drawing from aquifer(s) of concern within a 3-mile radius and population served by each:

Tinker AFB, pop served = 3,320 (Ref. 6); 27 wells on base. At least 16 of 43 Midwest City water supply wells are within 3 miles of the site and screened in the aquifer of concern (Ref. 21). Radial system is used, so the entire population of 55,400 customers are potentially affected (Ref. 6).

Computation of land area irrigated by supply well(s) drawing from aquifer(s) of concern within a 3-mile radius, and conversion to population (1.5 people per acre):

Unidentified

Total population served by ground water within a 3-mile radius:

Minimum 3,320 + 55,400 (Ref. 6)

Ref
1/31/85

SURFACE WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected in surface water at the facility or downhill from it (5 maximum):

Chromium
Tetrachloroethylene (Ref. 7, pages 7-9 and Table 1)

Rationale for attributing the contaminants to the facility:

Contaminants found in water of storm sewer coming from building 3001 and draining into tributary of Soldier Creek. Since these tributaries show as intermittent streams on USGS Quad maps (Midwest City and Choctaw, Okla. Ref. 22) no observed release is recorded for HRS purposes.

* * *

2 ROUTE CHARACTERISTICS

Facility Slope and Intervening Terrain

Average slope of facility in percent:
Route has not been evaluated because no targets within the 3 mile HRS limit have been identified. Thus the route score is 0.

Name/description of nearest downslope surface water:

Average slope of terrain between facility and above-cited surface water body in percent:

Is the facility located either totally or partially in surface water?

1/31/85

Is the facility completely surrounded by areas of higher elevation?

1-Year 24-Hour Rainfall in Inches

Distance to Nearest Downslope Surface Water

Physical State of Waste

* * *

3 CONTAINMENT

Containment

Method(s) of waste or leachate containment evaluated:

Method with highest score:

ECG
1/31/85

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated

Compound with highest score:

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

Basis of estimating and/or computing waste quantity:

* * *

5 TARGETS

Surface Water Use

Use(s) of surface water within 3 miles downstream of the hazardous substance:

KCJ
1/31/85

Is there tidal influence?

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

Distance to critical habitat of an endangered species or national wildlife refuge, if 1 mile or less:

Population Served by Surface Water

Location(s) of water-supply intake(s) within 3 miles (free-flowing bodies) or 1 mile (static water bodies) downstream of the hazardous substance and population served by each intake:

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1/31/85

Computation of land area irrigated by above-cited intake(s) and conversion to population (1.5 people per acre):

Total population served:

Name/description of nearest of above water bodies:

Distance to above-cited intakes, measured in stream miles.

KCJ
1/31/89

AIR ROUTE

1 OBSERVED RELEASE NO RELEASE DETECTED, ROUTE SCORE = 0.

Contaminants detected:

Date and location of detection of contaminants

Methods used to detect the contaminants:

Rationale for attributing the contaminants to the site:

* * *

2 WASTE CHARACTERISTICS

Reactivity and Incompatibility

Most reactive compound:

Most incompatible pair of compounds:

RNJ 1/31/85

Toxicity

Most toxic compound:

Hazardous Waste Quantity

Total quantity of hazardous waste:

Basis of estimating and/or computing waste quantity:

* * *

3 TARGETS

Population Within 4-Mile Radius

Circle radius used, give population, and indicate how determined:

0 to 4 mi 0 to 1 mi 0 to 1/2 mi 0 to 1/4 mi

Distance to a Sensitive Environment

Distance to 5-acre (minimum) coastal wetland, if 2 miles or less:

Distance to 5-acre (minimum) fresh-water wetland, if 1 mile or less:

RCG 1/31/89

Distance to critical habitat of an endangered species, if 1 mile or less:

Land Use

Distance to commercial/industrial area, if 1 mile or less:

Distance to national or state park, forest, or wildlife reserve, if 2 miles or less:

Distance to residential area, if 2 miles or less:

Distance to agricultural land in production within past 5 years, if 1 mile or less:

Distance to prime agricultural land in production within past 5 years, if 2 miles or less:

Is a historic or landmark site (National Register or Historic Places and National Natural Landmarks) within the view of the site?

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1/31/85

1 CONTAINMENT

Hazardous substances present:

Threat not observed by field measurement or Fire Marshall certification Ref. HRS manual pp 49 sect. 7.0

Type of containment, if applicable:

* * *

2 WASTE CHARACTERISTICS

Direct Evidence

Type of instrument and measurements:

Ignitability

Compound used:

Reactivity

Most reactive compound:

Incompatibility

Most incompatible pair of compounds:

* * *

Rej 1/31/85

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility:

Basis of estimating and/or computing waste quantity:

* * *

I TARGETS

Distance to Nearest Population

Distance to Nearest Building

Distance to Sensitive Environment

Distance to wetlands:

Distance to critical habitat:

Land Use

Distance to commercial/industrial area, in 1 mile or less:

RCH 1/31/85

Distance to national or state park, forest, or wildlife reserve, if 2 miles or less:

Distance to residential area, if 2 miles or less:

Distance to agricultural land in production within past 5 years, if 1 mile or less:

Distance to prime agricultural land in production within past 5 years, if 2 miles or less:

Is a historic or landmark site (National Register of Historic Places and National Natural Landmarks) within the view of the site?

Population Within 2-Mile Radius

Buildings Within 2-Mile Radius

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1 OBSERVED INCIDENT

Date, location, and pertinent details of incident:

NONE

* * *

2 ACCESSIBILITY

Describe type of barrier(s):

Site is a controlled entry and exit area owned by DOD.

* * *

3 CONTAINMENT

Type of containment, if applicable:

* * *

4 WASTE CHARACTERISTICS

Toxicity

Compounds evaluated:

Compound with highest score:

* * *

Rcd 1/31/89

5 TARGETS

Population within one-mile radius

Distance to critical habitat (of endangered species)

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1/31/85

REFERENCES

If the entire reference is not available for public review in the EPA regional files on this site, indicate where the reference may be found:

Reference Number	Description of the Reference
1	**Uncontrolled Hazardous Waste Site Ranking System; A Users Manual.**
	National Oil and Hazardous Substances Contingency Plan, Appendix A (40 CFR 300)(47 FR 31219), July 16, 1982.
2	Site Inspection Report, USEPA form 2070-3. Kelly Nash. 4/23/84.
3	Installation Restoration Program, Phase I - Records Search. Tinker AFB, Okalhoma. April 1982.
4	Installation Restoration Program, Phase II Stage 1. Field Evaluation. Tinker AFB, Oaklahoma. Draft Final Report. Nov. 1984.
5	"Building 3001: Buried Pit and ~~Trails~~ TANK Survey." Radian Corp. 31 Aug. 1984.
6	"Public Water Supply Report" for Midwest City and for Tinker AFB. 1982.
7	"Inspection Report - Tinker Air Force Base." Oklahoma Water Resources, Water Quality Division. Dated June 19, 1984.
8	Record of Communication. Drew Ratfer, USEPA, to Lt. Bill Johnson, Tinker AFB. Location of wells 8 & 9, along with map showing location. 11/28/84.
9	CERCLA 103C Notification, Tinker AFB. 28 May 81.
10	Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahoma: Sheet 2 - Bedrocks Aquifers and Recharge Areas. Compiled by K.S. Johnson, Oklahoma Geological Survey, 1963.
	Testimony: Dr. C.J. Mankin, Director, Oklahoma Geological Survey, at Tinker Air Force Base Hearing, Subcommittee on Environment, Energy and Natural Resources, Dec. 12, 1984.
11	Map: Oklahoma City Industrial Districts and Expressway Systems. Oklahoma City Chamber of Commerce, Economic Development Division.
12	Analytical Results, Wells 6A through 6G, 1984. Transmitted by WM Little, Radian Corp, to Cpt. R.W. Bauer, Tinker AFB. 8/8/84 and 9/13/84.

RCB 1/31/85

14 Record of Communication: Drew Puffer, USEPA to Wm Little, Radian Corp. 1/8/85.

15 Analytical Results, Well 16. Transmitted by E.A. Jeffrey, USEPA to Cpt. D.R. Escoriaza, Tinker AFB on 30 Aug. 1982.

16 Letter: David W. McElwey, Major, USAF to E.A. Jeffrey, USEPA. 30 Sep. 1982.

17 Analytical Results from Ground Water Supply Study. Transmitted by Ed. Jeffrey, USEPA, to Mike Harrell. 3/2/82.

18 Groundwater Supply Survey, by J.J. Westrick et al., Journal AWWA, pages 52-59. May 1964.

19 Oklahoma Water Quality Standards - 1982. Publication 111. Oklahoma Water Resources Board.

20 Record of Communication: Drew Puffer, USEPA to Capt. Cornell, Tinker AFB. 11/5/84.

21 Record of Communication: Kelly Nash, USEPA to T. Perdue, USEPA. 1/30/85, with attachment of Midwest City well locations.

22 USGS topo quad maps: Choctaw and Midwest City, both photorevised to 1975.

RCA 1/29/85

Reference #2
Site Inspection Report, USEPA form 2070-3 Kelly Nash. 4/23/84.

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT

REGION	SITE NUMBER (to be assigned by HQ)
6	OK-03646

GENERAL INSTRUCTIONS: Complete Sections I and III through XV of this form as completely as possible. Then use the information on this form to develop a Tentative Disposition (Section II). File this form in its entirety in the regional Hazardous Waste Log F[illegible] sure to include all appropriate Supplemental Reports in the file. Submit a copy of the forms to: U.S. Environmental Protection Agency, Site Tracking System, Hazardous Waste Enforcement Task Force (EN-335), 401 M St., SW, Washington, DC 20460.

I. SITE IDENTIFICATION

A. SITE NAME: Tinker Air Force Base

B. STREET (or other identifier): 2854 CES/DEEX

C. CITY: Oklahoma City

D. STATE: OK.

E. ZIP CODE:

F. COUNTY NAME:

G. SITE OPERATOR INFORMATION

1. NAME: U.S. Air Force

2. TELEPHONE NUMBER:

3. STREET:

4. CITY:

5. STATE:

6. ZIP CODE:

H. REALTY OWNER INFORMATION (If different from operator of site)

1. NAME: U.S. Air Force

2. TELEPHONE NUMBER:

3. CITY:

4. STATE:

5. ZIP CODE:

I. SITE DESCRIPTION: Airbase, aircraft maintenance, jet engine rebuilding

J. TYPE OF OWNERSHIP

[X] 1. FEDERAL [ ] 2. STATE [ ] 3. COUNTY [ ] 4. MUNICIPAL [ ] 5. PRIVATE

II. TENTATIVE DISPOSITION (complete this section last)

A. ESTIMATE DATE OF TENTATIVE DISPOSITION (mo., day, & yr.):

B. APPARENT SERIOUSNESS OF PROBLEM

[ ] 1. HIGH [ ] 2. MEDIUM [ ] 3. LOW [ ] 4. NONE

C. PREPARER INFORMATION

1. NAME: Kelly Nash

2. TELEPHONE NUMBER: (214)767-9706

3. DATE (mo., day, & yr.): 4/23/84

III. INSPECTION INFORMATION

A. PRINCIPAL INSPECTOR INFORMATION

1. NAME:

2. TITLE:

3. ORGANIZATION:

4. TELEPHONE NO. (area code & no.):

B. INSPECTION PARTICIPANTS

1. NAME	2. ORGANIZATION	3. TELEPHONE NO.

C. SITE REPRESENTATIVES INTERVIEWED (corporate officials, workers, residents)

1. NAME	2. TITLE & TELEPHONE NO.	3. ADDRESS

Continue On Reverse

22

Continued From Front

III. INSPECTION INFORMATION *(continued)*

D. GENERATOR INFORMATION *(sources of waste)*

1. NAME	2. TELEPHONE NO.	3. ADDRESS	4. WASTE TYPE GENERATED

E. TRANSPORTER/HAULER INFORMATION

1. NAME	2. TELEPHONE NO.	3. ADDRESS	4. WASTE TYPE TRANSPORTED

F. IF WASTE IS PROCESSED ON SITE AND ALSO SHIPPED TO OTHER SITES, IDENTIFY OFF-SITE FACILITIES USED FOR DISPOSAL.

1. NAME	2. TELEPHONE NO.	3. ADDRESS

G. DATE OF INSPECTION (mo., day, & yr.)	H. TIME OF INSPECTION	I. ACCESS GAINED BY. *(credentials must be shown in all cases)*
		☐ 1. PERMISSION ☐ 2. WARRANT

J. WEATHER *(describe)*

IV. SAMPLING INFORMATION

Mark 'X' for the types of samples taken and indicate where they have been sent e.g., regional lab, other EPA lab, contractor, and estimate when the results will be available.

1. SAMPLE TYPE	2. SAMPLE TAKEN (mark 'X')	3. SAMPLE SENT TO:	4. DATE RESULTS AVAILABLE
a. GROUNDWATER			
b. SURFACE WATER			
c. WASTE			
d. AIR			
e. RUNOFF			
f. SPILL			
g. SOIL			
h. VEGETATION			
i. OTHER *(specify)*			

B. FIELD MEASUREMENTS TAKEN *(e.g., radioactivity, explosivity, PH, etc.)*

1. TYPE	2. LOCATION OF MEASUREMENTS	3. RESULTS

Continued From Page 2

IV. SAMPLING INFORMATION (continued)

C. PHOTOS

1. TYPE OF PHOTOS

☐ a. GROUND ☐ b. AERIAL

2. PHOTOS IN CUSTODY OF:

D. MAPPED?

ES. SPECIFY LOCATION OF MAPS

E. COORDINATES

1. LATITUDE (deg.-min.-sec.)

2. LONGITUDE (deg.-min.-sec.)

V. SITE INFORMATION

A. SITE STATUS

☒ 1. ACTIVE (Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.)

☐ 2. INACTIVE (Those sites which no longer receive wastes.)

☐ 3. OTHER (specify): _____ (Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.)

B. IS GENERATOR ON SITE?

☐ 1. NO ☐ 2. YES (specify generator's four-digit SIC Code): _____

C. AREA OF SITE (in acres)

D. ARE THERE BUILDINGS ON THE SITE?

☐ 1. NO ☒ 2. YES (specify):

VI. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major site activity(ies) and details relating to each activity by marking 'X' in the appropriate boxes.

X	A. TRANSPORTER	X	B. STORER	X	C. TREATER	X	D. DISPOSER
	1. RAIL		1. PILE		1. FILTRATION	X	1. LANDFILL
	2. SHIP	X	2. SURFACE IMPOUNDMENT		2. INCINERATION		2. LANDFARM
	3. BARGE		3. DRUMS		3. VOLUME REDUCTION		3. OPEN DUMP
	UCK	X	4. TANK, ABOVE GROUND		4. RECYCLING/RECOVERY	X	4. SURFACE IMPOUNDMENT
	ELINE	X	5. TANK, BELOW GROUND		5. CHEM./PHYS./TREATMENT		5. MIDNIGHT DUMPING
	OTHER (specify):		6. OTHER (specify):		6. BIOLOGICAL TREATMENT		6. INCINERATION
					7. WASTE OIL REPROCESSING		7. UNDERGROUND INJECTION
					8. SOLVENT RECOVERY		8. OTHER (specify):
					9. OTHER (specify):		

E. SUPPLEMENTAL REPORTS If the site falls within any of the categories listed below, Supplemental Reports must be completed. Indicate which Supplemental Reports you have filled out and attached to this for..

☐ 1. STORAGE ☐ 2. INCINERATION ☐ 3. LANDFILL ☐ 4. SURFACE IMPOUNDMENT ☐ 5. DEEP WELL

☐ 6. CHEM/BIO/PHYS TREATMENT ☐ 7. LANDFARM ☐ 8. OPEN DUMP ☐ 9. TRANSPORTER ☐ 10. RECYCLOR/RECLAIMER

VII. WASTE RELATED INFORMATION

A. WASTE TYPE

☒ 1. LIQUID ☒ 2. SOLID ☒ 3. SLUDGE ☐ 4. GAS

B. WASTE CHARACTERISTICS

☐ 1. CORROSIVE ☒ 2. IGNITABLE ☒ 3. RADIOACTIVE ☐ 4. HIGHLY VOLATILE

☒ 5. TOXIC ☐ 6. REACTIVE ☒ 7. INERT ☒ 8. FLAMMABLE

☐ 9. OTHER (specify):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

Phase I Assessment completed, Phase II report expected 5/84.

Continue On Reverse

VII. WASTE RELATED INFORMATION (continued)

2. Estimate the amount (specify unit of measure) of waste by category. mark 'X' to indicate which wastes are present.

a. SLUDGE	b. OIL	c. SOLVENTS	d. CHEMICALS	e. SOLIDS	f. OTHER
AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT	AMOUNT
UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE	UNIT OF MEASURE
X (1) PAINT, PIGMENTS	X (1) OILY WASTES	X (1) HALOGENATED SOLVENTS	X (1) ACIDS	X (1) FLYASH	X (1) LABORATORY, PHARMACEUT.
(2) METALS SLUDGES	(2) OTHER (specify)	X (2) NON-HALOGNTD. SOLVENTS	(2) PICKLING LIQUORS	(2) ASBESTOS	(2) HOSPITAL
(3) POTW		(3) OTHER (specify)	(3) CAUSTICS	(3) MILLING/MINE TAILINGS	(3) RADIOACTIVE
(4) ALUMINUM SLUDGE			X (4) PESTICIDES	(4) FERROUS SMELTING WASTES	X (4) MUNICIPAL
(5) OTHER (specify)			(5) DYES/INKS	(5) NON-FERROUS SMLTG. WASTES	(5) OTHER (specify)
			(6) CYANIDE	(6) OTHER (specify)	
			(7) PHENOLS	Military ammunition	
			(8) HALOGENS		
			(9) PCB		
			X (10) METALS		
			(11) OTHER (specify)		

D. SUBSTANCES OF GREATEST CONCERN WHICH ARE ON THE SITE (place in descending order of hazard)

1. SUBSTANCE	2. FORM (mark 'X')			3. TOXICITY (mark 'X')				4. CAS NUMBER	5. AMOUNT	6. UNIT
	a. SOLID	b. LIQ.	c. VAPOR	a. HIGH	b. MED.	c. LOW	d. NONE			
Tetrachloroethylene		X		X						
Dichloroethylene		X			X					
Trichloroethylene		X			X					
Toluene		X			X					

VIII. HAZARD DESCRIPTION

FIELD EVALUATION HAZARD DESCRIPTION. Place an 'X' in the box to indicate that the listed hazard exists. Describe the hazard in the space provided.

☐ A. HUMAN HEALTH HAZARDS

organic compounds present in drinking water aquifer

Continue On Page 5

Continued From Page 4

VII. HAZARD DESCRIPTION (continued)

☐ B. NON-WORKER INJURY/EXPOSURE

☐ C. WORKER INJURY/EXPOSURE

☒ D. CONTAMINATION OF WATER SUPPLY

Documented contamination of base water supply wells. Municipal supply wells within 3 miles.

☐ E. CONTAMINATION OF FOOD CHAIN

☒ F. CONTAMINATION OF GROUND WATER

Substances in VII D. documented in base water supply wells (EPA ground water supply survey).

☐ G. CONTAMINATION OF SURFACE WATER

Continued From Front

VIII. HAZARD DESCRIPTION (continued)

☐ H. DAMAGE TO FLORA/FAUNA

☐ I. FISH KILL

☐ J. CONTAMINATION OF AIR

☐ K. NOTICEABLE ODORS

☐ L. CONTAMINATION OF SOIL

☐ M. PROPERTY DAMAGE

Continue On Page 7

Continued From Page 6

VIII. HAZARD DESCRIPTION (continued)

☐ N. FIRE OR EXPLOSION

☐ O. SPILLS/LEAKING CONTAINERS/RUNOFF/STANDING LIQUID

☐ P. SEWER, STORM DRAIN PROBLEMS

☐ Q. EROSION PROBLEMS

☐ R. INADEQUATE SECURITY

☐ S. INCOMPATIBLE WASTES

VII. HAZARD DESCRIPTION (continued)

☐ T. MIDNIGHT DUMPING

☐ U. OTHER (specify):

IX. POPULATION DIRECTLY AFFECTED BY SITE

A. LOCATION OF POPULATION	B. APPROX. NO. OF PEOPLE AFFECTED	C. APPROX. NO. OF PEOPLE AFFECTED WITHIN UNIT AREA	D. APPROX. NO. OF BUILDINGS AFFECTED	E. DISTANCE TO SITE (specify units)
1. IN RESIDENTIAL AREAS	68,000			
2. IN COMMERCIAL OR INDUSTRIAL AREAS				
3. IN PUBLICLY TRAVELLED AREAS				
4. PUBLIC USE AREAS (parks, schools, etc.)				

X. WATER AND HYDROLOGICAL DATA

A. DEPTH TO GROUNDWATER (specify units)	B. DIRECTION OF FLOW	C. GROUNDWATER USE IN VICINITY
75-100 ft.		drinking water, commercial, industrial
D. POTENTIAL YIELD OF AQUIFER	**E. DISTANCE TO DRINKING WATER SUPPLY (specify unit of measure)**	**F. DIRECTION TO DRINKING WATER SUPPLY**
500 gpm	0 ft.	

PE OF DRINKING WATER SUPPLY

☐ 1. NON-COMMUNITY < 15 CONNECTIONS ☒ 2. COMMUNITY (specify name): Midwest City, Tinker AFB > 15 CONNECTIONS

☐ 3. SURFACE WATER ☐ 4. WELL

Continue On Page 9

Co: From Page 8

X. WATER AND HYDROLOGICAL DATA (continued)

H. LIST ALL DRINKING WATER WELLS WITHIN A 1/4 MILE RADIUS OF SITE

1. WELL	2. DEPTH (specify unit)	3. LOCATION (proximity to population/buildings)	4. NON-COMMUNITY (mark 'X')	5. COMMUNITY (mark 'X')
1-26	125 ft.	Tinker AFB		X
	Garber			
	Wellington			

I. RECEIVING WATER

1. NAME: Canadian River

☐ 2. SEWERS ☒ 3. STREAMS/RIVERS ☐ 4. LAKES/RESERVOIRS ☐ 5. OTHER (specify)

6. SPECIFY USE AND CLASSIFICATION OF RECEIVING WATERS

Contact and non-contact recreation
Propagation of fish and wildlife.

XI. SOIL AND VEGITATION DATA

LOCATION OF SITE IS IN:

☐ A. KNOWN FAULT ZONE ☐ B. KARST ZONE ☐ C. 100 YEAR FLOOD PLAIN ☐ D. WETLAND

☐ E. A REGULATED FLOODWAY ☐ F. CRITICAL HABITAT ☒ G. RECHARGE ZONE OR SOLE SOURCE AQUIFER

XII. TYPE OF GEOLOGICAL MATERIAL OBSERVED

Mark 'X' to indicate the type(s) of geological material observed and specify where necessary, the component parts.

'X'	A. OVERBURDEN	'X'	B. BEDROCK (specify below)	'X'	C. OTHER (specify below)
X	1. SAND		Sandstone		
	2. CLAY				
	3. GRAVEL				

XIII. SOIL PERMEABILITY

☐ A. UNKNOWN ☐ B. VERY HIGH (100,000 to 1000 cm/sec.) ☐ C. HIGH (1000 to 10 cm/sec.)

☒ D. MODERATE (10 to .1 cm/sec.) ☐ E. LOW (.1 to .001 cm/sec.) ☐ F. VERY LOW (.001 to .00001 cm/sec.)

G. RECHARGE AREA

☒ 1. YES ☐ 2. NO 3. COMMENTS

H. DISCHARGE AREA

☐ 1. YES ☐ 2. NO 3. COMMENTS

I. SLOPE

1. ESTIMATE % OF SLOPE 2. SPECIFY DIRECTION OF SLOPE, CONDITION OF SLOPE, ETC.

J. OTHER GEOLOGICAL DATA

Continue On Reverse

30

XIV. PERMIT INFORMATION

List all applicable permits held by the site and provide the related information.

A. PERMIT TYPE (e.g., RCRA, State, NPDES, etc.)	B. ISSUING AGENCY	C. PERMIT NUMBER	D. DATE ISSUED (mo., day, & yr.)	E. EXPIRATION DATE (mo., day, & yr.)	F. IN COMPLIANCE (mark 'X')		
					1. YES	2. NO	3. UNKNOWN

XV. PAST REGULATORY OR ENFORCEMENT ACTIONS

☒ NONE ☐ YES (summarize in this space)

NOTE: Based on the information in Sections III through XV, fill out the Tentative Disposition (*Section II*) information on the first page of this form.

132 pp

DK 3646

INSTALLATION RESTORATION PROGRAM

PHASE I – RECORDS SEARCH

TINKER AFB, OKLAHOMA

PREPARED FOR

UNITED STATES AIR FORCE
AFESC/DEV
Tyndall AFB, Florida

ES ENGINEERING-SCIENCE

APRIL, 1982

A-1

Reference #3
Installation Restoration Program, Phase I - Records Search.
Tinker AFB, Oklahoma. April 1982.

INSTALLATION RESTORATION PROGRAM
PHASE I: RECORDS SEARCH
TINKER AFB, OKLAHOMA

Prepared For

United States Air Force
AFESC/DEV
Tyndall AFB, Florida

April, 1982

By

ENGINEERING-SCIENCE
57 Executive Park South, NE
Suite 590
Atlanta, Georgia 30329

This report has been prepared for the U.S. Air Force by Engineering-Science for the purpose of aiding in the implementation of the Air Force Installation Restoration Program. It is not an endorsement of any product. The views expressed herein are those of the contractor and do not necessarily reflect the official views of the publishing agency, the United States Air Force or the Department of Defense.

ES ENGINEERING-SCIENCE

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CABLE ADDRESS ENGINSCI
TELEX: 54-2882

9656

April 15, 1982

Mr. Bernard Lindenberg
AFESC/DEVP
Tyndall AFB, Florida 32403

Dear Mr. Lindenberg:

Enclosed is the Engineering-Science, Inc. (ES) final report entitled "Installation Restoration Program, Phase I Records Search, Tinker AFB, Oklahoma." This report has been prepared in accordance with the ES proposal dated July 15, 1981 and Air Force Contract Number F08637-80-G-0009 Call #0008.

Presented in this report are introductory background information on the Installation Restoration Program, a description of the Tinker AFB installation including past activities, mission and environmental setting, a review of industrial activities at Tinker AFB, an inventory of major solid and hazardous waste from past activities, a review of past and present waste handling, treatment and disposal facilities, an evaluation of the pollution potential of waste disposal sites, and recommendations for the Installation Restoration Program, Phase II, Problem Confirmation.

Any questions concerning this report should be refered to the Office of Public Affairs, Tinker Air Force Base, (405) 734-2026.

We appreciate the opportunity to work with you and the other Air Force personnel who contributed information to us for the completion of this assessment.

Very truly yours,

ENGINEERING-SCIENCE, INC.

E J Schroeder

E. J. Schroeder, P.E.
Manager, Solid & Hazardous Waste

EJS/lmr

Enclosure

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Department of Defense (DOD) has developed a program to identify and evaluate past hazardous material sites on DOD property, to control the migration of hazardous contaminants, and to control hazards to health or welfare that may result from these past disposal operations. This program is called the Installation Restoration Program (IRP). The IRP has four phases consisting of Phase I, Initial Assessment/Record Search; Phase II, Problem Confirmation; Phase III, Technology Base Development; and Phase IV, Operations. Engineering-Science (ES) was retained by the Air Force Engineering and Services Center to conduct the Phase I, Initial Assessment/Records Search at Tinker AFB under Contract No. F08637-80-G0009, Call No. 0008, using funding provided by the Air Force Logistics Command.

INSTALLATION DESCRIPTION

Tinker AFB is located in central Oklahoma southeast of Oklahoma City and contiguous with Midwest City. The base covers 4,277 acres and contains approximately 500 buildings. The base was activated in March 1942. The primary mission of the base is serving as a worldwide repair depot for several aircraft and a multitude of weapons and engines. This mission has remained unchanged since the late 1940's.

ENVIRONMENTAL SETTING

The environmental setting data reviewed for this study indicate the following key items concerning the impact of past waste disposal practices on the base:

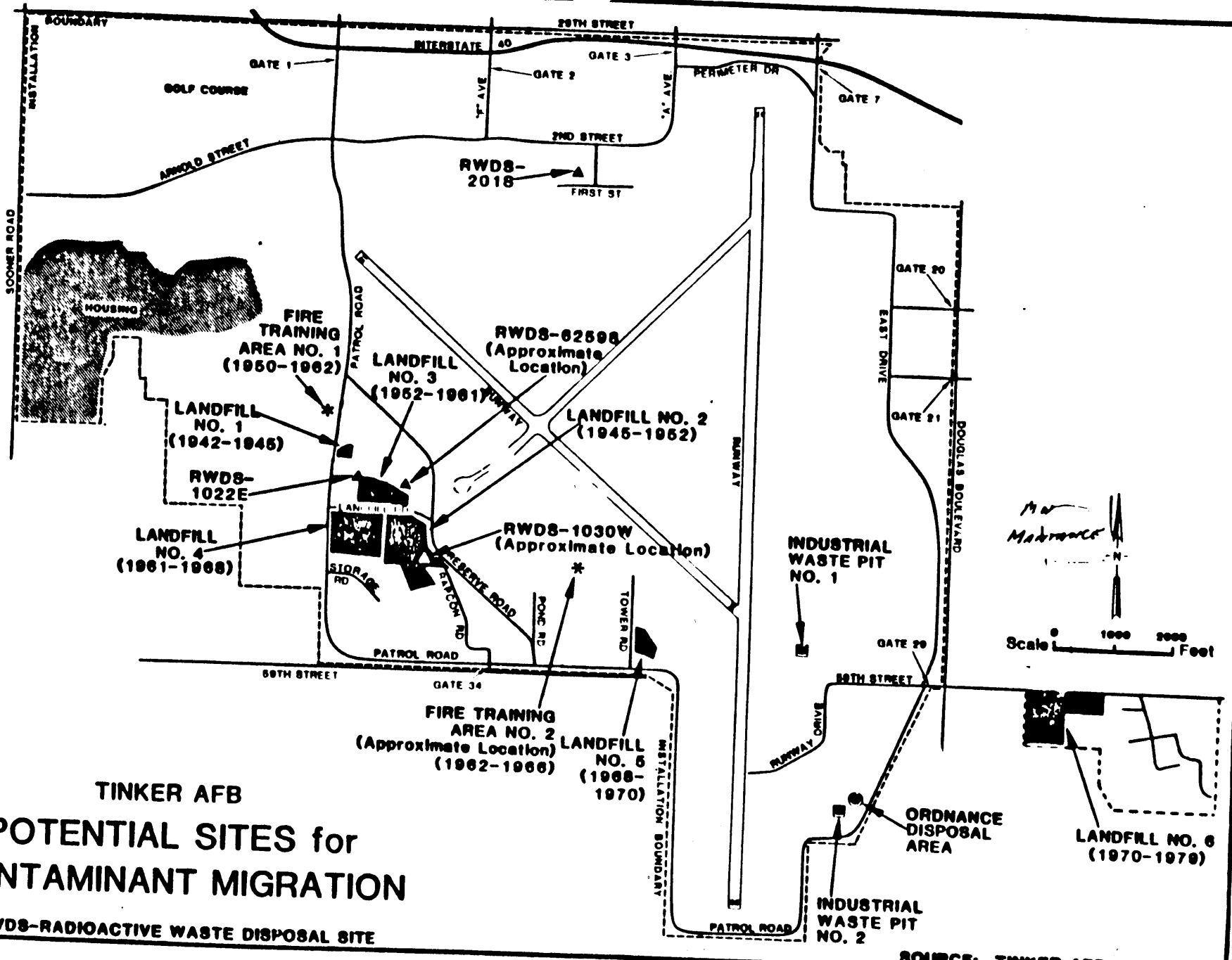
- Surficial soils at Tinker AFB are predominantly sands or silts which characteristically exhibit moderate to high permeabilities.
- The primary regional aquifer, the Garber-Wellington, is present at or near ground-surface over most of the base area. Ground water is encountered within the aquifer at moderate depth (250

feet). The upper section of the aquifer is primarily an unsaturated zone.

- Tinker AFB is located within a recharge area of the primary regional aquifer.
- The historical contamination of base surface waters and associated sediments has been documented. Stream water percolation is known to be one form of recharge to the Garber-Wellington Aquifer.
- The Tinker AFB mean annual precipitation is 32.4 inches, while lake evaporation is given at 60 inches as Tinker AFB is located in a water deficient zone of the U.S. Precipitation events releasing as much as 6.2 inches rainfall in a twenty-four hour period at Tinker AFB have been reported, causing local flooding (Weather Squadron Data).

METHODOLOGY

During the course of this project, interviews were conducted with base personnel (past and present) familiar with past waste disposal practices, file searches were performed for facilities which have generated, handled, transported, and disposed of waste materials, interviews were held with local, state and federal agencies, and site inspections were conducted at facilities that have generated, treated, stored, and disposed of hazardous waste. Fourteen disposal sites located on the Tinker AFB property were identified as containing hazardous waste resulting from past waste disposal activities (Figure 1). These sites have been assessed using a hazardous assessment rating methodology (HARM) which takes into account factors such as site characteristics, waste characteristics, potential for contaminant migration and waste management practices. The details of the rating procedure are presented in Appendix G and the results of the assessment are given in Table 1. The rating system is designed to indicate the relative need for follow-on action.



TINKER AFB

POTENTIAL SITES for CONTAMINANT MIGRATION

NOTE: RWDS-RADIOACTIVE WASTE DISPOSAL SITE

SOURCE: TINKER AFB DOCUMENTS

FIGURE 1

TABLE 1

PRIORITY RANKING OF POTENTIAL CONTAMINATION SOURCES

TINKER AFB

Rank	Site Name	Date of Operation or Occurrence	Overall Total Score
1	Landfill No. 4	1961-1968	70
2	Industrial Waste Pit No. 2	1958-1965	68
3	Landfill No. 2	1945-1952	65
4	Industrial Waste Pit No. 1	1947-1958	61
5	Landfill No. 3	1952-1961	60
6	RWDS 1030W	Prior to 1955	59
7	Landfill No. 6	1970-1979	56
8	Fire Training Area No. 1	1950-1962	55
9	Landfill No. 5	1968-1970	51
10	RWDS 1022E	Mid 1950's	49
11	Fire Training Area No. 2	1962-1966	47
12	Landfill No. 1	1942-1945	45
13	RWDS 62598	Early 1950's	37
14	RWDS 201S	Unknown	35

Note: This ranking was performed according to the Hazardous Assessment Rating Methodology (HARM) described in Appendix G. Individual site rating forms are in Appendix H.

FINDINGS AND CONCLUSIONS

The following conclusions have been developed based on the results of the project team's field inspection, review of base records and files and interviews with base personnel.

The areas determined to have a high potential for contaminant migration are as follows:

- Landfill No. 4
- Industrial Waste Pit No. 2
- Landfill No. 2

The areas determined to have a moderate potential for contaminant migration are as follows:

- Industrial Waste Pit No. 1
- Landfill No. 3
- RWDS 1030W
- Landfill No. 6
- Fire Training Area No. 1
- Landfill No. 5

The areas determined to have a low potential for contaminant migration are as follows:

- RWDS 1022E
- Fire Training Area No. 2
- Landfill No. 1
- RWDS 62598
- RWDS 201S

RECOMMENDATIONS

The detailed recommendations developed for further assessment of potential contaminant migration are presented in Chapter 6. These recommendations are summarized as follows:

- Landfill No. 4 — Conduct geophysical survey and additional groundwater monitoring. Sample and analyze any leachate streams.

o Industrial Waste Pits No. 1 and No. 2	-	Obtain soil borings in and around the waste pits. Conduct geophysical survey to define site boundaries and identify any leachate plumes.
o Landfill No. 3, No. 5 and No. 6	-	Conduct geophysical survey and additional groundwater monitoring.
o Fire Training Area No. 1	-	Obtain soil borings in and around the fire training area. Conduct geophysical survey to define site boundaries and identify any leachate plumes.
o Base Streams	-	Conduct sediment sampling and additional water quality sampling on base streams. Measure stream water levels in conjunction with base monitoring wells to determine if the stream is the source of the shallow aquifer water.
o Water Supply Wells	-	Collect and analyze water samples from well Nos. 6, 7, 16, 18, 22, 23, 24, 25, 27 and 28.

CHAPTER 1

INTRODUCTION

CHAPTER 1
INTRODUCTION

BACKGROUND

The United States Air Force, due to its primary mission, has long been engaged in a wide variety of operations dealing with toxic and hazardous materials. Federal, state and local governments have developed strict regulations to require that disposers identify the locations and contents of disposal sites and take action to eliminate the hazards in an environmentally responsible manner. The Department of Defense (DOD) has issued Defense Environmental Quality Program Policy Memorandums 80-6 and 81-5 which require the identification and evaluation of past hazardous material disposal sites on DOD property, the control of migration of hazardous contaminants, and the control of hazards to health or welfare that resulted from these past operations. This program is called the Installation Restoration Program (IRP). The IRP will be a basis for response actions on Air Force Installations under the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980.

PURPOSE AND SCOPE OF THE ASSESSMENT

The Installation Restoration Program has been developed as a four-phased program as follows:

- Phase I - Initial Assessment/Records Search
- Phase II - Problem Confirmation
- Phase III - Technology Base Development
- Phase IV - Operations (Control Measures)

Engineering-Science (ES) was retained by the Air Force Engineering and Services Center to conduct the Phase I Records Search at Tinker AF Base under Contract No. F08637-80-G0009, Call No. 0008, using funding provided by the Air Force Logistics Command. This report contains a summary and an evaluation of the information collected during Phase I of the IRP.

The goal of the first phase of the program was to identify the potential for environmental contamination from past waste disposal practices at Tinker AFB, and to assess the potential for contaminant migration. The activities undertaken in Phase I included the following:

- Review site records
- Interview personnel familiar with past generation and disposal activities
- Inventory wastes
- Determine quantities and locations of current and past hazardous waste storage, treatment and disposal
- Define the environmental setting at the base
- Review past disposal practices and methods
- Conduct field inspection
- Gather pertinent information from federal, state and local agencies
- Assess potential for contaminant migration

In order to perform the on-site portion of the records search phase, ES assembled the following core team of professionals:

- E. J. Schroeder, Environmental Engineer and Project Manager, MSCE, 14 years of professional experience
- J. R. Absalon, Hydrogeologist, BS Geology, 8 years of professional experience
- D. G. Johnson, Environmental Engineer, MSCE, 4 years of professional experience
- M. I. Spiegel, Environmental Scientist, BS Environmental Science, 5 years of professional esperience
- R. M. Reynolds, Chemical Engineer, BSChE, 8 years of professional experience

More detailed information on these individuals is presented in Appendix A.

METHODOLOGY

The methodology utilized in the Tinker AFB Records Search began with a review of past and present industrial operations conducted at the

base. Information was obtained from available records such as shop files and real property files, as well as interviews with past and present base employees from the various operating areas of the base. Those interviewed included current and past environmental personnel associated with the Civil Engineering Squadron, the Bioenvironmental Engineering Services Division office, and the Directorate of Maintenance. Several current or past personnel associated with the wastewater treatment plant, the pesticide operations, fuels management and the base solid waste disposal areas were interviewed extensively. Experienced personnel from the tenant organizations were also interviewed. Formal interviews were conducted with 71 individuals to obtain the needed past activity information.

Concurrent with the base interviews the applicable federal, state and local agencies were contacted and interviewed for pertinent base related environmental data. The agencies contacted are listed as follows:

- Oklahoma Geological Survey, Norman, Oklahoma
- U.S. Geological Survey, Water Resources Division, Oklahoma City, Oklahoma
- Oklahoma Water Resources Board, Oklahoma City, Oklahoma
- US Environmental Protection Agency, Region VI, Dallas, Texas
- University of Oklahoma Health Sciences Center, Department of Environmental Health, Oklahoma City, Oklahoma

The next step in the activity review was to determine the past management practices regarding the use, storage, treatment, and disposal of hazardous materials from the various operations on the base. Included in this part of the activities review was the identification of all known past disposal sites and any other possible sources of contamination such as fuel-saturated areas resulting from large fuel spills.

An aerial overflight and a general ground tour of identified sites were then made by the ES Project Team to gather site specific information including (1) visual evidence of environmental stress, (2) the

presence of nearby drainage ditches or surface-water bodies, and (3) visual inspection of these water bodies for any obvious signs of contamination or leachate migration.

A decision was then made, based on all of the above information, whether a potential exists for hazardous material contamination at any of the identified sites using the decision tree shown in Figure 4.1. If no potential exists, the site was deleted from further consideration. For those sites where a potential for contamination was identified, a determination of the potential for migration of the contamination was made by considering site-specific conditions. If the potential for contaminant migration was considered significant, then the site was evaluated and prioritized using the hazardous assessment rating methodology (HARM).

The HARM score indicates the relative potential for contaminant migration at each site. For those sites showing a high potential, recommendations are made to quantify the potential contaminant migration problem under Phase II of the Installation Restoration Program. For those sites showing a moderate potential, a limited Phase II program may be recommended to confirm that a contaminant migration problem does or does not exist. For those sites showing a low potential, no further follow-up Phase II work would be recommended.

CHAPTER 2

INSTALLATION DESCRIPTION

CHAPTER 2

INSTALLATION DESCRIPTION

LOCATION, SIZE AND BOUNDARIES

Tinker AFB is located approximately in the center of the State of Oklahoma and contiguous with Oklahoma City (Figures 2.1, 2.2 and 2.3). The Base is within the North Canadian River drainage basin and drains principally into Crutcho and Soldier Creeks. The boundaries of the base cover 4,277 acres and contain approximately 500 buildings with 9.4 million square feet of floor space dedicated to operational, industrial, administrative and ordnance functions. Present land areas adjacent to the base are primarily as follows:

North - residential and commercial;

West - residential

South - residential, commercial and agricultural

East - residential, commercial and agricultural

The most prominent physiographic feature of the area is the North Canadian River.

BASE HISTORY

The initial construction of Midwest Air Depot (what is now Tinker AFB) began in July 1941, and the base was activated in March 1942. During World War II, the depot was responsible for reconditioning, modifying and modernizing aircraft, vehicles and equipment and the civilian employment peaked at 14,925 employees.

At the conclusion of World War II, the Douglas Aircraft Plant located east of the north-south runway was combined with the Base. Tinker became involved in jet engine overhaul and later modification of aircraft out of storage in a program to rebuild the nation's airpower. In 1948 Tinker Air Force Base became a worldwide repair depot for several aircraft and a multitude of other weapons and engines. The level of activity has fluctuated during history of the base, however the primary mission has

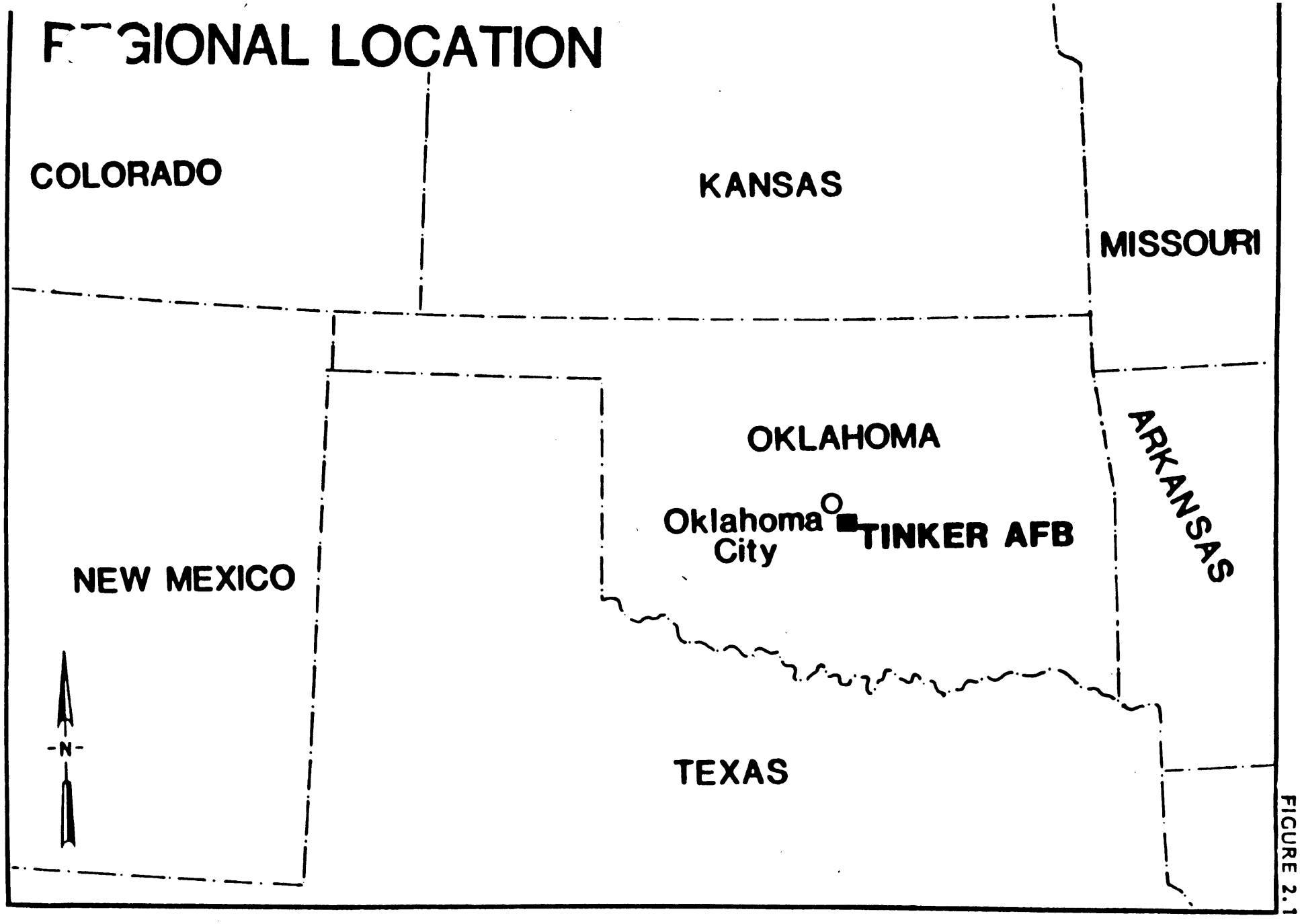

REGIONAL LOCATION
COLORADO
KANSAS
MISSOURI
OKLAHOMA
ARKANSAS
Oklahoma City
TINKER AFB
NEW MEXICO
TEXAS
N

FIGURE 2.1

FIGURE 2.2

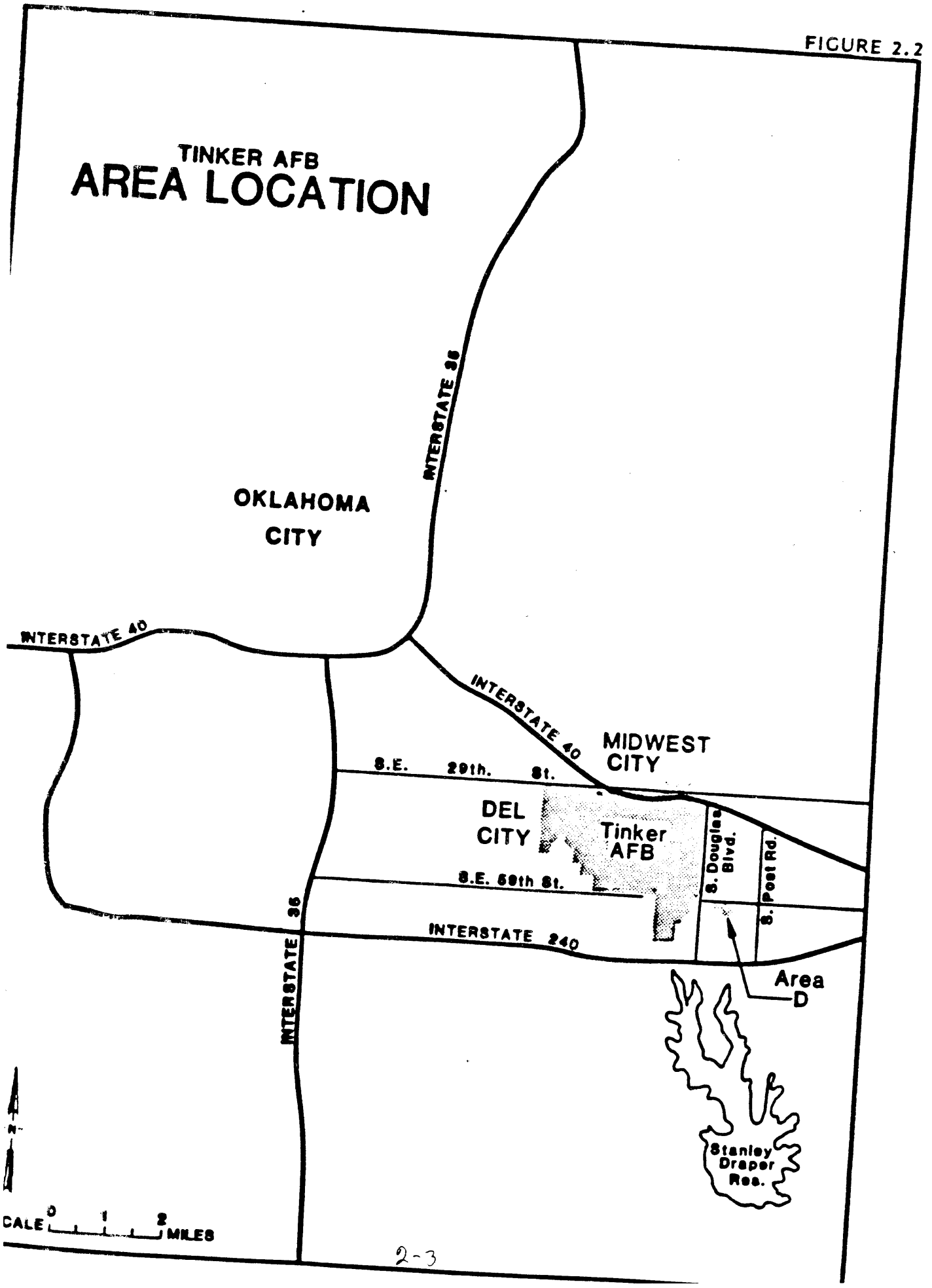
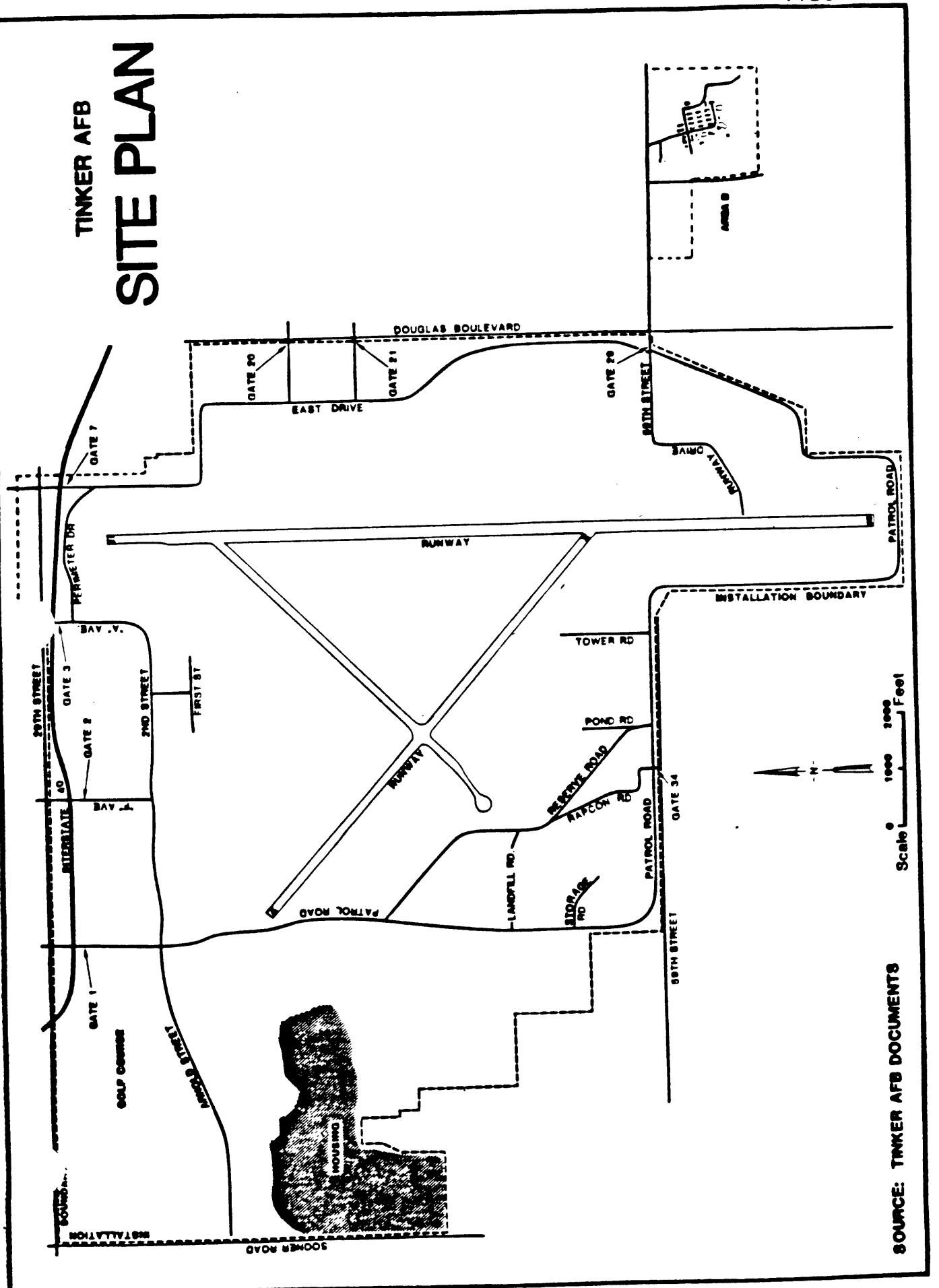

TINKER AFB
AREA LOCATION
OKLAHOMA CITY
INTERSTATE 35
INTERSTATE 40
INTERSTATE 40
MIDWEST CITY
S.E. 29th. St.
DEL CITY
Tinker AFB
S. Douglas Blvd.
S. Post Rd.
S.E. 59th St.
INTERSTATE 35
INTERSTATE 240
Area D
Stanley Draper Res.
N
SCALE 0 1 2 MILES

FIGURE 2.3

TINKER AFB SITE PLAN



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not changed and Tinker AFB is still a major industrial complex for overhauling, modifying, and repairing military aircraft, aircraft engines, and accessory items.

The base has made several land acquisitions besides the Douglas Aircraft Plant. During 1951 the Air Force acquired a parcel of land located one half mile east of the southeast corner of Tinker AFB (Area "D"). The area was named the Oklahoma City Air Force Station and was supported by Tinker AFB. In 1956, the area officially became a separate entity; however support was still provided by Tinker AFB. The area was initially occupied by the 33rd Air Division and is presently occupied by the Engineering Installations Center, part of the Air Force Communications Command. In 1954 the base acquired a parcel of land south of the 59th Street boundary to extend the existing main runway. The land acquisition consisted of approximately 300 acres. During 1956, the base acquired additional land in the same area completing the parcel of land south of 59th Street presently within Tinker AFB jurisdiction. In 1957, a 638 acre tract of land immediately west of the original air base was acquired to develop permanent military housing and community support facilities. In 1975 the base acquired an additional 187 acres of land situated contiguous to the westside of Air Depot Boulevard between SE 59th Street and SE 44th Street.

A complete history of Tinker Air Force Base is presented in Appendix B.

ORGANIZATION AND MISSION

Tinker AFB has a multi-fold flying mission consisting of logistics support, administrative flight and pilot proficiency training. Production flight checks of aircraft that have undergone depot maintenance, repair and/or modification comprises the major portion of the logistic support flight mission. The 552nd Airborne Warning and Control Group (AWACW) operates and maintains the E-3A Sentry aircraft. The 552nd's mission includes training flights as well as support of the Tactical Air Commands worldwide mobile strike force. The Det 507, 301 Tactical Fighter Group (Reserves) performs tactical fighter training in the F-4 aircraft. The reserve unit maintains combat proficiency and readiness of the personnel and aircraft.

The support function for the base is performed by the 2854th Air Base Wing which contains all administrative, security, maintenance, housekeeping, housing, fire protection, legal assistance and logistical support for the base.

The Oklahoma City Air Logistics Center (OCALC) is the major organization at Tinker AFB. The mission of the OCALC is to provide logistic support to the operating commands of the USAF. The OCALC is the logistic support manager for almost all of the Strategic Air Command's bomber and tanker fleet, three air-launched missiles, a substantial portion of the jet engines in the Air Force inventory, and approximately 140,000 items in the hydraulics, pneumatics and instrument areas. The Center also supports a huge industrial complex to overhaul, modify and repair the aircraft, aircraft engines and a vast number of accessory items.

A description of the tenants and their missions is presented in Appendix B. The tenants of the 2854th Air Base Group include the following units:

- 552 Airborne Warning and Control Group (AWACG)
- Engineering and Installation Center
- Det 507, 301 Tactical Fighter Group
- 3rd Combat Communications Group
- Communications Computer Programming Center
- 6th Weather Squadron Mobile
- Air Force Audit Agency Office
- Defense Logistics Agency, Memphis Region
- Defense Property Disposal Office, Oklahoma City
- USAF Hospital, Tinker
- 2953rd Combat Logistics Support Squadron
- Det, 3025 AFLC Mgt Engr Team
- 1985th Communications Squadron
- AF Office of Special Investigation
- Corps of Engineers, Resident Engineer
- Dept of Transp, Federal Aviation Administration
- Det 1, 60th Military Airlift Wing
- Det 1, 17th Weather Squadron
- Det 15, 1365th Audio Visual Squadron
- Military Air Traffic Coord. Office

- General Services Administration
- U.S. General Accounting Office
- 403rd Combat Logistics Support Squadron (Reserves)
- OLCA 2400 Reserve Readiness and Mobile Squadron
- 72nd Aerial Port Squadron (Reserves)

CHAPTER 3

ENVIRONMENTAL SETTING

CHAPTER 3

ENVIRONMENTAL SETTING

The environmental setting of Tinker Air Force Base is described in this section with the primary emphasis directed toward identifying features that affect the movement of hazardous waste contaminants. A summary of the environmental setting pertinent to this study is presented at the end of the section.

METEOROLOGY

Temperature, precipitation and other relevant data furnished by Detachment 1, 17th Weather Squadron, Tinker AFB is presented in Table 3.1. The indicated period of record is 30 years. The summarized data indicate that mean annual precipitation is 32.4 inches and that mean annual snowfall is eleven inches. According to the Climatic Atlas of the United States, annual lake evaporation for the Oklahoma City area is estimated to be 60 inches.

GEOGRAPHY

The Oklahoma City area is located within the Central Redbed Plains section of the Central Lowland Physiographic Province (Curtis and Ham, 1972). The area is characterized by nearly level to gently rolling hills, broad flat plains and well-entrenched main streams. The valleys of secondary streams may exhibit a sag and swale appearance, indicative of the erosion of somewhat cohesive residual soils.

Topography

The topography of Oklahoma City and surrounding area varies from generally level to gently rolling in appearance. Local relief is primarily the result of dissection by erosional activity or stream channel development. At Oklahoma City, surface elevations are typically in the range of 1,070 to 1,400 feet MSL. At Tinker Air Force Base ground surface elevations vary from 1,210 feet MSL at the point where

the east branch of Crutcho Creek intersects the base boundary to approximately 1,320 feet MSL at Area D, located on 59th Street, east of the main installation.

Drainage

Drainage of Tinker Air Force Base land areas is accomplished by overland flow of runoff to diversion structures and thence to area surface streams, which flow intermittently. The northeast portion of the base is drained primarily by Soldier Creek, a tributary of Crutcho Creek. The north and west sections of the base including the main instrument runway, drain to Crutcho Creek, a tributary of the North Canadian River. Two small unnamed intermittent streams crossing installation boundaries south of the main instrument runway generally do not receive significant quantities of base runoff due to site grading designed to preclude such drainage. These streams, when flowing, extend to Stanley Draper Lake, approximately one half mile south of the base. Installation drainage and the flow directions of surface streams are depicted on Figure 3.1.

Surface Soils

The surface soils of Tinker Air Force Base have been studied by the USDA, Soil Conservation Service (1969) and by several soil boring projects conducted for geotechnical (foundation construction) investigations. Three major soil associations have been mapped within installation limits and are depicted on Figure 3.2. The individual soil types are summarized on Table 3.2. The surface soils of the installation area are predominantly of two basic types: residual and alluvial. The residual soils associations, Darrell-Stephenville and Renfrow-Vernon-Bethany are the product of the weathering of underlying bedrock. The alluvial materials are stream-deposited silts and sands, whose occurrence is typically restricted to the floodplains of area streams.

GEOLOGY

The geology of the Oklahoma City area has been reported by Miser et al. (1954), Bingham and Moore (1975), Johnson and Luza (1980), among others. A brief review of the published information has been summarized in support of this investigation.

TABLE 3.1

SUMMARY OF WEATHER DATA AT TINKER AFB, OK

MONTH	TEMPERATURE (°F) MEAN DAILY MAX	MEAN DAILY MIN	MEAN MONTHLY	EXTREME MAX	EXTREME MIN	PRECIPITATION (IN) MONTHLY MEAN	MONTHLY MAX	MONTHLY MIN	MAX 24 HRS	SNOWFALL (IN) MONTHLY MEAN	MONTHLY MAX	MAX 24 HRS	SURFACE WINDS PREVAILING DIRECTION (16 PT)	MEAN SPEED (KT)
JAN	47	28	37	80	-7	1.2	6.1	0	2.2	4	25	6	S	11
FEB	52	32	42	85	-1	1.3	2.8	0	1.7	2	8	5	S	11
MAR	59	38	49	90	-1	2.0	5.2	.1	1.8	2	18	9	S	13
APR	71	51	61	94	25	3.3	8.7	.7	2.9	0	1	1	S	13
MAY	78	59	69	98	35	5.6	11.4	.3	5.7	0	0	0	S	11
JUN	87	68	78	105	52	4.2	13.5	.4	5.1	0	0	0	S	12
JUL	92	72	82	107	53	3.3	8.2	.1	3.7	0	0	0	S	10
AUG	92	71	82	107	56	2.4	9.3	0	2.8	0	0	0	S	10
SEP	84	64	74	107	40	3.5	11.3	0	6.2	0	0	0	S	10
OCT	74	53	64	98	26	2.5	7.5	0	2.7	0	0	0	S	10
NOV	60	40	50	83	11	1.6	7.3	0	2.0	1	6	2	S	11
DEC	50	31	41	85	0	1.5	3.5	0	2.3	2	11	6	S	11
ANN	71	50	61	107	-7	32.4	13.5	.0	6.2	11	25	9	S	11

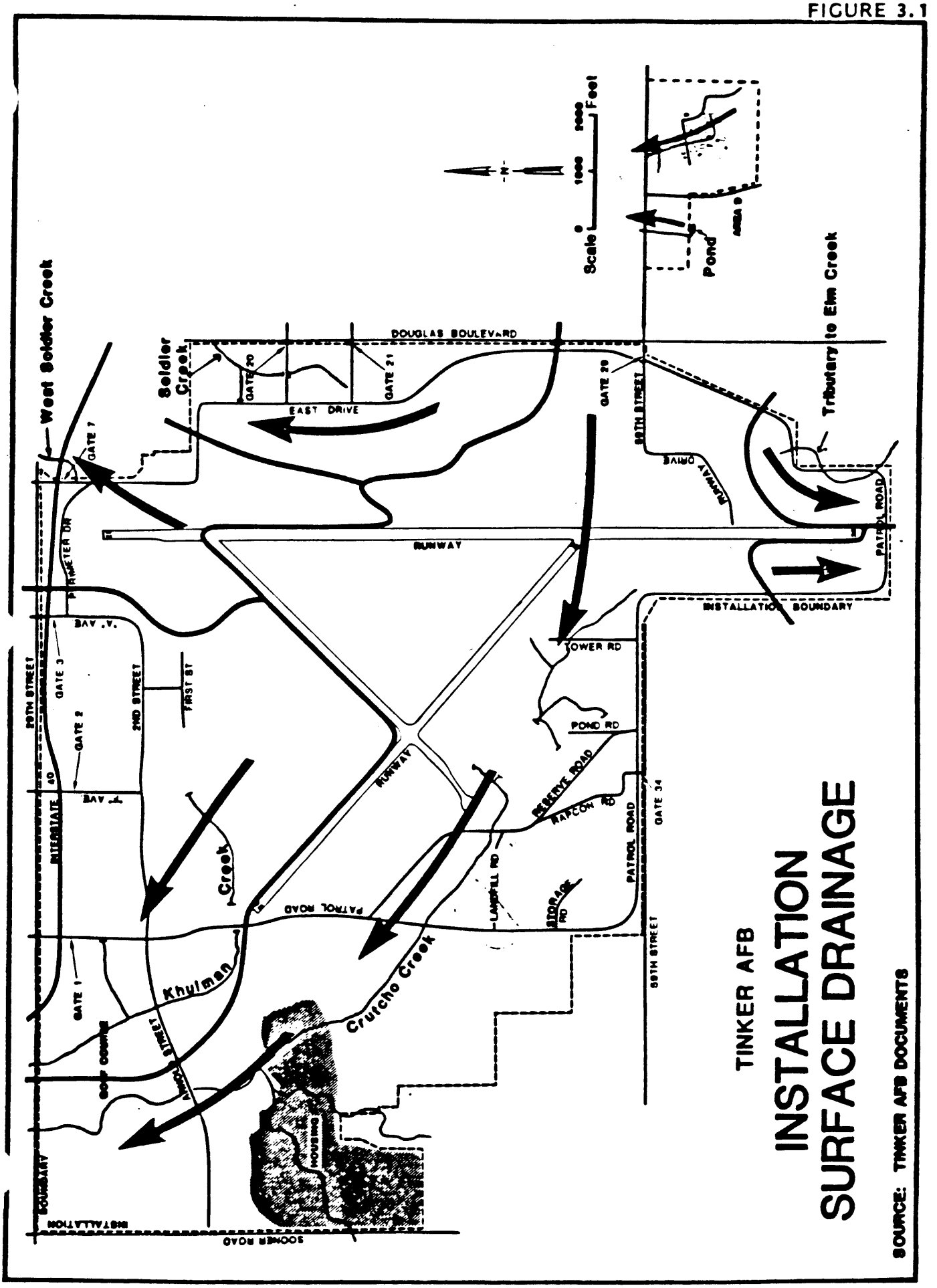
Base Elevation: 1,291 feet
Period of Record: 1942-1972
0: trace amount

SOURCE: Detachment 1, 17th Weather Squadron

[illegible]
[illegible]
[illegible] 4.[illegible]
13.1 [illegible]
[illegible] (USDA [illegible], 1977 Climatic Atl.)
15° - 3 mo.

15
- 13.1
1.9"

FIGURE 3.1



TINKER AFB
INSTALLATION
SURFACE DRAINAGE
SOURCE: TINKER AFB DOCUMENTS
West Soldier Creek
Soldier Creek
Tributary to Elm Creek
Pond
Scale 0 1000 2000 Feet
N
DOUGLAS BOULEVARD
EAST DRIVE
GATE 20
GATE 21
GATE 29
GATE 7
GATE 3
GATE 2
GATE 1
GATE 34
RUNWAY
RUNWAY DRIVE
PATROL ROAD
INSTALLATION BOUNDARY
TOWER RD
POND RD
RESERVE ROAD
RAPCON RD
LANDFILL RD
STORAGE RD
PATROL ROAD
59TH STREET
29TH STREET
2ND STREET
FIRST ST
INTERSTATE 40
Khulman Creek
Crutcho Creek
HOUSING
SOONER ROAD
INSTALLATION BOUNDARY

FIGURE 3.2

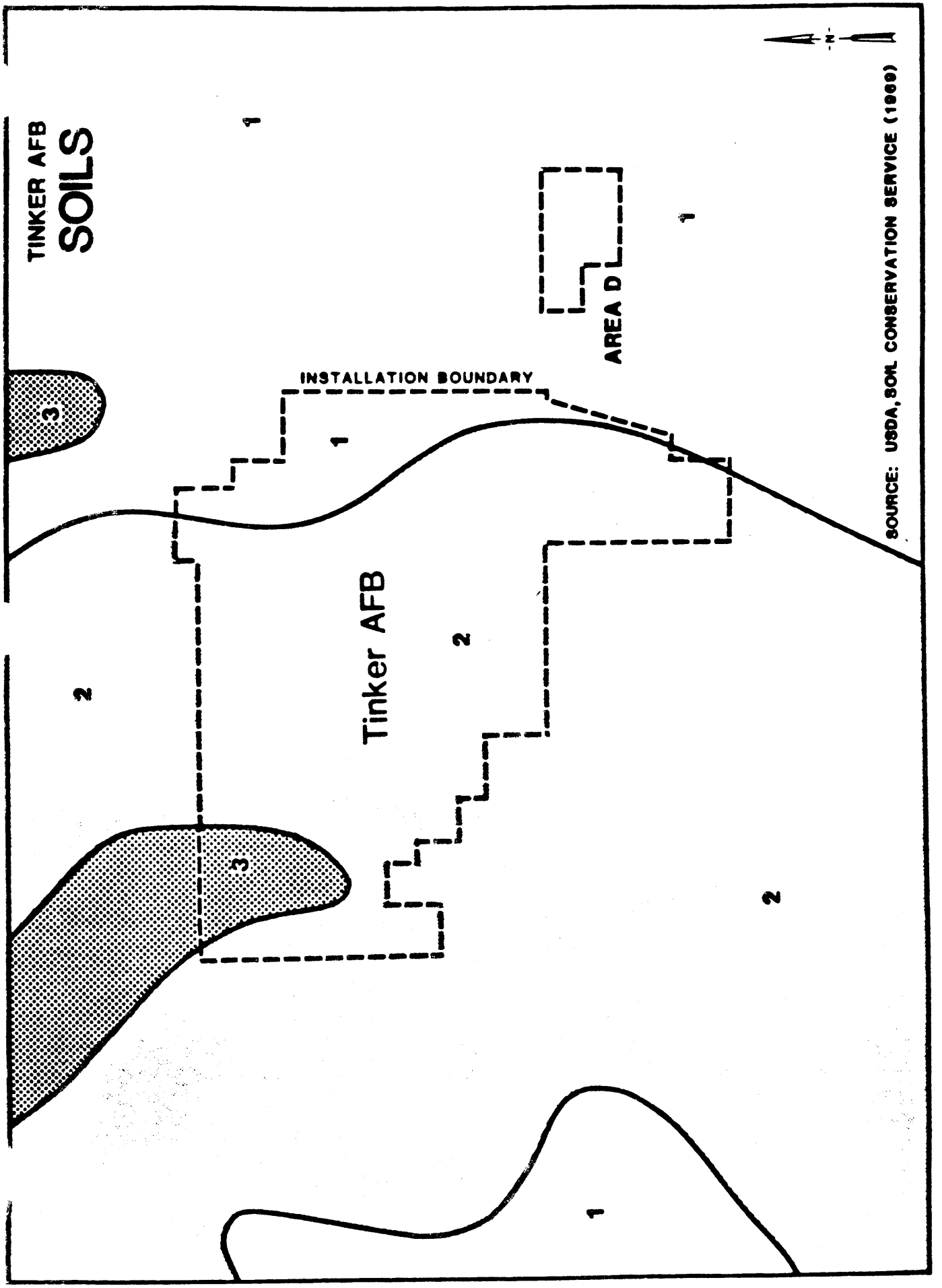


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TABLE 3.2

TINKER AIR FORCE BASE SOIL ASSOCIATIONS

Symbol	Name	Description	Thickness in.	Unified Class.	Permeability in/hr*
1	Darrell-Stephenville: loamy soils of wooded uplands.	Sandy loam. Sandy clay loam. Soft sandstone. (Garber Sandstone)	12 - 54	SM,ML,SC	2.0 - 6.30
2	Renfrow-Vernon-Bethany: loamy and clayey soils on prairie uplands.	Silt loam - clay. Clay loam. Shale. (Fairmont Shale)	12 - 60	ML, CL MH, CH	<0.06 - 0.20
3	Dale-Canadian-Port: loamy soils on low benches near large streams.	Fine sandy loam. Silty clay loam. Loam. Clay loam	12 - 60	SM, ML CL	0.05 - 6.30

Source: USDA, SCS (1969).

* Although this characteristic of base soils is called "Permeability" by the Soil Conservation Service, it is actually a description of infiltration rates - the speed that water moves through unsaturated earth materials.

Stratigraphy

Geologic units ranging in age from Permian to Quaternary have been described in the Oklahoma County area and are summarized as Table 3.3. The lithologies of these units include unconsolidated deposits and sedimentary rocks.

Distribution

The physical distribution of significant geologic units relevant to this study are mapped as Figure 3.3, which has been modified from the work of Bingham and Moore (1975). Tinker Air Force Base geologic units are summarized on Table 3.4. Generally, the surficial geology of the north section of the installation is dominated by the Garber Sandstone, which crops out across a broad area of Oklahoma County. Weathering of the Garber has probably produced Darrell-Stephenville soils. The south portion of the base's surficial geology is reportly dominated by the Kingman Siltstone and the Fairmont Shale (as indicated on geologic maps by Miser (1959) and Bingham & Moore (1975). An inspection of the base and a review of available drilling information has failed to confirm the presence of the siltstone unit on base. Drilling information obtained as a result of geotechnical investigations and monitoring well installation does indicate the presence of the Fairmont Shale separating surface soils from the underlying Garber Sandstone. At some locations, however, the shale appears to be thin and/or discontinuous. In other base areas, the shale is absent as shown on Figure 3.3. The stratigraphic relationships of major geologic units present on base are presented on Figures 3.4 and 3.5, the logs of base monitoring wells.

Structure

Tinker Air Force Base lies within a tectonically stable area. No major faults or fracture zones have been mapped near the base. Most of the consolidated rock units of the Oklahoma City area are nearly flat-lying. The reported regional dip is forty feet per mile in a generally westward direction (Bingham and Moore, 1975).

HYDROLOGY

Ground-water hydrology of the Tinker Air Force Base - Oklahoma City area has been reported by Jacobsen and Reed (1949), Wood and Burton (1968), Bingham and Moore (1975), Bedinger and Sniegocki (1976) and

MAJOR GEOLOG[illegible]ITS OF OKLAHOMA COUNTY

System	Series	Stratigraphic Unit	Thickness (feet)	Description and Distribution	Water-bearing Properties
QUATERNARY	RECENT	Dune sand	0-20	Fine-to coarse-grained wind-blown sand. Consists chiefly of subrounded quartz grains. Forms a thin mantle or hummocky surface that obscures older rocks. Most extensive deposits on north side of North Canadian River near Lake Overholser.	Moderately to highly permeable, but mostly above the water table and saturated only locally. Where saturated, yields water readily to domestic or stock wells, but supply may not be permanent. Water most likely to occur in this unit where underlain by poorly permeable redbeds. Provides infiltration areas for recharge to underlying rocks.
	PLEISTOCENE AND RECENT	Alluvium	0-70	Unconsolidated and interfingering lenses of sand, silt, clay, and gravel in the flood plains and channels of streams.	Moderately permeable. Yields small to moderate quantities of water to wells in valleys of larger streams. Water is very hard, but suitable for most uses, unless contaminated by industrial wastes or oil-field brines.
		Terrace deposits	0-100	Unconsolidated and interfingering lenses of sand, silt, gravel, and clay that occur at one or more levels above the flood plains of the principal streams.	Moderately permeable. Locally above the water table and not saturated. Where deposits have sufficient saturated thickness, they are capable of yielding moderate quantities of water to wells. Water is moderately hard to very hard, but less mineralized than water in other aquifers. Suitable for most uses unless contaminated by oil field brines.
PERMIAN	LOWER PERMIAN	Chickasha Formation and Duncan Sandstone	200 ±	Beds of reddish-brown sandstone, siltstone, shale, and siltstone conglomerate. Individual beds of sandstone highly cross-bedded and well cemented, in western part of area between Canadian and North Canadian Rivers.	Poorly permeable. Tapped by only a few small-capacity wells for domestic or stock use. Water is hard and in places highly mineralized.
		Hennessey Group (Includes Kingman Siltstone and Fairmont Shale)	700	Deep-red clay shale containing thin beds of red sandstone and white or greenish bands of sandy or limy shale. Forms relatively flat to gently rolling grass-covered prairies.	Poorly permeable. Yields meager quantities of very hard, moderately to highly mineralized water to shallow domestic and stock wells. In places water contains large amounts of sulfate.
		Garber Sandstone	500 ±	Deep-red to reddish-orange, massive and cross-bedded fine-grained sandstone interbedded with and interfingered with red shale and siltstone.	Poorly to moderately permeable. Important source of ground water in Cleveland and Oklahoma Counties. Yields small to moderate quantities of water to deep wells; heavily pumped for industrial and municipal uses in the Norman and Midwest City areas. Water from shallow wells hard to very hard; water from deep wells moderately hard to soft. Lower part contains water too salty for domestic and most industrial uses.
		Wellington Formation	500 ±	Deep-red to reddish-orange massive and cross-bedded fine-grained sandstone irregularly interbedded with red, purple, maroon, and gray shale. Base of formation not exposed in the area.	

Source: Modified from Wood and Burton, 1968

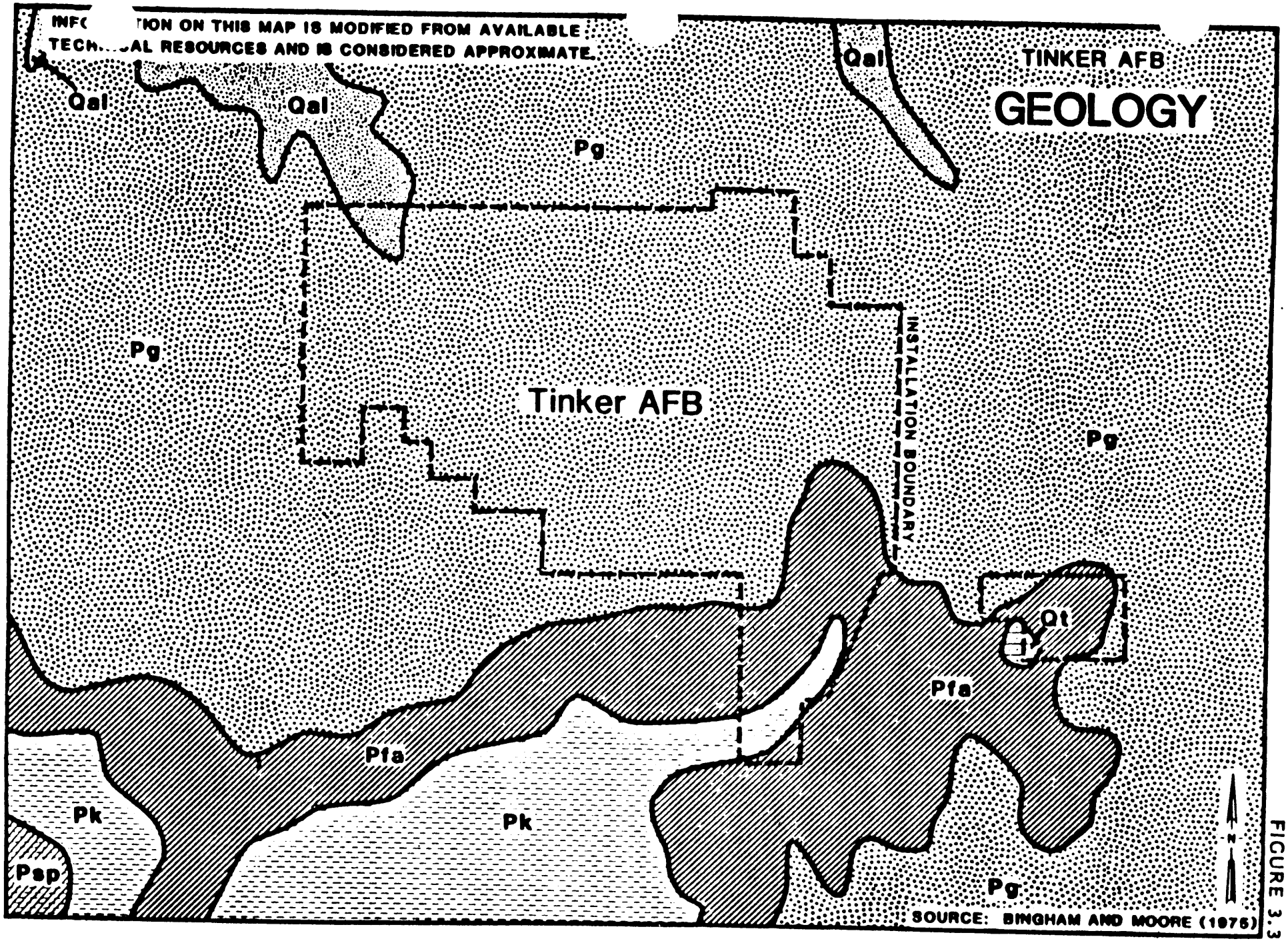

INFO TION ON THIS MAP IS MODIFIED FROM AVAILABLE
TECH AL RESOURCES AND IS CONSIDERED APPROXIMATE.
TINKER AFB
GEOLOGY
Qal
Qal
Qal
Pg
Pg
Pg
Pg
Tinker AFB
INSTALLATION BOUNDARY
Qt
Pfa
Pfa
Pk
Pk
Psp
N
SOURCE: BINGHAM AND MOORE (1975)

FIGURE 3.3

TABLE 3.4

TINKER AIR FORCE BASE GEOLOGIC UNITS (PERMIAN)

Map Symbol	Unit	Lithology	Thickness, ft.	Structure	Geomorphic Features	Remarks
Qal	Alluvium	Sand, silt, clay, gravel	5-100	varies	Floodplains, low areas near streams	Local aquifer
Qt	Terrace Deposits	Sand, silt, clay, gravel	10-100	varies	Upland areas, benches near streams	Local aquifer
Pk	Kingman	Even-bedded siltstones; some sandstone and shale	30	flat-lying	Gently rolling plains	Aquitard
Pfa	Fairmont	Blocky shale; thin sandstone interbeds	30	flat-lying	Gently rolling plains	Aquitard
Pg	Garber	Fine-grained sandstone; shale, chert and mudstone conglomerate	150-400	flat-lying	Gently rolling and broad flat plains	Major regional aquifer
Psp	Salt Plains	Blocky shale and siltstone	200	flat-lying	Not exposed	Aquiclude

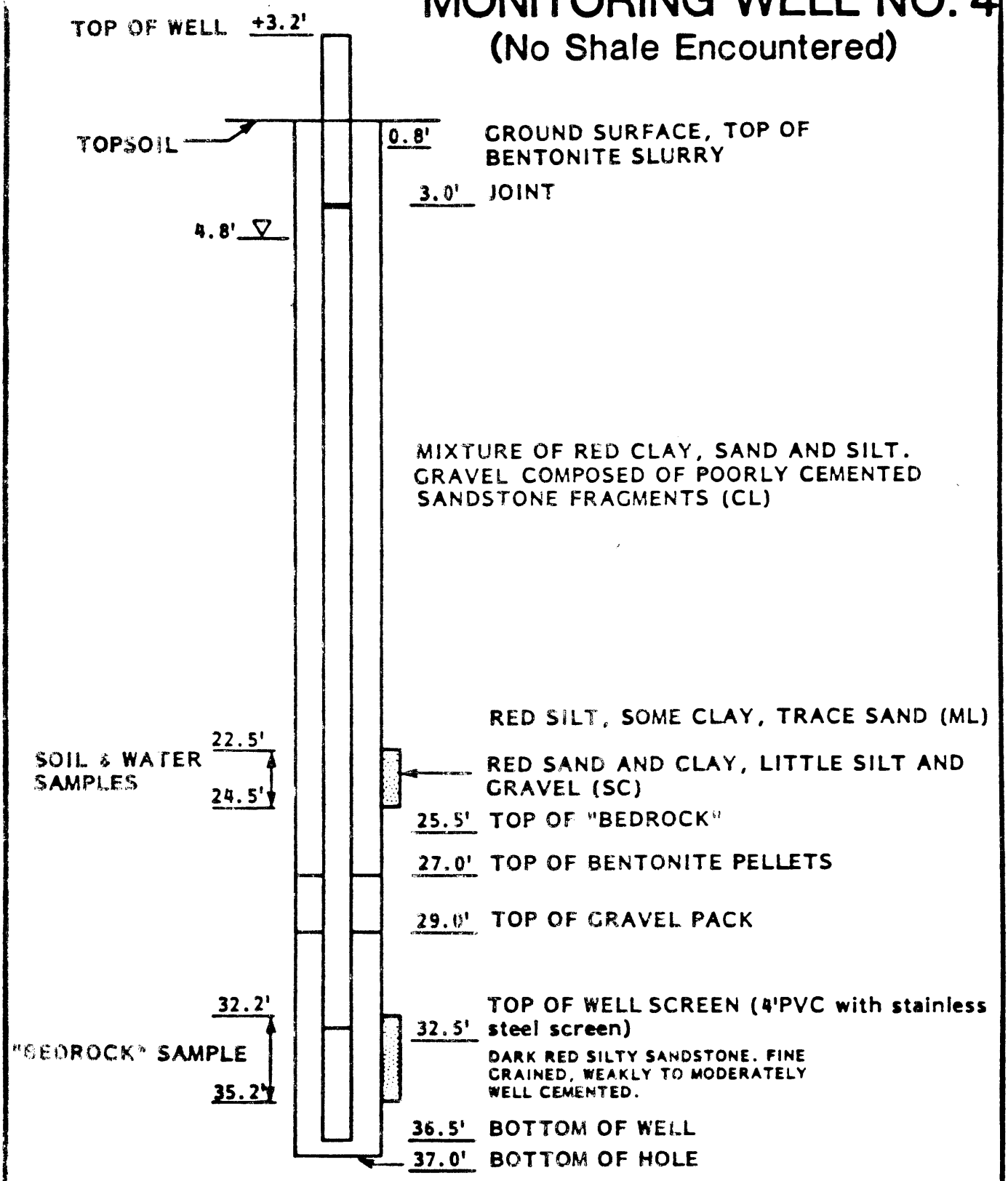
Source: Bingham and Moore (1975)
Johnson and Luza (1980)

FIGURE 3.4

TINKER AFB

MONITORING WELL NO. 4

(No Shale Encountered)



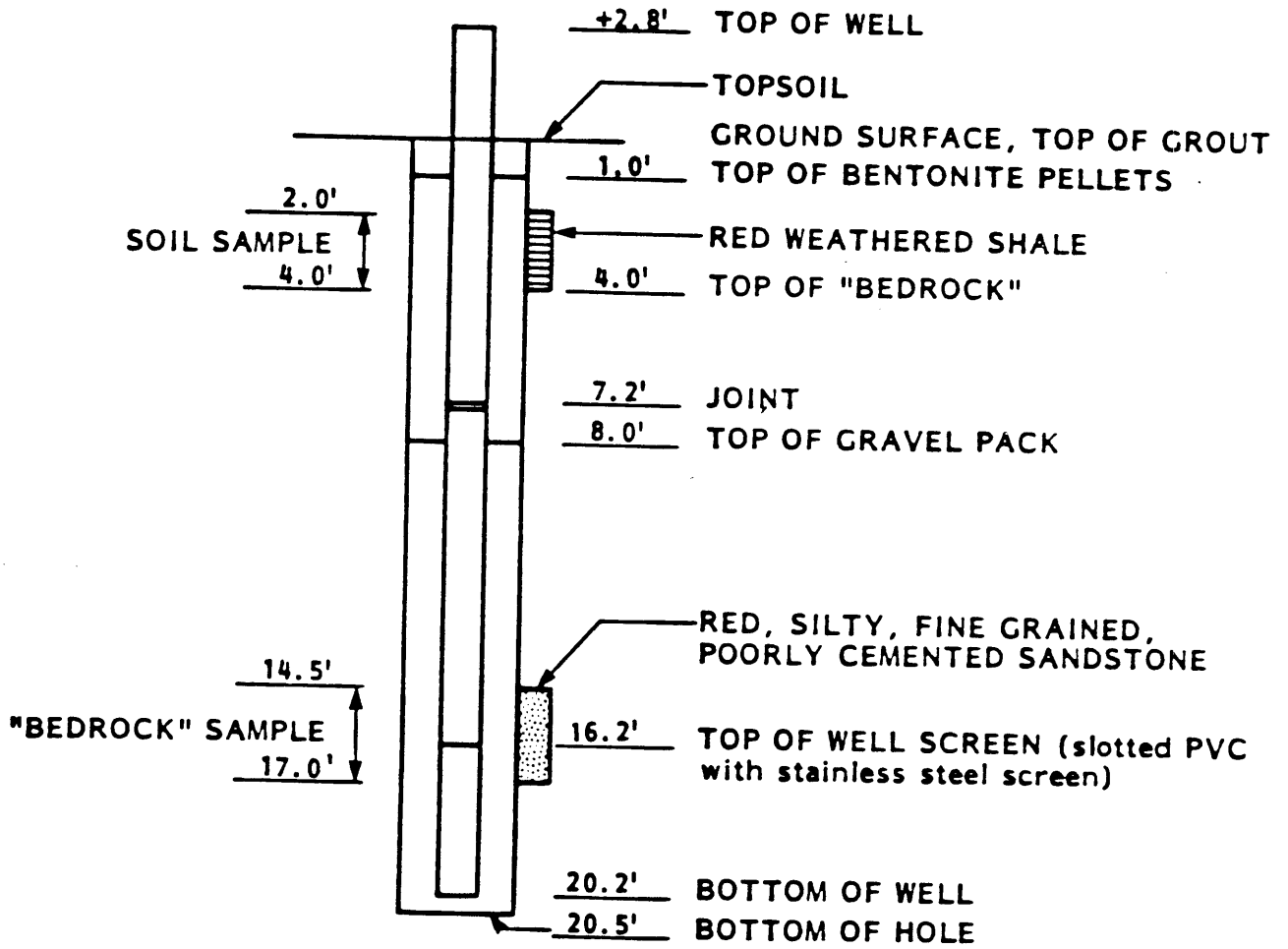
NOTE: GROUND-WATER LEVEL MEASURED AT TIME OF DRILLING AT 4.8'. THIS MAY ONLY REFLECT THE WATER LEVEL OF A NEARBY POND NOTED ON DRILLER'S LOG.

SOURCE: TINKER AFB DOCUMENTS

TINKER AFB

MONITORING WELL NO. 8

(Shale Encountered)



NOTE: DRY WELL - NO GROUND WATER ENCOUNTERED.

SOURCE: TINKER AFB DOCUMENTS

Wickersham (1979). Additional information has been obtained from interviews with officials of the Oklahoma Water Resources Board and the District Office, U.S. Geological Survey Water Resources Division and from the ground-water quality monitoring program presently being implemented at Tinker AFB.

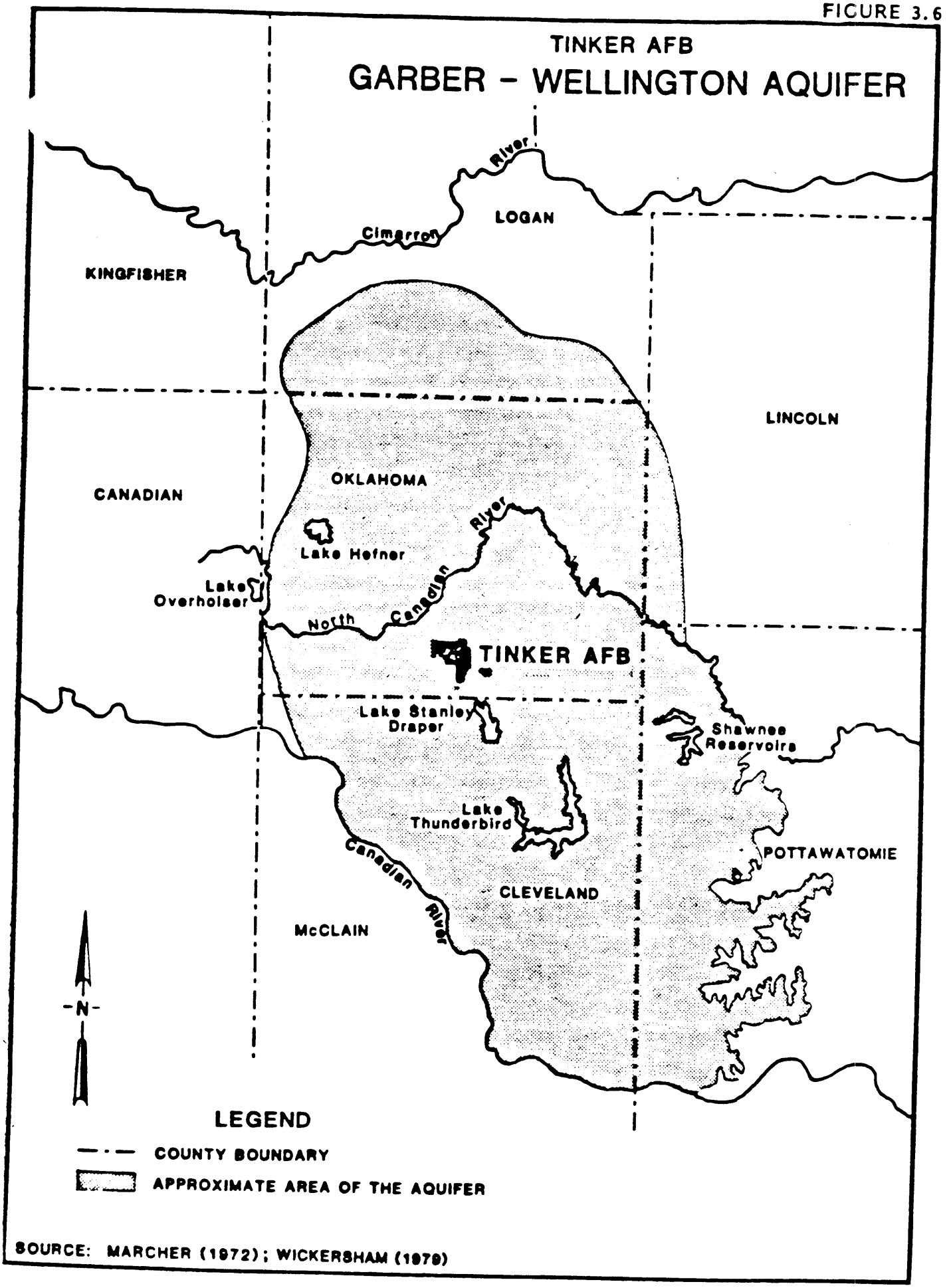
Garber-Wellington Aquifer

Tinker Air Force Base lies within the limits of the Garber-Wellington Ground-Water Basin. The Garber Sandstone and the Wellington Formation are considered to be a single aquifer and provide the most significant source of ground-water supplies in the Oklahoma City area. At the present time, Tinker Air Force Base derives most of its water supplies from this aquifer and supplements the supply by purchasing from the Oklahoma City Water Department. The nearby communities of Midwest City, and Del City derive water supplies from both surface sources and wells tapping the aquifer. Industrial operations, individual homes, farm irrigation, and small communities not served by a municipal distribution systems also depend on the Garber-Wellington Aquifer. Communities presently depending upon surface supplies such as Oklahoma City also maintain a well system drilled into the Garber-Wellington as a standby source of water in the event of drought. The aquifer area is depicted in Figure 3.6.

The Garber Sandstone and the Wellington Formation are considered to be a single aquifer as they were deposited under similar conditions and consist of lenticular beds of sandstone, siltstone and shale that tend to vary in thickness over relatively short horizontal distances (Wood and Burton, 1968). The sediments constituting the aquifer tend to be loosely cemented and have a maximum thickness of some 1,000 feet. In the area of outcrop, ground water occurs under water table (unconfined) conditions and may occur at relatively shallow depths below ground surface (100 to 150 feet). In areas overlain by younger geologic units, ground water occurs in the aquifer under artesian (confined) conditions and wells must be drilled deeper (200-250 feet) in order to encounter it (Wickersham, 1979).

The Garber-Wellington aquifer is exposed at ground surface or mantled by a thin soil over the northern two-thirds of Tinker Air Force Base. It is believed that the aquifer is overlain by a thin,

FIGURE 3.6



SOURCE: MARCHER (1972); WICKERSHAM (1979)

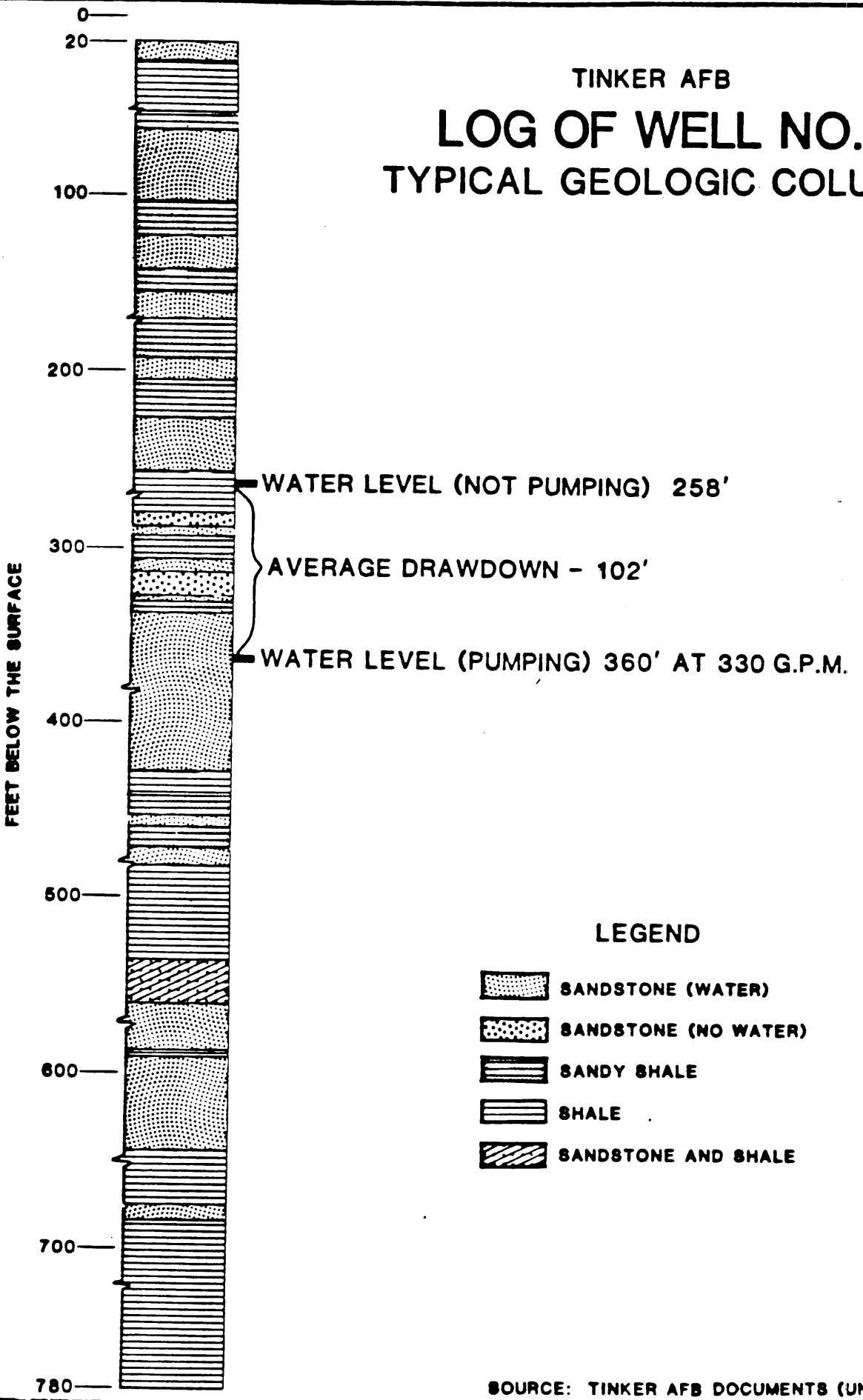
discontinuous sequence of Hennessey Group sediments (Kingman Siltstone and Fairmont Shale) over the southern portion of the base. Water in the Garber-Wellington is normally encountered at a depth of some 100 feet at Tinker Air Force Base. Figure 3.7, a Tinker AFB well log, depicts local hydrogeology. A geologic cross-section of base wells developed by Wickersham (1979) is presented as Figure 3.8. This figure graphically depicts the lenticular nature of the sandy zones. Although most of the aquifer is believed to be saturated, multiple screened wells are usually constructed in order to obtain water from the more productive zones.

Recharge of the Garber-Wellington Aquifer is accomplished principally by percolation of surface waters crossing the area of outcrop and by rainfall infiltration in this same area. Because most of Tinker Air Force Base is located in an aquifer outcrop area, it is therefore assumed that this portion of the base is situated in a recharge zone (Havens, 1981). The aquifer is susceptible to contamination in the study area. Ground-water levels and flow directions (1976 data) are presented as Figure 3.9. According to the indicated hydraulic gradients, ground-water flow at Tinker AFB is presently directed to the northwest and south.

According to Wood and Burton (1968) and Wickersham (1979), the quality of ground water derived from the Garber-Wellington Aquifer is generally good, although wide variations in the concentrations of some constituents are known to occur. Wells drilled to excessive depths may encounter a saline zone, generally greater than 900 feet below ground surface. Wells drilled to such depths or those accidentally encountering the saline zone are either grouted over the lowest screens or may be abandoned.

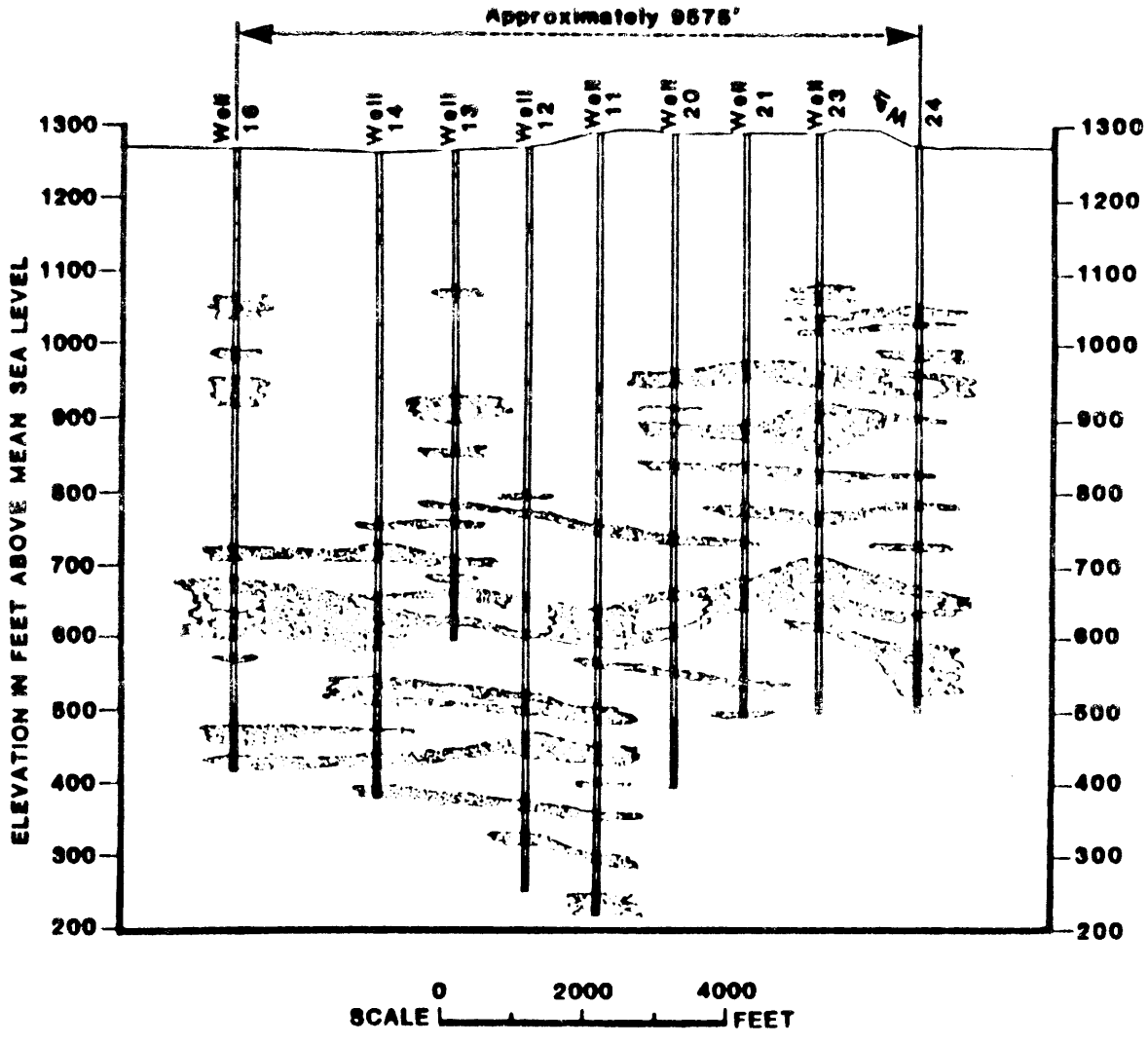
Tinker Air Force Base presently obtains its water supplies from a distribution system comprised of 27 water wells constructed along the east and west base boundaries, as shown by Figure 3.10 and by purchase from the Oklahoma City Water Department. All base wells are finished into the Garber-Wellington Aquifer. Base wells range from 700 to 900 feet in finished depth, with yields ranging from 205 to 250 gallons per minute. The wells incorporate multiple screens, deriving water supplies from sand zones that vary in thickness from 103-184 feet (Wickersham, 1979).

FIGURE 3.7

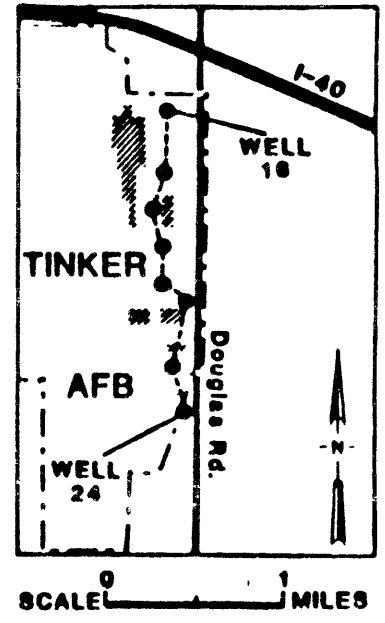


SOURCE: TINKER AFB DOCUMENTS (UNDATED)

GEOLOGIC SECTION OF THE GARBER-WELLINGTON AQUIFER AT TINKER AFB



LOCATION OF THE SECTION



LEGEND

- WATER-PRODUCING ZONE (SAND)
- NONPRODUCING ZONE (SHALE/SILTSTONE)

SOURCE: WICKERSHAM (1979)

FIGURE 3.8

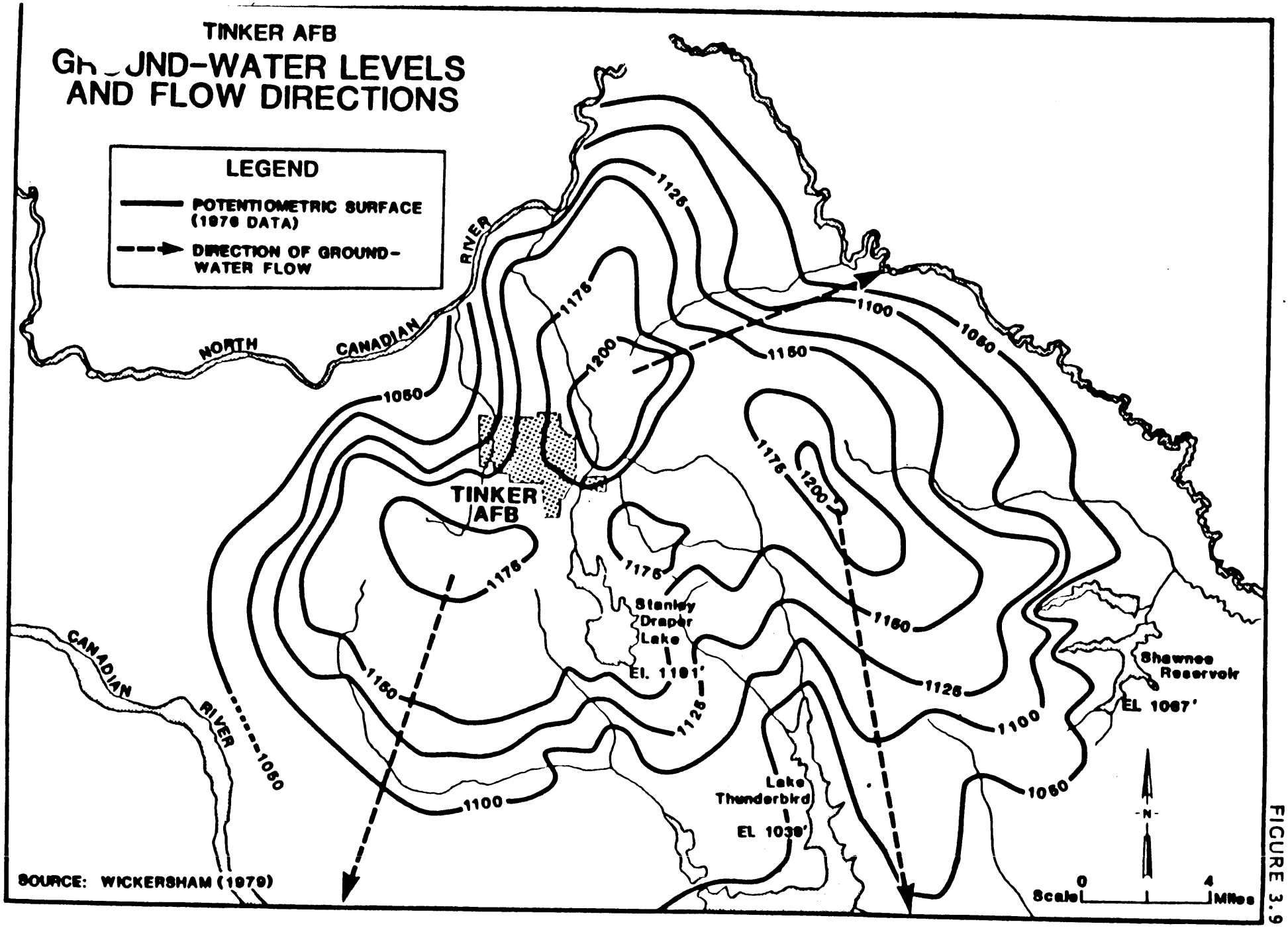
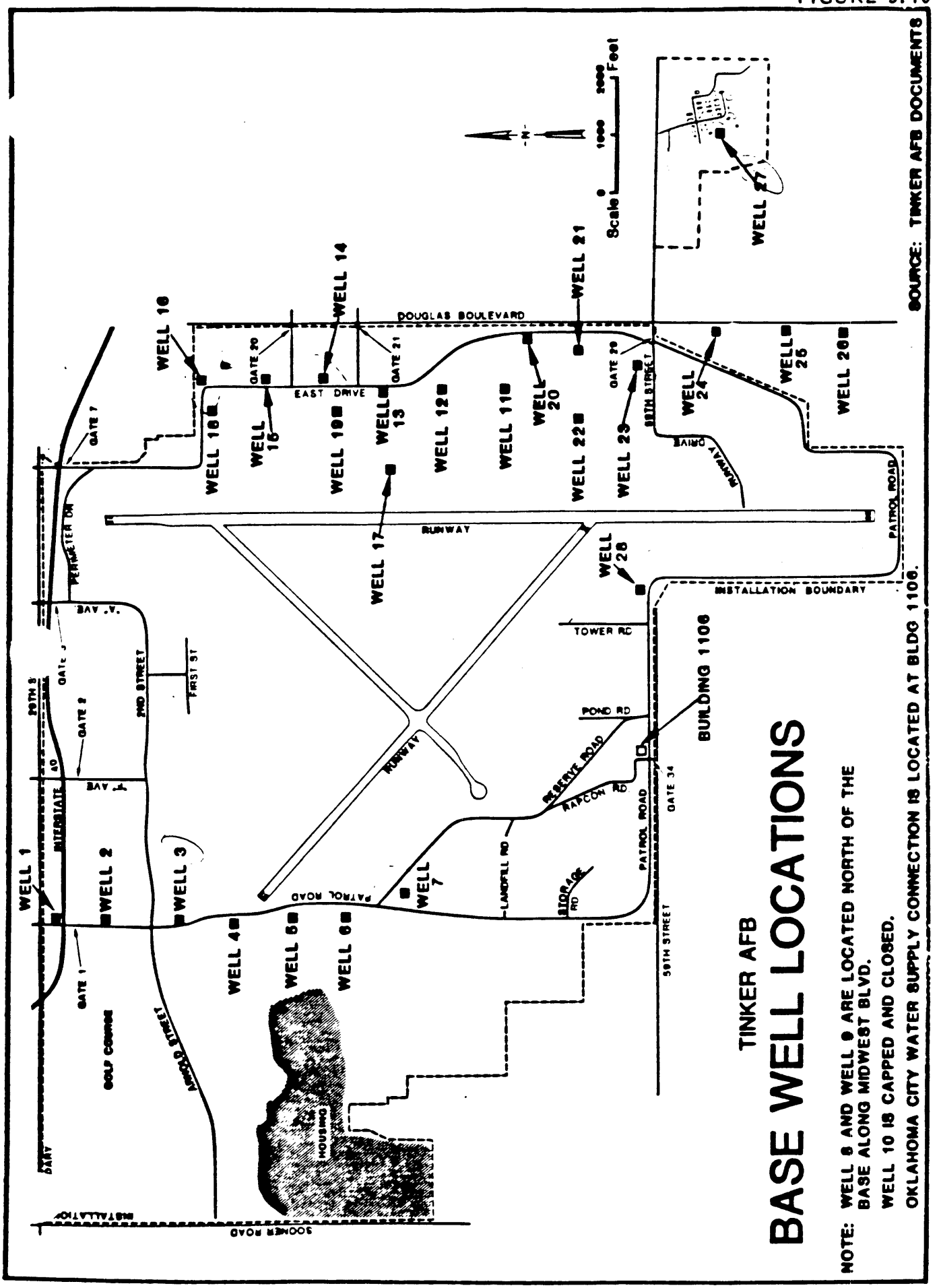

TINKER AFB
GROUND-WATER LEVELS AND FLOW DIRECTIONS
LEGEND
POTENTIOMETRIC SURFACE (1976 DATA)
DIRECTION OF GROUND-WATER FLOW
NORTH CANADIAN RIVER
CANADIAN RIVER
TINKER AFB
Stanley Draper Lake
El. 1181'
Lake Thunderbird
EL 1039'
Shawnee Reservoir
EL 1067'
1050
1100
1125
1150
1175
1200
N
Scale 0 4 Miles
SOURCE: WICKERSHAM (1979)

FIGURE 3.9

FIGURE 3.10

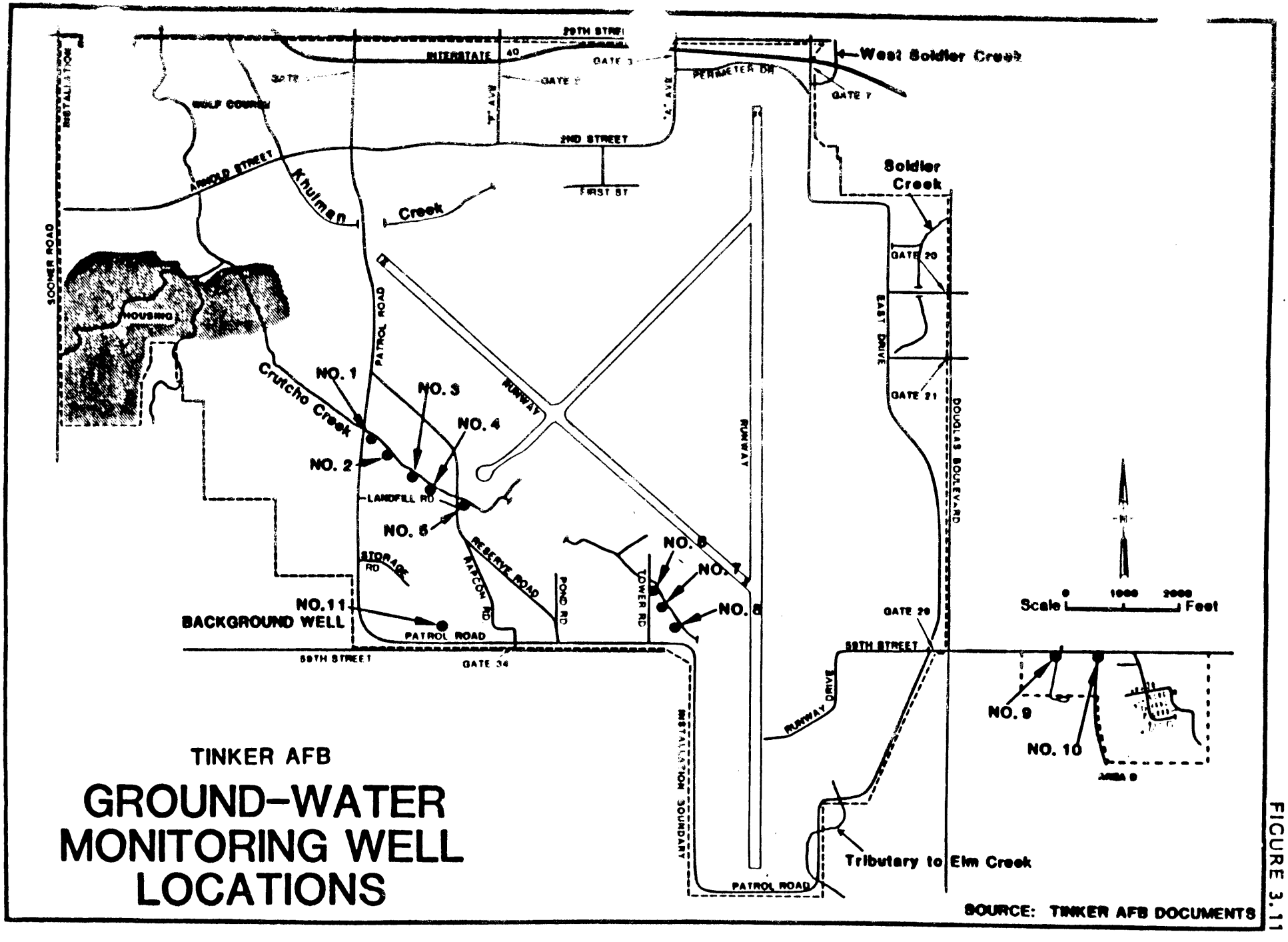

TINKER AFB
BASE WELL LOCATIONS
NOTE: WELL 8 AND WELL 9 ARE LOCATED NORTH OF THE BASE ALONG MIDWEST BLVD.
WELL 10 IS CAPPED AND CLOSED.
OKLAHOMA CITY WATER SUPPLY CONNECTION IS LOCATED AT BLDG 1106.
SOURCE: TINKER AFB DOCUMENTS
Scale 0 1000 2000 Feet
N
DOUGLAS BOULEVARD
EAST DRIVE
RUNWAY
INSTALLATION BOUNDARY
PATROL ROAD
TOWER RD
POND RD
RESERVE ROAD
RAPCON RD
LANDFILL RD
STORAGE RD
BUILDING 1106
GATE 34
59TH STREET
2ND STREET
FIRST ST
INTERSTATE 40
GOLF COURSE
ARNOLD STREET
HOUSING
SOONER ROAD
INSTALLATION
DARY
WELL 1
WELL 2
WELL 3
WELL 4
WELL 5
WELL 6
WELL 7
WELL 8
WELL 11
WELL 12
WELL 13
WELL 14
WELL 15
WELL 16
WELL 17
WELL 18
WELL 19
WELL 20
WELL 21
WELL 22
WELL 23
WELL 24
WELL 25
WELL 26
WELL 27
WELL 28
GATE 1
GATE 2
GATE 7
GATE 20
GATE 21
GATE 29
GATE 34

Shallow Aquifer Zones

Shallow aquifers may exist temporarily within the study area where zones of alluvium border streams or where shallow sandy residual soils may collect precipitation. At Tinker AFB, sandy residual soils overlying bedrock at shallow depths may form such an ephemeral aquifer. Soil aquifers are typically recharged directly by precipitation, gradually running dry seasonally as base flow to local streams and recharging of underlying rock aquifers deplete limited supplies. A local soil aquifer was encountered during ground-water quality monitoring recently underway at Tinker, AFB. Locations of the ground-water monitoring wells on base are shown in Figure 3.11. It is apparently perched above the Fairmont Shale at some locations and absent at others. The soil unit is moderately to highly permeable. Thickness of the soil unit varies from four to thirty feet and the depth to ground water in this unit varies from three to seventeen feet. In some cases, monitoring well logs indicated the absence of ground water in this unit. The significance of the shallow aquifer is that it may facilitate the contamination of important lower aquifers or surface waters by generation and mobilization of wastes. The shallow aquifer may not facilitate the detection of developing ground-water contamination problems because of their localized nature and ephemeral character. It is not known, to what degree if any, this aquifer communicates with base surface waters.

SURFACE WATER QUALITY

Tinker AFB has several streams and surface drainage systems which originate or flow through the base property. These streams have been monitored routinely at several locations by the base Bioenvironmental Engineering Office (BESD). In addition, special sampling studies have been conducted by the US Geological Survey, Oklahoma Water Resources Board and a student at the University of Oklahoma conducting research for his Ph.D dissertation (Frank, 1969). The on-base sampling stations are depicted on Figure 3.12 and summaries of the data evaluated are included in Appendix C. The data are discussed in the following paragraphs by sub-basins. In most instances there were no water quality limits on these surface streams in the past.



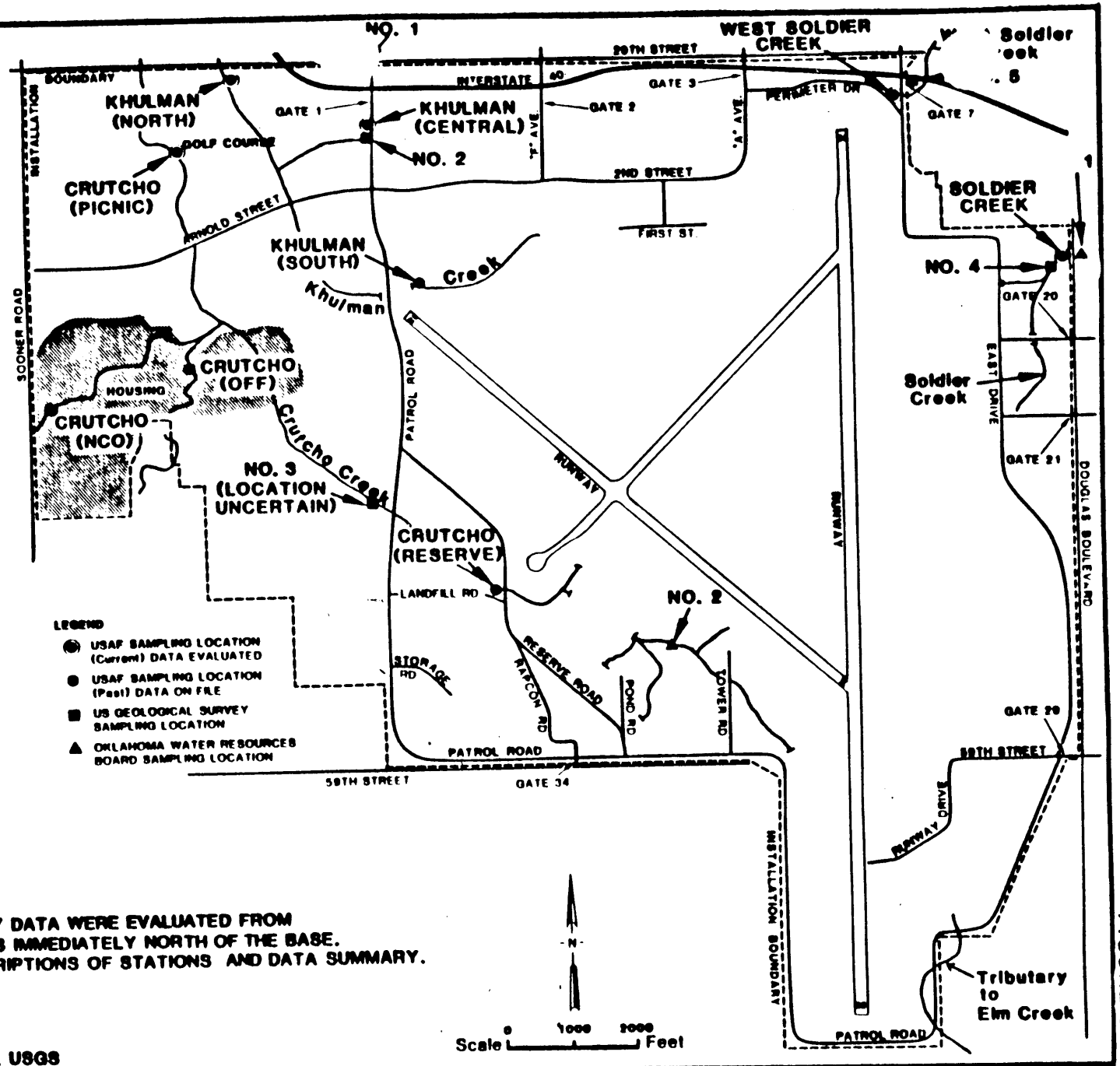
TINKER AFB

GROUND-WATER MONITORING WELL LOCATIONS

FIGURE 3.11

TINKER AFB

WATER QUALITY SAMPLING LOCATIONS



NOTE: ADDITIONAL WATER QUALITY DATA WERE EVALUATED FROM THREE SAMPLING LOCATIONS IMMEDIATELY NORTH OF THE BASE. SEE APPENDIX C FOR DESCRIPTIONS OF STATIONS AND DATA SUMMARY.

SOURCE: TINKER AFB DOCUMENTS; USGS

FIGURE 3.14

Crutcho Creek and its tributaries traverse the southern and western portions of the base. The earlier water quality data evaluated (USGS data collected during 1963) revealed lead values of 45 µg/l. Data collected from Crutcho Creek in 1968 (Frank, 1969) indicated concentrations of total chromium ranging from 50 to 1,800 µg/l and concentrations of cadmium ranging from 80 to 300 µg/l. Recent data collected by the base BESD (1980) indicated the levels of chromium were typically below 50 µg/l (the detectable limit of the test procedure used). One monthly sample during 1980 did however indicate 54 µg/l of chromium. Cadmium concentrations for Crutcho Creek were consistently below 10 µg/l during 1980.

Khulman Creek originates on base from surface drainage and storm runoff and drains the north central portion of the base. The 1963 USGS data revealed chromium values of 129 µg/l and cadmium values of 26 µg/l. The 1980 data showed iron concentrations ranged from 0.12 to 3.1 mg/l and manganese concentrations ranged from <0.050 to 4.5 mg/l. On occasions, oil and grease were also detected in the 1980 samples. West Soldier Creek originates on base and drains the northeast portion of the base. The 1963 USGS data revealed high metals contamination in the creek. The cadmium concentration was in the range of 46,000 µg/l and the chromium concentration was in the range of 31,000 µg/l. Aluminum, iron manganese and nickel were also analyzed and their respective concentrations were 620, 540, 1,400 and 242 µg/l. These high metals concentrations may have originated from direct discharge of industrial wastes and industrial spillage into the stream. Since the 1963 sampling, new controls and treatment measures have been implemented on base reducing the metal concentrations in the streams. By 1968, the surface water discharge contained chromium and cadmium concentrations of 7,200 µg/l and 2,000 µg/l respectively (Frank, 1969). The 1979 BESD data indicated a significant reduction of chromium and cadmium concentrations had occurred in the creek. Occasionally elevated levels of oil and grease and phenol were detected.

Soldier Creek originates on base and drains the eastern portion of the base. The domestic and industrial wastewater treatment plants presently contribute the majority of the creek's flow. The 1963 USGS data revealed chromium concentrations of 2,950 µg/l and cadmium concentrations of 2,180 µg/l. Nickel and manganese were detected at 129 and 58 µg/l, respectively. The 1968 University of Oklahoma data detected chromium concentrations within the range of 250 to 3,400 µg/l. Cadmium ranged from 30 to 2,800 µg/l, nickel ranged from 200 to 6,500 µg/l and iron range from 0.44 to 14 mg/l. BESD data collected in 1980 detected consistently high concentrations of total chromium; however hexavalent chromium, the valence state considered to be toxic, was consistently below the primary drinking water standard (50 µg/l). Cadmium concentrations were at or below the 10 µg/l drinking water standards. Nickel was the only parameter which was consistently detected at levels higher than the recent EPA ambient water quality criterion of 13.4 µg/l.

In addition to the water quality sampling conducted on the base, in 1981, the Oklahoma Water Resources Board collected sediment samples from Soldier Creek and soil samples from Crutcho Creek. The Soldier Creek samples had high levels of chromium, nickel and cadmium. The Crutcho Creek sample was collected near the fire training area and had levels of COD, oil and grease, and lead above background levels.

SUMMARY OF ENVIRONMENTAL SETTING

The environmental setting data reviewed for this study indicate the following key items concerning the impact of past waste disposal practices on the base:

- Surficial soils at Tinker AFB are predominantly sands or silts which characteristically exhibit moderate to high permeabilities.
- The primary regional aquifer, the Garber-Wellington, is present at or near ground-surface over most of the base area. Ground water is encountered within the aquifer at moderate depth (250 feet). The upper section of the aquifer is primarily an unsaturated zone.
- Tinker AFB is located within a recharge area of the primary regional aquifer.

- The historical contamination of base surface waters and associated sediments has been documented. Stream water percolation is known to be one form of recharge to the Garber-Wellington Aquifer.
- The Tinker AFB mean annual precipitation is 32.4 inches, while lake evaporation is given at 60 inches as Tinker AFB is located in a water deficient zone of the U.S. Precipitation events releasing as much as 6.2 inches rainfall in a twenty-four hour period at Tinker AFB have been reported, causing local flooding (Weather Squadron Data).

From these conditions it may be concluded that the potential for the contamination of the major regional aquifer exists. This potential exists because recharge of aquifer occurs where rainfall directly contacts the aquifer or where streams cross the area of outcrop. The aquifer is exposed at Tinker AFB and is therefore vulnerable to contamination at the base. Contaminant transport would primarily result from heavy rainfall events causing rapid overland flow and localized flooding. Contaminants would be expected to infiltrate through the unsaturated position of the aquifer with recharging meteoric waters, eventually reaching the ground-water reservoir.

CHAPTER 4

FINDINGS

CHAPTER 4

FINDINGS

To assess hazardous waste management at Tinker Air Force Base, waste generation and disposal methods were reviewed. This chapter summarizes the hazardous waste generated by activity, describes waste disposal methods, identifies the disposal sites located on the base and evaluates the potential for contaminant migration. Figure 4.1 presents the decision tree methodology used in the review of waste practices. The methodology provides a logical algorithm for the consistent evaluation of all base practices.

PAST SHOP AND BASE ACTIVITY REVIEW

To identify past base activities that resulted in generation and disposal of hazardous waste, a review was conducted of current and past waste generation and disposal methods. This review consisted of interviews with base employees, a search of files and records, and site inspections.

The sources of most hazardous waste that are generated on Tinker AFB can be associated with one of the following activities:

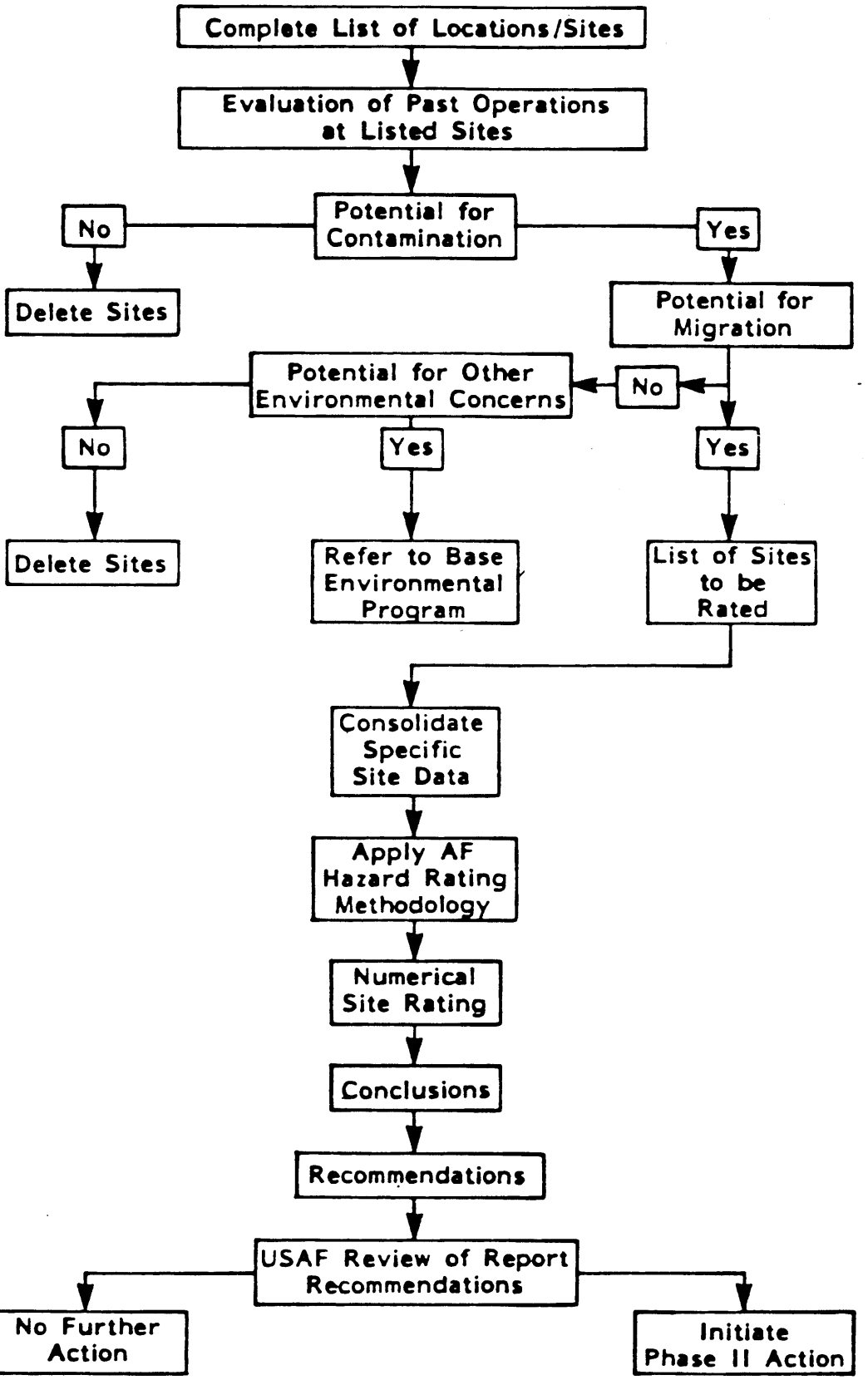
- Industrial shops
- Fire control training
- Pesticide utilization
- Fuels management
- Industrial Waste Treatment

The following discussion addresses only those wastes generated on base which are either hazardous or potentially hazardous. In this discussion a hazardous waste is defined as hazardous by the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) or by the Tinker AFB documents which have been reviewed. A potentially hazardous waste is one which is suspected of being hazardous although insufficient data are available to fully characterize the waste material.

FIGURE 4.1

PHASE I INSTALLATION RESTORATION PROGRAM

DECISION TREE



Industrial Shops

The industrial operations at Tinker AFB can be divided into two major groups as follows: The Directorate of Maintenance and other base maintenance support activities. The Directorate of Maintenance provides facilities for servicing and repairing various types of aircraft and jet engines. Five major divisions embody most of the shop activities for the Directorate of Maintenance. The divisions include the Aircraft Division, Plant Management Division, Propulsion Division, Quality Division and Accessories Division. The greatest quantity of waste materials generated at Tinker AFB were from the Directorate of Maintenance areas.

Other base maintenance support activities are the industrial shops from the Directorate of Distribution, the 2854 Air Base Group, the 2854 Civil Engineering Squadron, the 3rd Combat Communications Group, the 6th Weather Squadron, the 507 Tactical Fighter Group and the 552 Aircraft Warning and Control Wing. These industrial operations include primarily vehicle, electrical and aircraft maintenance and repair.

To assess those shops which handle hazardous materials and/or generate hazardous waste, a review was made of the Bioenvironmental Engineering Office shop files. The results of this file review are shown in Appendix D, Master List of Industrial Shops.

Following the compilation of a master list of industrial shops, personnel within the Directorate of Maintenance and other base maintenance support functions were interviewed. A timeline of disposal methods was established for major waste generated. The information from the interviews with base personnel is summarized in Table 4.1. This table shows the building locations as well as the waste material names, waste quantities, and disposal method timeline.

TABLE 4.1

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY (1)	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 – 1960 – 1970 – 1980)
DIRECTORATE OF MAINTENANCE				
THE FOLLOWING PETROLEUM WASTE ITEMS HAVE BEEN CONSOLIDATED FOR ALL DIVISION SHOPS	NA	RECLAIMABLE WASTE OIL	22,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
		RECLAIMABLE WASTE FUEL	30,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
		WASTE FUELS AND FLUIDS	250,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
		WASTE CALIBRATION FLUID	140,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
		CHLORINATED SOLVENTS (2)	15,000 GALS./YR.	INDUSTRIAL WASTE PITS → DRUMMED TO DPDO CONTRACTOR
AIRCRAFT DIVISION				
COMPOSITE - ALL SHOPS	2122, 2280 3001	PAINT STRIPPER, PHENOLIC	900 GALS./DAY	STORM SEWERS → DISCHARGE TO IWTP (3)
		METHYL ETHYL KETONE (MEK)	55 GALS./DAY	INDUSTRIAL WASTE PITS → DRUMMED TO MADE (4) CONTRACTOR
		PAINT STRIPPER SLUDGES	150 GALS./DAY	INDUSTRIAL WASTE PITS → DRUMMED TO MADE CONTRACTOR
PROPULSION DIVISION				
ELECTROPLATING AREAS	3001	CHROME PLATING WASTES	30,000 GALS./YR.	INDUSTRIAL WASTE PITS → ON-BASE IWTP OR OFF-BASE MADE CONTRACTOR (5)
		ALKALINE-CYANIDE WASTES	37,300 GALS./YR.	INDUSTRIAL WASTE PITS → ON-BASE IWTP OR OFF BASE MADE CONTRACTOR
		MIXED WASTE ACIDS	77,000 GALS./YR.	INDUSTRIAL WASTE PITS → IWTP OR MADE CONTRACTOR
		VARIOUS PLATING SOLUTIONS	2,000 GALS./YR.	INDUSTRIAL WASTE PITS → MADE CONTRACTOR
		PERCHLOROETHYLENE/WAX	7,300 GALS./YR.	INDUSTRIAL WASTE PITS → MADE CONTRACTOR
		CONTAMINATED VAT RIM HOODS	150 DRUMS/YR.	1950 BASE LANDFILLS → MADE CONTRACTOR
CLEANING AREAS	3001	CARBON REMOVER (6)	10,900 GALS./YR.	1955 INDUSTRIAL WASTE PIT → IWTP OR MADE CONTRACTOR
		ALKALINE CLEANERS	22,900 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		CHROMIC/PHOSPHORIC ACID	3,500 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

(1) BASED ON CURRENT RATES AND BEST ESTIMATES OF PAST RATES. PAST RATES ARE ESTIMATED TO BE BETWEEN 50% AND 100% OF VALUES SHOWN.

(2) INCLUDING TRICHLOROETHANE, PERCHLOROETHYLENE AND FREON.

(3) IWTP - INDUSTRIAL WASTE TREATMENT PLANT.

(4) MADE - PLANT MANAGEMENT DIVISION OFFICE SYMBOLS, RESPONSIBLE FOR DISPOSAL CONTRACTORS.

(5) INDICATES A CHOICE IS MADE BY "MADE" TO EITHER TREAT THE WASTES ON BASE AT THE IWT FACILITY OR OBTAIN AN OFF BASE CONTRACTOR TO TRANSPORT AND DISPOSE OF THE WASTE.

(6) CONTAINS ORTHO DICHLOROBENZENE AND CAPRYLIC ACID.

TABL. (cont'd.)

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 – 1980)
PROPULSION DIVISION (cont'd.)				
CLEANING AREAS (cont'd.)	3001	RUBBER REMOVER	1,100 GALS./YR.	INDUSTRIAL WASTE PIT → 1976 → MADE CONTRACTOR
		PHOSPHORIC ACID	45,000 GALS./YR.	INDUSTRIAL WASTE PIT → WTP OR MADE CONTRACTOR
		HOT TANK STRIPPER	5,000 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		EMULSION CLEANER	5,000 GALS./YR.	INDUSTRIAL WASTE PIT → 1976 → MADE CONTRACTOR
		NITRIC/HYDROFLUORIC ACID	1,000 GALS./YR.	INDUSTRIAL WASTE PIT → WTP OR MADE CONTRACTOR
		PERCHLOROETHYLENE WASTES	INCLUDED ABOVE	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
NON-DESTRUCTIVE INSPECTION	3001	PENETRANT	1,800 GALS./YR.	INDUSTRIAL WASTE PIT 1955 → MADE CONTRACTOR
		DEVELOPER	1,500 GALS./YR.	INDUSTRIAL WASTE PIT 1955 → MADE CONTRACTOR
		EMULSIFIER	16,300 GALS./YR.	INDUSTRIAL WASTE PIT 1955 → WTP OR MADE CONTRACTOR
PAINT AREAS	3001	THINNERS	1,700 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		WASTE PAINTS	7,000 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		ACETONE	1,375 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
MACHINE SHOP AREAS	3001	COOLANT OIL	80,000 GALS./YR.	INDUSTRIAL WASTE PIT → MADE CONTRACTOR
		MAGNESIUM THORIUM	600 LBS./YR.	NEVADA AEC DISPOSAL SITE 1964 – 1975
ACCESSORIES DIVISION				
COMPOSITE - ALL SHOPS	229, 230, 3001, 3113	CARBON REMOVER[6]	2,100 GALS./YR.	INDUSTRIAL WASTE PIT → WTP OR MADE CONTRACTOR
		ALKALINE CLEANERS	5,600 GALS./YR.	INDUSTRIAL WASTE PIT → WTP OR MADE CONTRACTOR

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

TABLE 4.1 (cont'd)

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 1960 1970 1980)
ACCESSORIES DIVISION (cont'd.)				
COMPOSITE - ALL SHOPS (cont'd.)	229, 230, 3001, 3113	PERCHLOROETHYLENE	INCLUDED ABOVE	INDUSTRIAL WASTE PIT — MADE CONTRACTOR
		TRICHLOROETHANE	INCLUDED ABOVE	INDUSTRIAL WASTE PIT — MADE CONTRACTOR
		FREON	INCLUDED ABOVE	INDUSTRIAL WASTE PIT — MADE CONTRACTOR
		PAINT WASTES	INCLUDED ABOVE	INDUSTRIAL WASTE PIT — MADE CONTRACTOR
		THINNERS	INCLUDED ABOVE	INDUSTRIAL WASTE PIT — MADE CONTRACTOR
		STRIPPERS, PHENOLIC	INCLUDED ABOVE	INDUSTRIAL WASTE PIT — WTP OR MADE CONTRACTOR
		COOLANT OIL	INCLUDED ABOVE	INDUSTRIAL WASTE PIT — MADE CONTRACTOR
MERCURY SHOP	230	MERCURY CONTAMINATED WASTES & FILTERS	5 LBS./2 MOS.	UNKNOWN (1950) — FORT McCELLAN RECOVERY — DPDO
2854 AIR BASE GROUP				
PHOTO LAB	1	FIXER SOLUTIONS	300 GALS./5 MOS.	SILVER RECOVERY THROUGH DPDO (1953) — IN-HOUSE SILVER RECOVERY
		OTHER PHOTOGRAPHIC SOLNS.	50 GALS./MO.	DISCHARGE TO SANITARY SEWER (1953)
VEHICLE TRANSPORTATION DIVISION	2101	WASTE OILS	300 GALS./MO.	INDUSTRIAL WASTE PIT — DRUMMED TO CES CONTRACTOR
		WASTE FUELS	100 GALS./MO.	INDUSTRIAL WASTE PIT — PUMP OUT TO CES CONTRACTOR
		O/W[7] SEPARATOR SLUDGE	20 GALS./MO.	INDUSTRIAL WASTE PIT — PUMP OUT TO CES CONTRACTOR
2854 CIVIL ENGINEERING SQUADRON (CES)				
LIQUID FUEL SYSTEMS MAINTENANCE	206	FUEL STORAGE TANK SLUDGE	90 GALS./YR.	TANK SLUDGE SPREAD AREA — DRUMMED TO CES CONTRACTOR
ENTOMOLOGY UNIT	773	SPRAYER RINSE WATER	300 GALS./MO.	DISCHARGE TO STORM SEWER (1950) — DRUMMED TO CES CONTRACTOR
		METAL RINSED CONTAINERS (5 GALS.)	5 EA./MO.	ON-BASE LANDFILL (1950) — DPDO

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

[7] O/W: OIL/WATER

TABLE 4.1 (cont'd.)

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1950 1960 1970 1980)
3 COMBAT COMMUNICATIONS GROUP (CCG)				
VEHICLE MAINTENANCE	1001	WASTE OIL	300 GALS./WK.	1955 INDUSTRIAL WASTE PIT → DRUMMED TO CES CONTRACTOR
6 WEATHER SQUADRON				
VEHICLE MAINTENANCE	2101	WASTE OILS, PAINT THINNERS	110 GALS./YR.	1955 INDUSTRIAL WASTE PIT → DRUMMED TO CES CONTRACTOR
		CLEANING SOLVENTS	110 GALS./YR.	1955 INDUSTRIAL WASTE PIT → DRUMMED TO CES CONTRACTOR
507 TACTICAL FIGHTER GROUP (TFG)				
THE PETROLEUM PRODUCTS LISTED AT RIGHT ARE CONSOLIDATED FOR ALL SHOPS.	1030, 1041, 1070	RESALABLE JET FUEL	1,000 GALS./MO.	1957 DRUMMED TO DPDO
		WASTE JET FUEL	100 GALS./MO.	1957 ON-BASE LANDFILL → PUMP OUT TO CES CONTRACTOR
		SYNTHETIC OILS	16 GALS./MO.	1957 ON-BASE LANDFILL → PUMP OUT TO CES CONTRACTOR
		HYDRAULIC FLUID ON RAGS, etc.	55 GALS./YR.	1957 ON-BASE LANDFILL → CITY LANDFILL
CORROSION CONTROL	1030	PAINT THINNERS, MEK	55 GALS./90 DAYS	1957 ON-BASE LANDFILLS → DRUMMED TO DPDO
NON-DESTRUCTIVE INSPECTION (NDI)	1030	PENETRANT	55 GALS./YR.	(NO NDI FUNCTION) 1972 DPDO
		DEVELOPER	55 GALS./YR.	(NO NDI FUNCTION) 1972 DPDO
		HYPOPHOTOGRAPHIC SOLUTION	55 GALS./YR.	(NO NDI FUNCTION) 1972 DPDO
ARMAMENT/GUN SHOP	1030	PD-680	55 GALS./YR.	1957 ON-BASE LANDFILL → PUMP OUT TO CES CONTRACTOR

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

TABLE - (cont'd.)

INDUSTRIAL OPERATIONS (Shops)

HAZARDOUS WASTE MANAGEMENT

SHOP NAME	LOCATION (BLDG. NO.)	WASTE MATERIAL	WASTE QUANTITY	METHOD(S) OF TREATMENT, STORAGE & DISPOSAL (1965 – 1970 – 1975 – 1980)
552 AIRCRAFT WARNING & CONTROL WING (AWACW)				
AIRCRAFT GENERATION SQUADRON (AGS)				
E3A & C135 AIRCRAFT MAINT. UNITS	230	WASTE OILS, FUELS, FLUIDS	400 GALS./MO.	DRUMMED TO CES CONTRACTOR → 1977
COMPONENT REPAIR SQUADRON (CRS)				
CORROSION CONTROL	289	SEPARATOR WASTE SLUDGE	50 GALS./MO.	PUMP OUT TO CES CONTRACTOR → 1977
		PAINT STRIPPERS	20 GALS./WK.	IWTP → 1977
		SOLVENTS, THINNERS	55 GALS./3 MOS.	DRUMMED TO ON BASE STORAGE[1] → 1977
FUEL CELL SECTION	230	WASTE JET FUELS	20 GALS./MO.	DRUMMED TO CES CONTRACTOR → 1977
AIRCRAFT GROUND EQUIPMENT BRANCH	228	WASTE OILS, PD-680, HYDRAULIC FLUIDS, SOLVENTS	100 GALS./WK.	DRUMMED TO CES CONTRACTOR → 1977
		SEPARATOR WASTE SLUDGE	30 GALS./MO.	PUMP OUT TO CES CONTRACTOR → 1977

KEY

——— CONFIRMED TIME-FRAME DATA BY SHOP PERSONNEL

- - - - - ESTIMATED TIME-FRAME DATA BY SHOP PERSONNEL

[1] ON-BASE STORAGE OF HAZARDOUS WASTES IS PROVIDED AT THE OLD WASTEWATER TREATMENT PLANT PENDING FINAL DISPOSAL OFF BASE

Many wastes generated from industrial operations were disposed of in waste disposal pits located south of Building 2121 from 1947 to 1965. These waste included: phenols, plating wastes, acids, and cyanide waste. When the waste disposal pits were closed, Civil Engineering Squadron (CES) began providing contractor pickup and disposal for waste materials off-base. In 1969 the Directorate of Maintenance began arranging for outside contractor pickup of waste materials from their shops and divisions. At this point the Civil Engineering Squadron provided outside contractor waste pickup and disposal only for on-base tenant Air Force units.

Fire Protection Training

Fire Protection Training (FPT) activities of the Fire Department on Tinker AFB commenced about 1950. Since that time, three Fire Training Areas (FTA) have been utilized, as shown on Figures 4.2.

FTA No. 1 was located directly south of the abandoned wastewater treatment facility, north of Crutcho Creek, and west of Air Depot Boulevard as shown on Figure 4.3. The training pit was diked and had a gravel bottom, but was unlined. FPT activities were conducted from approximately 1950 to 1962 at this location, with the heaviest usage occurring in the early 1950's. The procedure was to first add water to the pit to saturate the soil and reduce infiltration and then fuel was added on top of the water. Although fuel oil was often burned in the fire training practice, sometimes the operation included the burning of waste material from 55-gallon drums. No information is available concerning the types of materials contained in these drums; however, it is likely that materials such as solvents and waste oils were consumed in FTA No. 1. After waste materials and/or fuel were added to the pit, it was ignited and then extinguished with water and/or a protein-based foam. The residual mixture remaining in the pit would evaporate or infiltrate into the soil prior to the next training exercise.

After closure of FTA No. 1, fire control training activities were conducted in a temporary pit (FTA No. 2) located several hundred feet west of the present site, as shown on Figure 4.4. The training pit, diked but unlined, was used infrequently between 1962 and 1966. The practice of disposing of drummed waste in the fire training area was discontinued at this time. Fuel was brought in by tank truck, ignited

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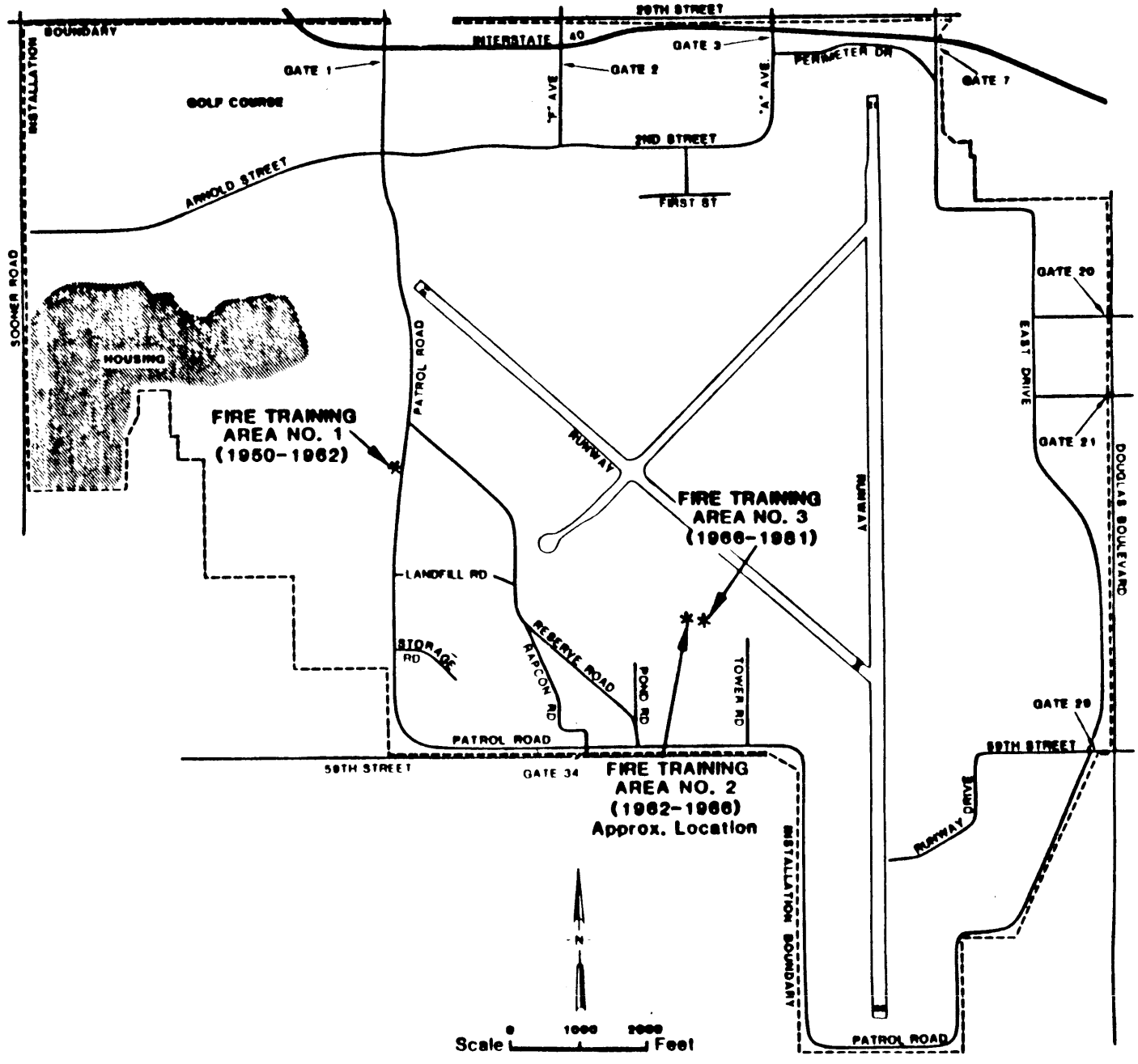
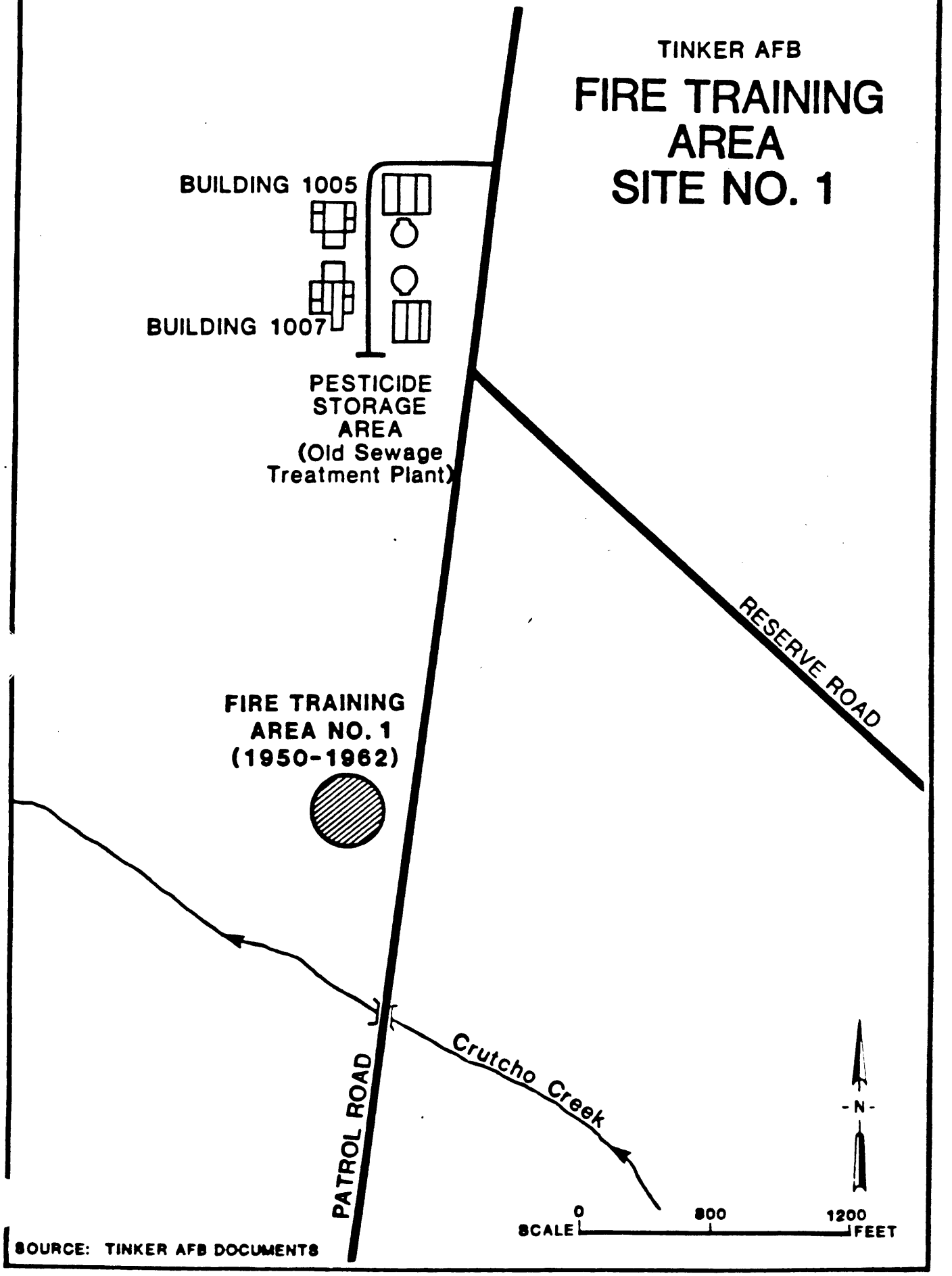
FIRE TRAINING AREAS



SOURCE: TINKER AFB DOCUMENTS

FIGURE 4.2

FIGURE 4.3



SOURCE: TINKER AFB DOCUMENTS

and extinguished in the training pit in the same location. The residue was left in the pit to evaporate and infiltrate prior to the next exercise.

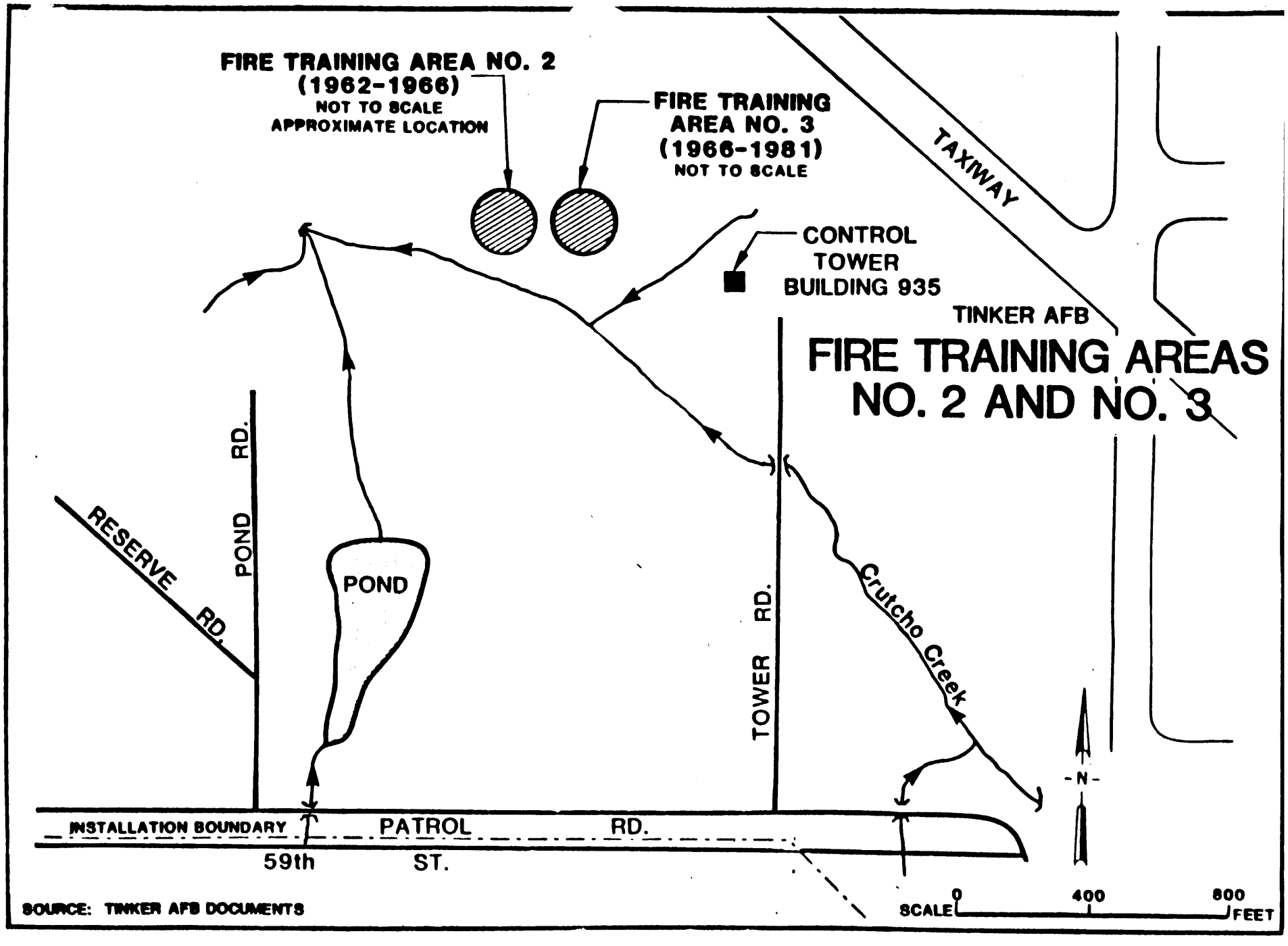
The Fire Department conducts training activities in FTA No. 3 located in the south central portion of the base, as shown on Figure 4.4. This site operated from 1966 to 1981. The training pit was unlined prior to the summer of 1981. The pit is presently being replaced with a concrete-lined training pit in the same location. Prior to training exercises, water was added to the pit to minimize infiltration. Both contaminated and uncontaminated JP-4 fuel have been used at this site. Approximately 600 to 700 gallons of fuel are used during a typical training exercise. After ignition, the fire is extinguished with water and a protein based foam. Training exercises occured only twice during 1979 and about once per month during 1980.

Although diked, overflow from FTA No. 3 had entered Crutcho Creek, according to a 1981 NPDES Compliance Inspection by the Oklahoma Water Resources Board. An area of dead vegetation was noted in the runoff path from the pit to West Crutcho Creek, and soil samples indicated high concentrations of COD and oil and grease were present. The base personnel implemented an excavation project to remove contaminated soil in the area of this training pit prior to constructing a new concrete lined facility as a result of the inspection and soil samples. Contaminated soil was also removed from the area between the pit and Crutcho Creek.

Pesticide Utilization

The pesticide program on Tinker AFB began in the early 1950's. Initially, the Entomology Shop conducted the insecticide program and the Grounds and Pavements Shop managed the herbicide program. In 1979, the Grounds and Pavements Shop transferred the responsibilities of the herbicide program to the Entomology Shop. Both shops are presently located in Building 773. Since 1975, all chemicals have been stored and mixed at the old domestic wastewater treatment plant along Air Depot Boulevard as shown in Figure 4.3. Both large truck-mounted sprayers and hand held sprayers are utilized. A variety of pest and weed control chemicals are used throughout the year.

The Entomology Shop personnel interviewed stated that poor quality chemicals are returned to the manufacturing company for disposal. Some



SOURCE: TINKER AFB DOCUMENTS

off-specification chemicals may have been disposed in the landfills during the 1950's and early 1960's.

Prior to 1975, there were no procedures for collecting rinse water. All cleaning water was allowed to run off to areas adjacent to Building 773, which eventually drains to Khulman Creek. Since 1975, batches of spray equipment rinse water have been drained into an underground storage tank. The rinse water has been pumped from the underground tank approximately once a month by a contractor for off-base disposal.

Prior to 1971, pesticide containers were usually single rinsed, mashed and disposed with the base refuse in the base landfills which were in use. In 1971, the base started a procedure for triple rinsing the pesticide containers and collecting the rinse water in an underground tank. The containers were either punched with holes, crushed or cut up prior to their disposal with general base refuse. Beginning approximately 1978, all metal pesticide containers were taken to DPDO for disposal.

Fuels Management

Numerous aboveground and underground storage tanks are contained in the fuels management system at Tinker AFB. Avgas, mogas, alcohol, fuel oil, diesel, solvents, lube oil, JP-4, and JP-5 are all used on base. The fuel used in the greatest quantities is JP-4 at approximately 5,500,000 gallons per month. Two large storage tanks, for JP-4 and for fuel oil are located in the central base area. Many smaller storage tanks are located throughout the base. A summary of storage capacities for fuels and other products compiled from the base Spill Prevention, Control and Countermeasures (SPCC) Plan is shown in Table 4.2.

A pipeline between the central and east base areas has been used to transfer fuels. The pipeline was periodically pressure tested to identify leakage. Underground tanks were also tested for leakage by monitoring tank levels over a 48-hour period. Most aboveground tanks on base are diked or have other spill control measures.

Fuel spills occur periodically on base. A majority of these are minor spills on the order of several gallons per incident. Spill records from late 1978 to 1981 were reviewed to identify significant spills (defined as greater than 1000 gallons). Four significant spills were identified during this time period. Summary information on these

TABLE 4.2

TINKER AIR FORCE BASE FUELS STORAGE

Product	Number of Tanks	Max. Tank Vol. (gals.)	Min Tank Vol (gals.)	Approx. Storage (gals.)
JP-4, JP-5	35	2,314,000	1,000	5,094,400
Alcohol	1	25,000	25,000	25,000
Avgas	8	25,000	25,000	200,000
Mogas	13	18,000	4,000	145,000
Diesel	9	50,000	2,400	129,200
Solvents and Lube Oil & Calibration Fluid	15	18,000	1,300	128,500
Fuel Oil	10	1,050,000	12,850	1,436,600
Waste Oil/JP-4	4	12,000	12,000	48,000
Calibration Fluid	1	30,000	30,000	30,000

Source: Tinker AFB Documents

spills appears in Table 4.3. Reference was also found to a chemical spill in Crutcho Creek on March 22, 1981, although the magnitude of the spill was undetermined. Records of spills prior to 1978 could not be located, although long-time base personnel did not remember any major spills occurring in previous years.

The major waste items from fuels management area are used fuel line filters and tank bottom sludge. The used filters have been disposed as general refuse, and are eventually buried in the sanitary landfills. Sludge residue accumulates as tank bottoms in leaded fuel storage tanks. At Tinker AFB, leaded tank bottoms were weathered in a small area on top of landfill No. 4. This practice was discontinued in 1977. Since that time, leaded sludges have been handled by contractor disposal.

DESCRIPTION OF PAST ON-SITE DISPOSAL METHODS

The on-site facilities which have been used for management and disposal of waste can be categorized as follows:

- Landfills
- Industrial Waste Pits
- Radioactive Waste Disposal Sites
- Industrial Wastewater Treatment Plant
- Sanitary Wastewater Treatment Plant
- Storm Sewer System
- Ordnance Disposal Sites
- Defense Property Disposal office

These waste management facilities are discussed individually below.

Landfills

Six landfills used for the disposal of refuse were identified at Tinker AFB. Landfill locations on-base are shown on Figure 4.5. Five of the landfills are located on the base, and one is located on leased property adjoining Area "D" east of the base. Table 4.4 contains a summary of information on each landfill.

Landfill No. 1

Landfill No. 1 is a small area, approximately 1 acre in size, south of Crutcho Creek along Air Depot Boulevard (as shown on Figure 4.6). This landfill was used from the formation of Tinker AFB in 1942 until 1945. Primarily general refuse from the base was disposed in the landfill, although the site may also have received waste solids from the

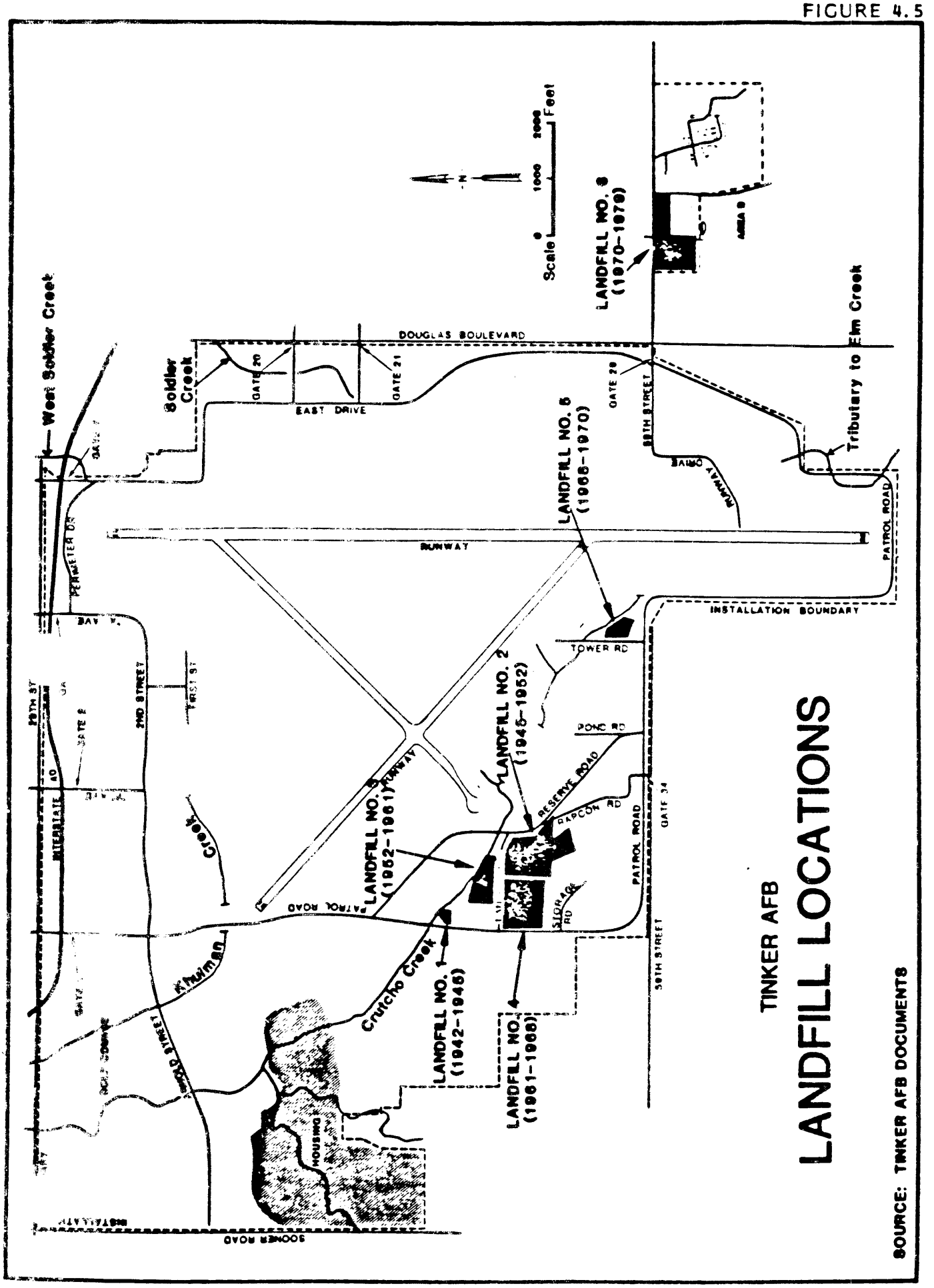
TABLE 4.3

TINKER AIR FORCE BASE SIGNIFICANT SPILLS, 1978-1981

Date	Location	Liquid Spills	Quantity Spilled	Comments
November 28, 1978	Facility 273	JP-4	1,200 gallons	Contained in dike and recovered
August 3, 1979	Building 3001	Acid scale conditioner	1,100 gallons	Neutralized
January 29, 1980	Building 486 (Hydrant System)	JP-4	1,500 gallons	No environmental damage
March 30, 1981	Building 486 (Hydrant System)	JP-4	2,500 gallons	No environmental damage

Source: Tinker AFB documents and employee interviews

FIGURE 4.5



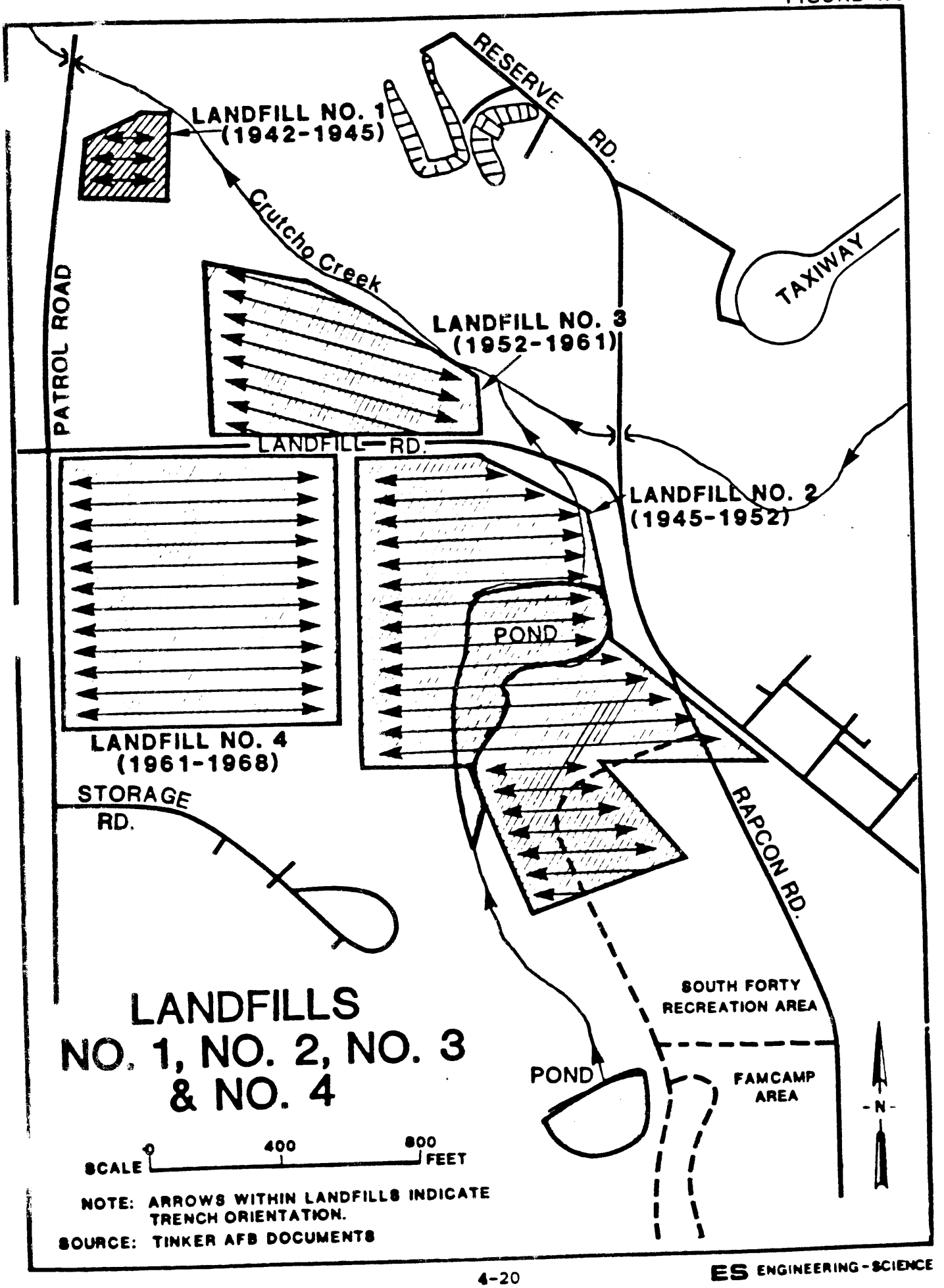
SOURCE: TINKER AFB DOCUMENTS

TABLE 4.4

SUMMARY OF LANDFILLS AT TINKER AIR FORCE BASE

Landfill	Period of Operation	Approximate Area (Acres)	Types of Wastes	Estimate Quantity (YD^3)	Method of Operation	Closure Status	Geological Setting	Surface Drainage	Comments
1	1942-1945	1.2	General Refuse	30,000	Burning, Trench	Closed, covered with earth, vegetation	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Some water ponding due to differential settling in trenches
2	1945-1952	20	General refuse, probably some industrial waste	500,000	Trench	Closed, covered with earth, vegetation	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	A large pond is present above the landfill
3	1952-1961	8	General refuse, probably some industrial waste	200,000	Trench	Closed, covered with earth	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Now used as storage area for hardfill and dirt
4	1961-1968	16	General refuse, probably some industrial waste, and POL sludges	400,000	Trench	Closed, covered with earth, partial vegetation	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Leachate visible along westside of landfill. Past leachate samples show high mercury and phenols
5	1968-1970	3	General Refuse, probably some industrial waste	75,000	Trench	Closed, covered with earth, vegetation	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Some leachate visible along side of landfill near creek
6	1970-1979	11	General Refuse, probably some industrial waste, and industrial waste treatment sludge	500,000	Trench	Closed, covered with earth, partial vegetation	Terrace; sand, silt, clays	To Soldier Creek	Covered and graded. No waste visible.

FIGURE 4.6



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domestic wastewater treatment plant. Refuse was disposed in trenches running east-west, and was typically burned to reduce volume. The trenches extended to a depth of 10 to 25 feet, through a 6 to 8 foot clay layer into a sand/rock zone. Landfill No. 1 is well covered and shows no exposure of the disposal cells; however, settlement in the trenches has resulted in surface depressions where water collects from rainfalls. This water evaporates or percolates through the landfill.

Landfill No. 2

After closure of landfill No. 1, landfill No. 2 was opened south of Landfill Road and west of Reserve Road (Figure 4.6). This landfill was utilized from 1945 until its closure in 1952. Approximately 20 acres were filled during this time period. Although most of the waste disposed of consisted of general refuse from the base, small quantities of paints and solvents were also buried. The waste was disposed of in trenches approximately 20 feet in depth and 35 to 40 feet wide, in an east-west orientation. The refuse was covered daily with several inches of excavated material, and completed trenches were covered with 3 to 4 feet of material.

Landfill No. 2 is well covered and vegetated with grasses and shows no erosion or exposure of landfill material. Several surface depressions with collected rain water caused by material settlement in the trenches are evident on the landfill. A pond, several acres in area, is also located on landfill No. 2. The pond was constructed in the mid-1960's either partly on top or adjacent to the landfill area. From the air, the outlines of trenches can be seen along the boundary of the pond where the water level is high enough to inundate portions of the trenches. Overflow from the pond enters the upper reaches of Crutcho Creek. It is presently unknown to what extent the pond waters percolate through the landfilled material.

Landfill No. 3

During the time period 1952-1961, wastes were disposed of in an eight acre area designated as landfill No.3. This area is located adjacent to landfill No. 2 north of Landfill Road and south of Crutcho Creek (Figure 4.6). The type of waste disposed of and disposal methods were similar to previous landfills. The landfilled material consisted primarily of general refuse, but did include paint buckets, insecticide cans, and empty barrels. A number of low-level radioactive vacuum tubes

were also disposed of at this site. Landfill material were disposed of in trenches running the length of the landfill. Trenches were approximately 25 feet deep, and extended through a surface clay layer into a sand/rock layer. The refuse was covered daily, and a final cover of 3 to 4 feet of excavated material was placed on completed trenches.

Additional radioactive material was reported to have been disposed of in a deep pit adjacent to the northwest corner of landfill No. 3. The area was formerly posted with radioactivity warning signs, which have been destroyed. Radioactive burial is discussed in greater detail later in a subsection of this chapter.

Landfill No. 3 shows no evidence of erosion along the creek or elsewhere around the landfill. At present, additional dirt and hardfill are being stored on top of the landfill. This practice has been in effect for approximately 5 years.

Landfill No. 4

After closure of the landfill No. 3, a 16-acre site south of Landfill Road between landfill No. 2 and Air Depot Boulevard was utilized for refuse disposal and designated landfill No. 4 (Figure 4.6). Disposal practices were essentially the same as previous landfills, with a daily cover of 3 to 6 inches of compacted excavated material applied to the refuse and a final cover of several feet of soil used for completed trenches. The landfill was closed in 1968.

Surface leachate and associated gases have been observed along the west slope of the landfill along Air Depot Boulevard on several occasions since closure. A major problem with leachate from the west bank of landfill No. 4 occurred during 1979. Unusually heavy rainfall occurred during that year. Leachate occurred in a drainage ditch eventually leading to Crutcho Creek. Leachate and drainage ditch wastewater samples analysis data, shown in Table 4.5, indicated high concentrations of COD, oil and grease, phenols, and heavy metals. Unusually high concentrations of mercury (Hg) were also found in the leachate and drainage ditch samples, indicating that significant hazardous wastes quantities may be present in landfill No. 4.

Although the landfill area was covered up with a layer of top soil, small discharges of leachate are still observeable along the west and

TABLE 4.5

1979 ANALYSIS OF DRAINAGE CREEK AND LEACHATE FROM LANDFILL NO. 4

Parameter	Leachate Conc. (mg/l)	Drainage Creek Conc. (mg/l)
COD	29,000	910
Oil and Grease	400	76
Phenols	9.6	1.2
Ba	8.0	24.0
Fe	24.0	21.0
Mn	9.6	9.8
Hg	5.3	7.2
Ni	1.1	0.65
Zn	11.0	9.8

Source: Tinker AFB BESD Files

north banks of landfill No. 4. Surface runoff from these areas, including leachate, enters the drainage ditch and eventually enters Crutcho Creek.

Landfill No. 5

Landfill No. 5 located north of Patrol Road and east of Tower Road, (Figure 4.7) was used during the period 1968-1970. The disposal practices and types of wastes were the same as at Landfill No. 4. The three acre site is well covered and no waste material is exposed; however, waste compaction in the trenches has resulted in surface depressions which collect and hold rain water. A small area of seepage is noticeable on the north eastern edge of the landfill adjacent to West Crutcho Creek.

Landfill No. 6

Landfill No. 6 was used for the disposal of refuse from 1970 to 1979. This landfill, shown on Figure 4.8. is located adjacent to Area "D" approximately 1/2 mile east of Tinker AFB along S.E. 59th Street on land leased from Oklahoma City. Although 40 acres are available at the site, only about 20 acres on the western half of the landfill were used prior to the closing of the site during 1979. Base refuse since that time has been disposed of off-site by private contractor.

Materials disposed in landfill No. 6 consisted primarily of general refuse with small quantities of industrial waste materials such as paint buckets, insecticide cans, etc. Industrial wastewater treatment plant sludge was also intermittently disposed of in this landfill. The refuse was covered daily with 6 to 8 inches of compacted soil, and several feet of compacted cover was used as a final trench covering. Highly permeable river sand was used for daily cover for several years, although other areas had a cover of excavated clay and sand/rock. After closure, the site was revegetated with grasses. Field reconnaissance of the site indicated moderate surface erosion and no observed leachate.

Waste Disposal Pits

Prior to the establishment of an industrial wastewater collection and treatment system, some of the industrial wastes were disposed of in large, open pits. Two waste disposal pit areas, shown on Figure 4.9, were located on the east side of the base south of the aircraft

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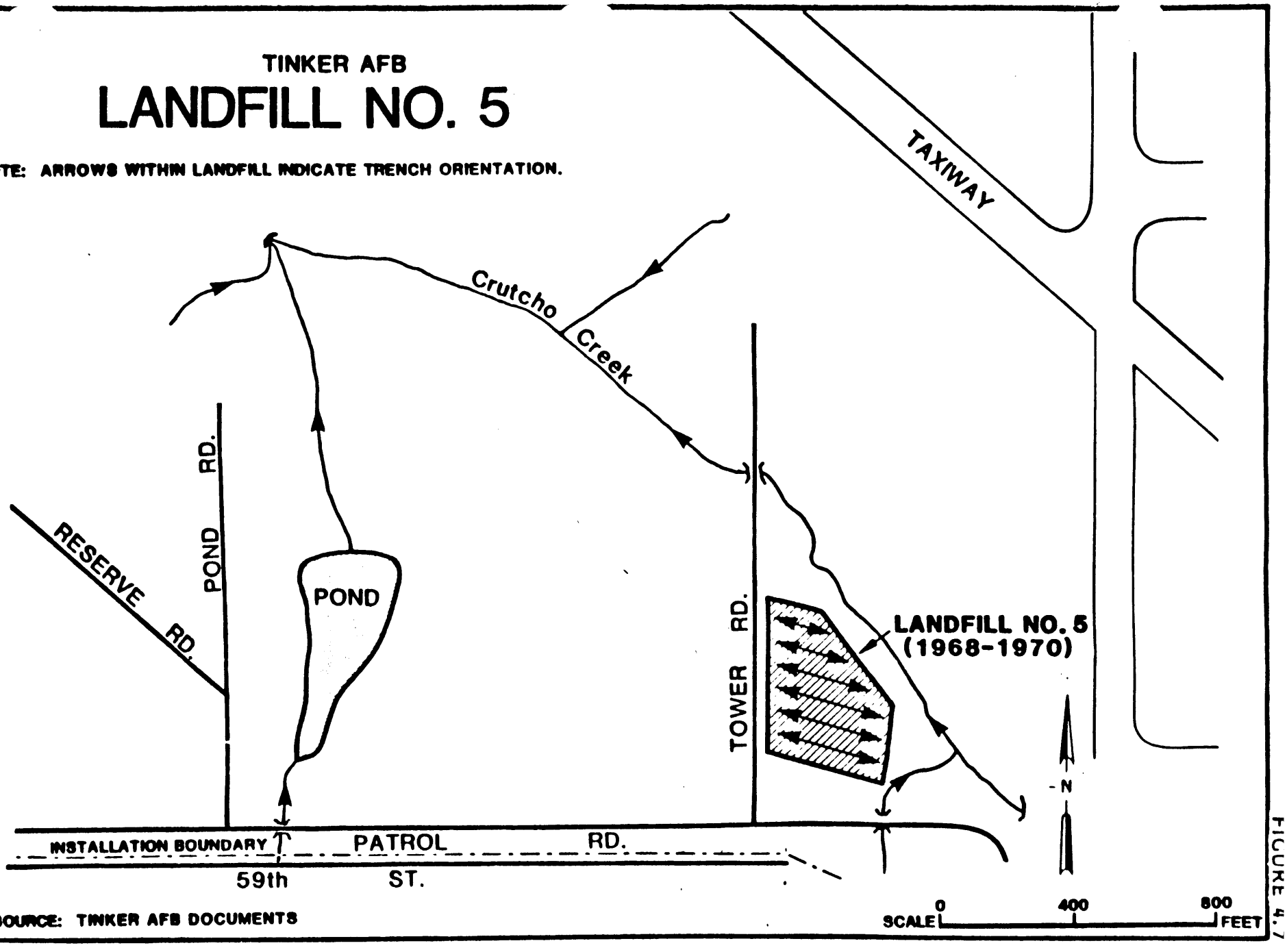
LANDFILL NO. 5

NOTE: ARROWS WITHIN LANDFILL INDICATE TRENCH ORIENTATION.



SOURCE: TINKER AFB DOCUMENTS

FIGURE 4.7

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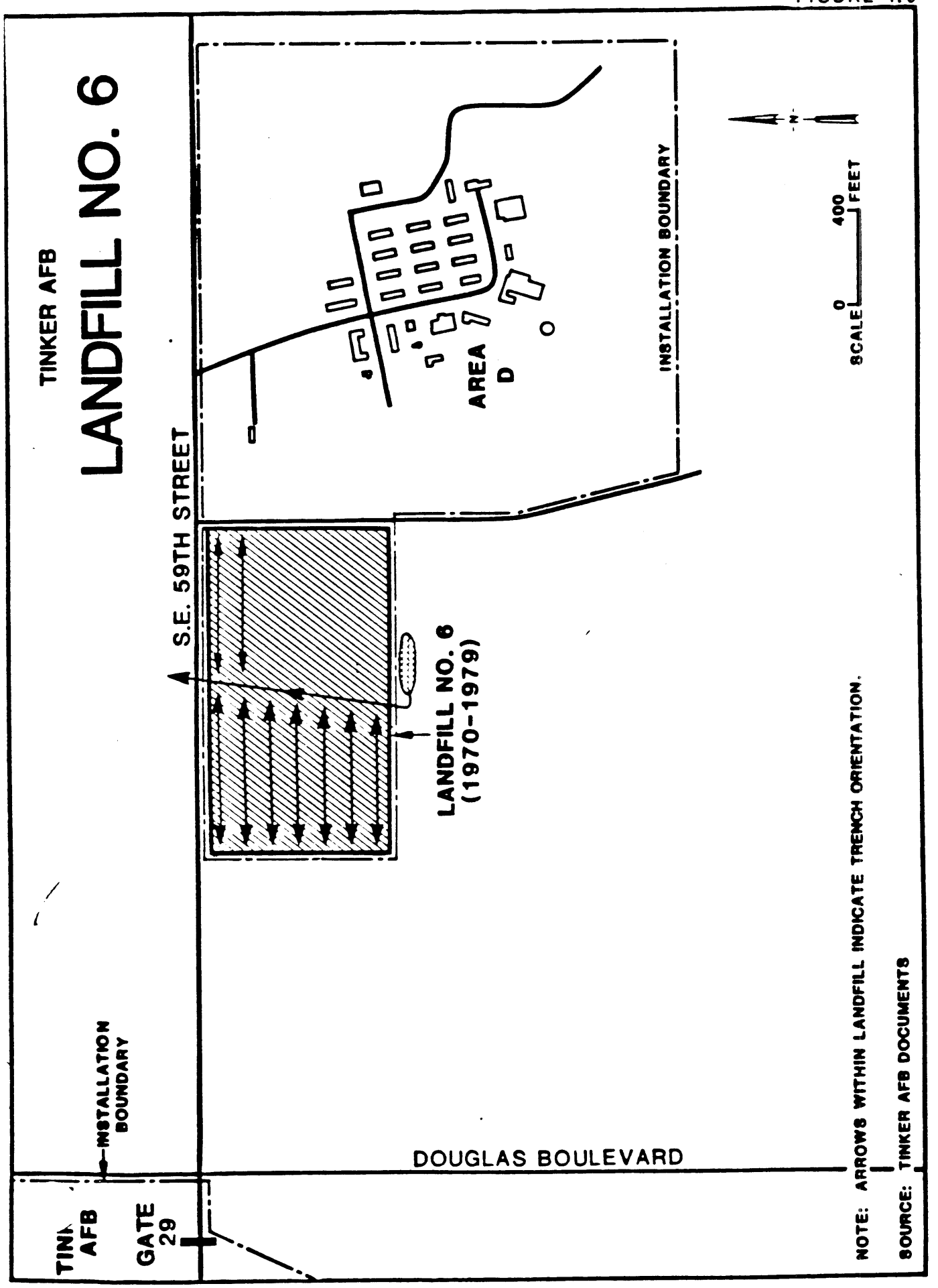
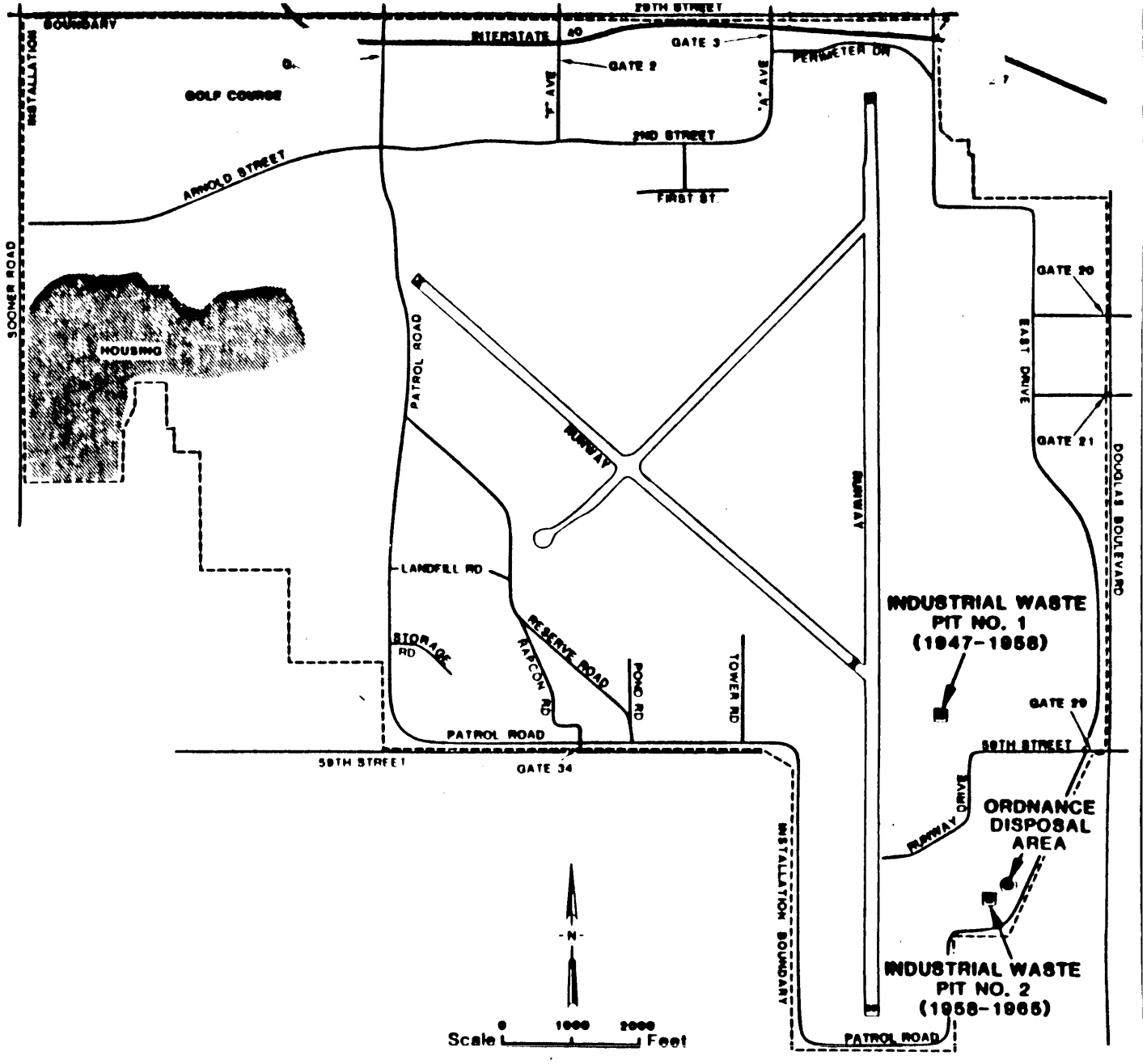
FIGURE 4.8


TINKER AFB
LANDFILL NO. 6
S.E. 59TH STREET
AREA D
INSTALLATION BOUNDARY
N
SCALE
0
400
FEET
LANDFILL NO. 6
(1970-1979)
INSTALLATION BOUNDARY
DOUGLAS BOULEVARD
TINKER AFB
GATE 29
NOTE: ARROWS WITHIN LANDFILL INDICATE TRENCH ORIENTATION.
SOURCE: TINKER AFB DOCUMENTS

TINKER AFB

INDUSTRIAL WASTE PITS and ORDNANCE DISPOSAL AREA



SOURCE: TINKER AFB DOCUMENTS

maintenance area. The pits were used for the disposal of industrial wastes between 1947 and 1965.

Industrial waste pit No. 1 was located southwest of Building 2121, as shown in Figure 4.10. Waste disposal occurred during the period 1947-1958. During the base records search, no written information was located to indicate what was placed in the pit, although interviews with several base personnel indicated large quantities of waste oils, contaminated fuels, chromates, phenols, cyanides, and waste acids and bases generated by plating and maintenance activities were disposed in this facility. The petroleum based contents of the pit may have been burned routinely.

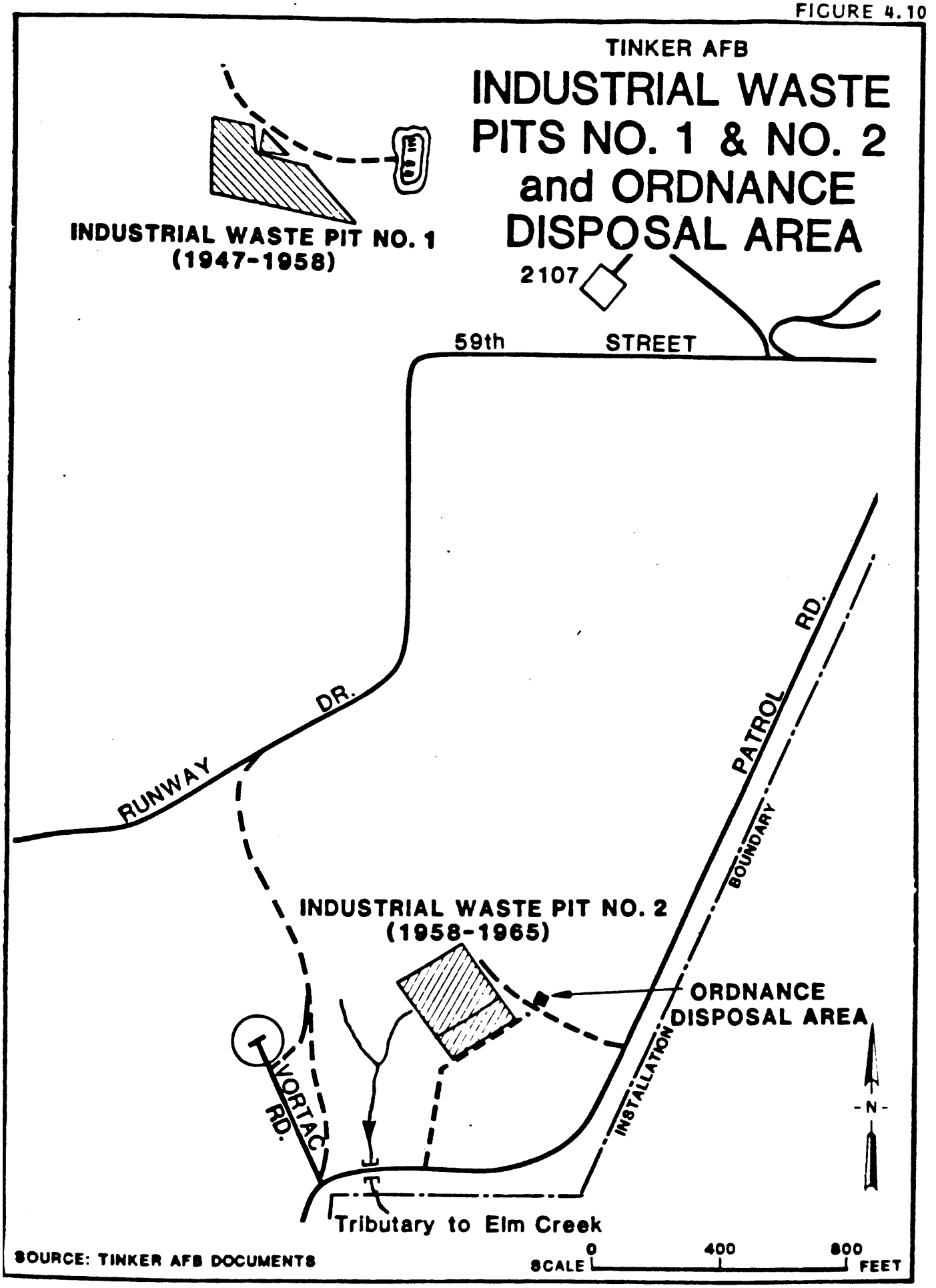
The pit was unlined, and unknown quantities of wastes may have migrated through the soil beneath and around the pit. Surface runoff from the No. 1 pit, if any, would have entered the headwaters of Crutcho Creek. Waste residue may still be present at the site, as there is no evidence that the pit was dredged to remove residual material when the pit was covered and graded over in 1958. There are no visible surface features to indicate exactly where pit No. 1 was located. However, aerial photographs obtained from the base historian and shown in Appendix E show the pit location during operation.

In 1958, industrial waste pit No. 1 was abandoned and a second pit was constructed on a hill between Patrol Road and the airfield runway (Figure 4.10). Industrial waste pit No. 2 also received hazardous wastes such as waste oils, cyanides, chromates, phenols, solvents, and waste acids and alkalies. During the records search, no information was found concerning the construction of the pit. If the pit were unlined, hazardous wastes may have migrated beyond the original pit area. Aerial photographs reveal that the waste pit may have an overflow discharge which drained into Elm Creek. Disposal of hazardous wastes in the pit continued until the early 1960's, and the pit was filled and graded in 1965. There was no information indicating that the waste pit was dredged before it was covered. A photograph of industrial waste pit No. 2 is also shown in Appendix E.

Radioactive Waste Disposal Sites

Radioactive wastes are reported to have been disposed at four locations within Tinker AFB. The burial sites identified as containing

FIGURE 4.10



SOURCE: TINKER AFB DOCUMENTS

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radioactive wastes are shown on Figure 4.11. A summary of information on each radioactive waste disposal site is contained in Table 4.6.

Radioactive Waste Disposal Site (RWDS) 2018 is located adjacent to the overhead conveyor south of Building 201 as shown in Figure 4.12. The site is marked by a concrete post, although radiation warning signs are not posted. Very little information is available concerning radioactive waste disposal at this site. The burial area encompasses approximately 10 square feet and was used for the disposal of radium paint dials and radium paint solids. The dates of operation of this disposal site are not known, and the area is no longer used for disposal of radioactive wastes. No information is available concerning the construction of the disposal pit, depth of burial, or quantity of waste disposed. Radiological monitoring of the site by the Bioenvironmental Engineering Services Division in October 1981 indicated no radioactivity in excess of natural background levels.

A second radioactive waste disposal site, RWDS 62598, is located south of Facility 1025 and north of Crutcho Creek (Figure 4.13). A concrete post with attached radiation warning sign marks the general disposal area. The site contains a "lead still" made of sheet lead used to evaporate methyl ethyl ketone (MEK) or acetone for reuse. The MEK and acetone were contaminated with radium paint from cleaning radium dials. After use, a residue of radium paint solids remained in the still. Following a period of usage, the lead still became radioactive due to the accumulation of solids. In the early 1950's, the lead still was reportedly buried in the general area marked by the concrete post. The depth of burial is not known. One Air Force document states the waste may later have been removed; however, no conclusive evidence exists for either the presence or absence of the waste. Recent radiological monitoring has identified no area of increased radioactivity near the site.

Another radioactive waste disposal site, RWDS 1022E, is located adjacent to the northwest corner of landfill No. 3 south of West Crutcho Creek (Figure 4.13). During the mid-1950's approximately 8 to 10 containers of radioactive material from Building 230 were disposed of at the site. The material was placed in a hole approximately 30 feet deep

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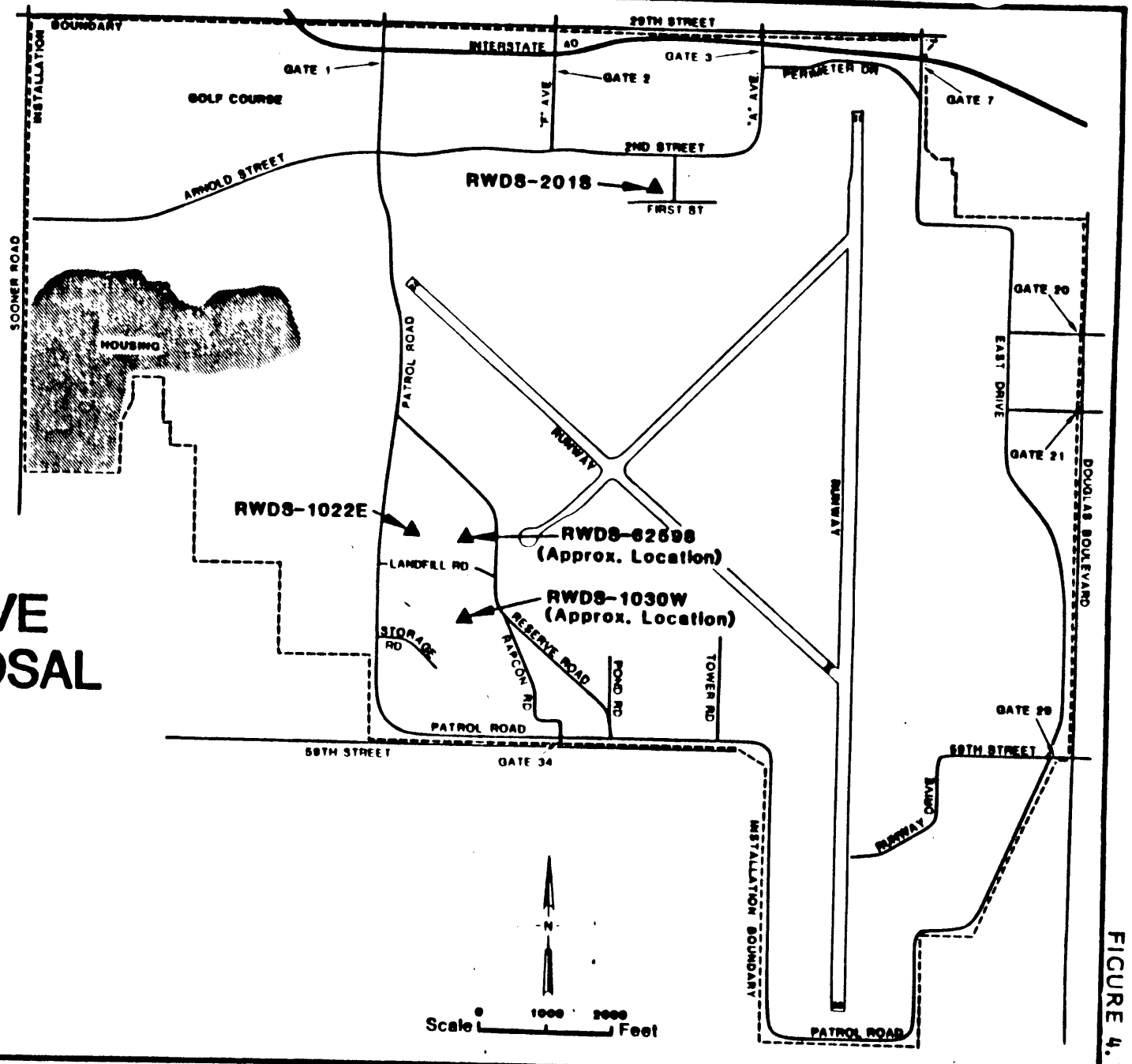
RADIOACTIVE WASTE DISPOSAL SITES



SOURCE: TINKER AFB DOCUMENTS

FIGURE 4.11

TABLE 4.6

SUMMARY OF RADIOACTIVE WASTE DISPOSAL SITES

Landfill	Period of Operation	Approximate Area (Acres)	Types of Wastes	Estimate Quantity (YD^3)	Method of Operation	Closure Status	Geological Setting	Surface Drainage	Comments
RWDS 6259B	Unknown	<0.1	Radioactive "lead still" used for distilling acetone	<10	Pit	Closed (Possibly removed)	Fine-grained sandstone; shale and mudstone	To Khulman Creek	Buried lead still behind Bldg 1025 and creek. Exact location not known.
RWDS 2018	Unknown	<0.1	Low-level radioactive radium paint solids	<10	Pit	Closed	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Radium paint solids buried in pit. Concrete cap.
RWDS 1022E	Late 1950's	<0.1	Low-level radioactive wastes	<10	Pit	Closed	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	8 to 10 kegs of low-level radioactive material buried.
RWDS 1030W	Prior to 1955	<0.1	Low-level radioactive wastes.	<10	Pit	Closed (Possibly Removed)	Fine-grained sandstone; shale and mudstone	To Crutcho Creek	Rags and acetone solutions which contained radium

FIGURE 4.12

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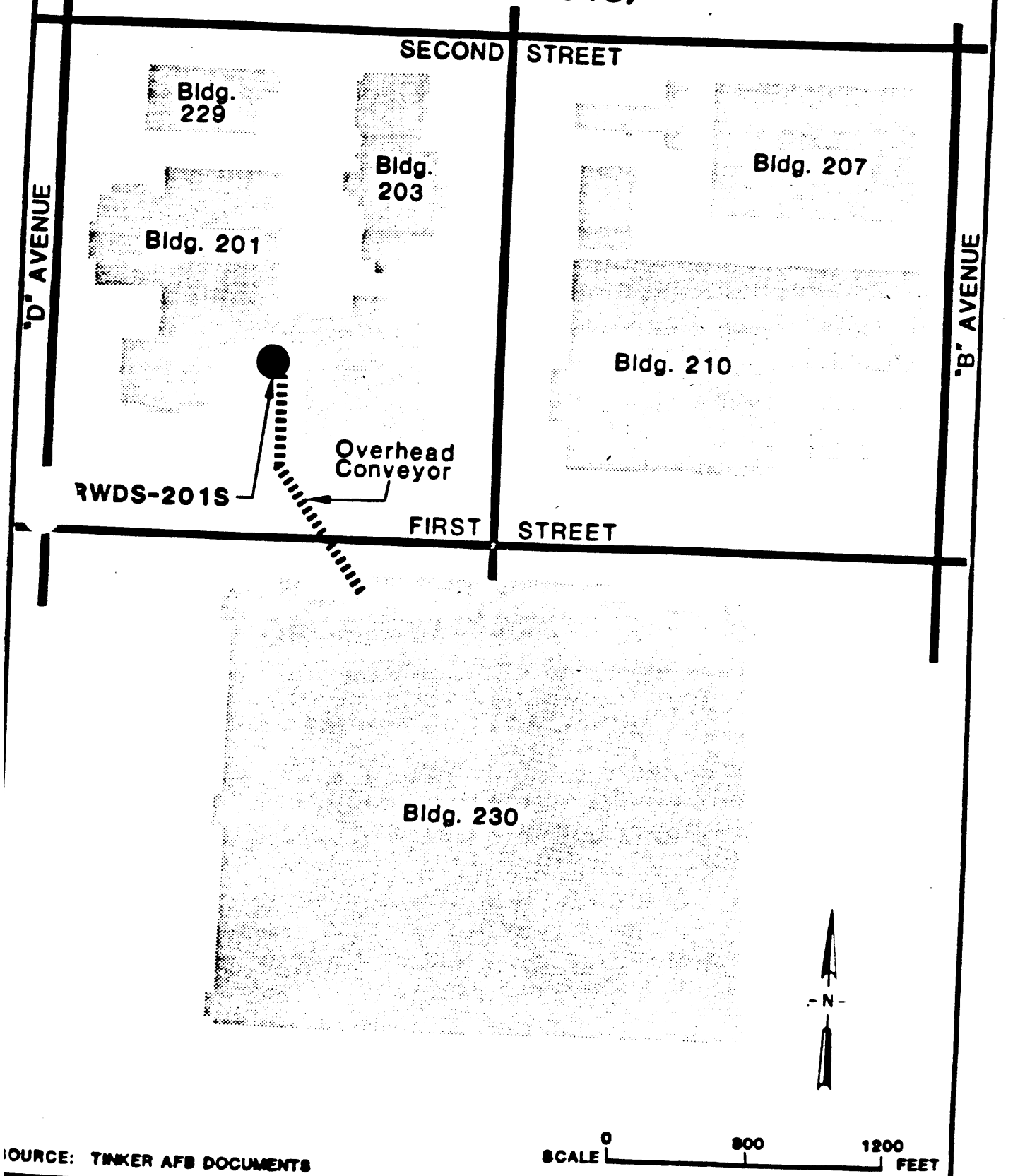
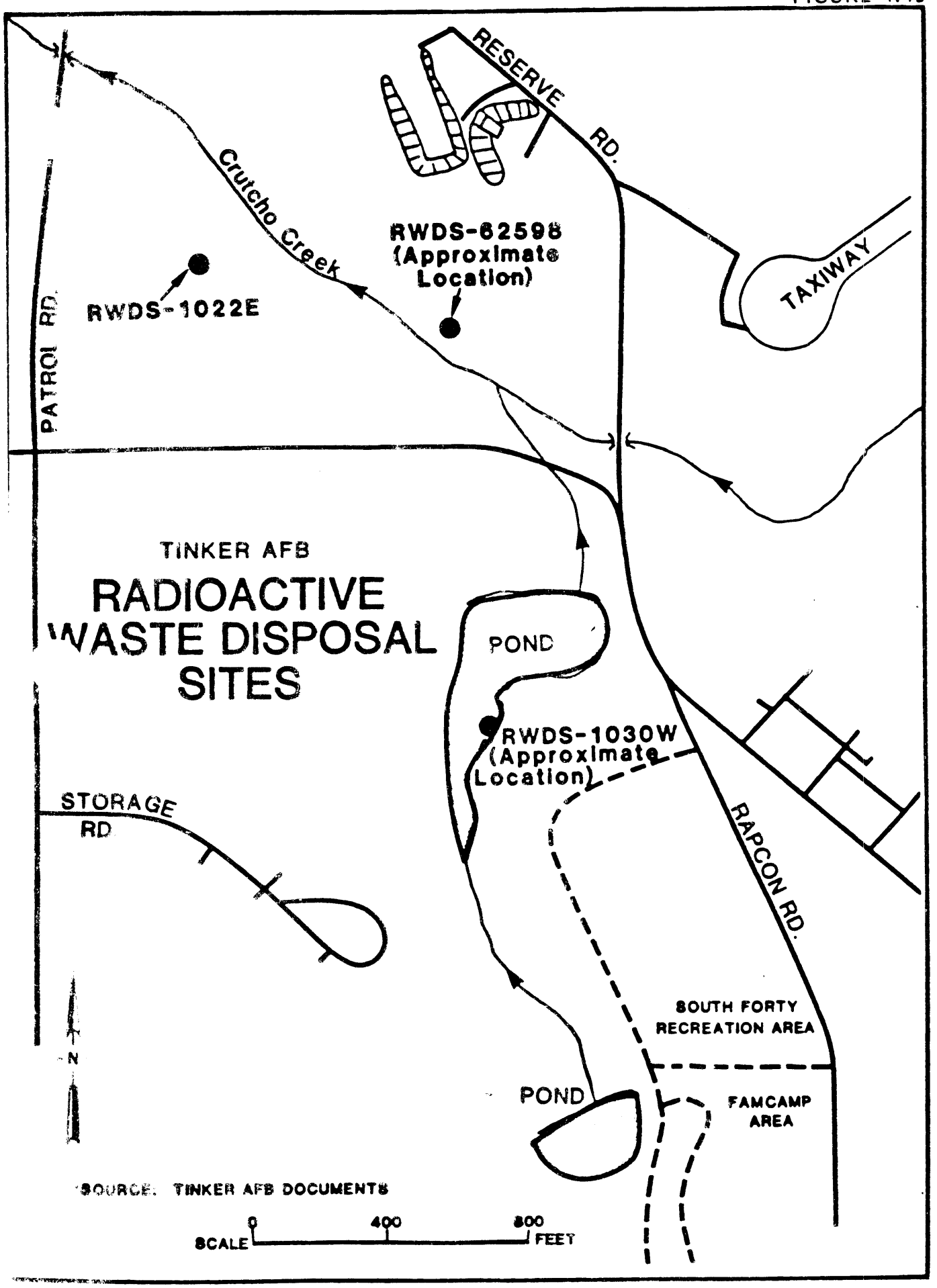
RADIOACTIVE WASTE DISPOSAL SITE (RWDS-201S)



SOURCE: TINKER AFB DOCUMENTS

FIGURE 4.13


RESERVE RD.
Crutcho Creek
RWDS-62598 (Approximate Location)
RWDS-1022E
PATROL RD.
TAXIWAY
TINKER AFB
RADIOACTIVE WASTE DISPOSAL SITES
POND
RWDS-1030W (Approximate Location)
STORAGE RD
RAPCON RD.
SOUTH FORTY RECREATION AREA
N
POND
FAMCAMP AREA
SOURCE: TINKER AFB DOCUMENTS
SCALE 0 400 800 FEET

located next to landfill No. 3, which was operative during the period 1952-1961. The area was marked with radiation warning signs, although none are now present. The area was surveyed with beta/gamma radioactivity detector equipment during November 1981. Radiation levels of 0.03 mr/hr above a background of 0.02 mr/hr were detected; indicating radioactive materials are present, but do not result in radioactivity levels hazardous to human health.

The fourth radioactive waste burial site was identified as being located 1200 feet west and 550 feet north of Building 1030. The site is under water in one of the base's fishing ponds. The area purportedly contained radium dial wastes. A verbal report referenced in an Air Force document asserts that all radioactive wastes were removed in 1955, when the sanitary landfill was established.

Industrial Wastewater Treatment Facilities

Treatment of industrial liquid waste streams began in 1963 and was located in the northeast corner of the base near Gate 19. The treatment facility has discharged treated wastewater to Soldier Creek. The waste facilities were designed to treat approximately 290,000 gallons per day of primarily waste electroplating solutions. In 1969, additional industrial sewer lines were installed to collect dilute streams of electroplating cleaning, and other maintenance area waste streams for treatment. Major improvements in the treatment system were completed in 1971 which increased the design capacity to 1.8 million gallons per day (MGD). Major concentrated streams of electroplating and cleaning solutions from the Directorate of Maintenance were treated by the upgraded facility.

The wastewater treatment units included batch processing of phenols, cyanides, and chrome solutions. Oil/water separators, equalization basins, chemical reduction units, solids contact clarifiers, biological treatment, and chlorine contact chambers are utilized.

Sludge from the industrial waste treatment facility has been disposed of off-base by a contract service. The sludge was occasionally disposed in base landfills through 1979.

Sanitary Wastewater Treatment Facilities

Domestic sewage has been treated on-base since 1942 by an actived sludge system and a single stage trickling filter system. The activated

sludge system served the north central and west base areas until the early 1970's. This system discharged treated effluent into a tributary to Crutcho Creek. This system is located on Patrol Road at Reserve Road and is now used for storage of pesticide chemical and drummed hazardous waste. This sewage treatment system may have received infrequent batches of oil and grease for treatment from the aircraft maintenance areas located in the north central base area. Domestic sewage from the north central and west base areas presently are connected to the Oklahoma City sanitary sewer system.

The single stage trickling filter treatment facility is located adjacent to the industrial waste treatment facility. This system treats domestic sewage from the east base area. The design capacity of the plant is 0.9 MGD, however normal discharge flow is estimated to be 60 percent of design flow. This treatment facility treated quantities of industrial waste streams from the early 1960's to the early 1970's prior and during the expansion of the industrial waste treatment facility. However, no process unit design changes were initiated for treatment of industrial wastes.

Storm Sewer System

Evidence of hazardous liquid waste disposal in the base storm sewer systems was obtained primarily through a report prepared by USAF Occupational and Environmental Health Laboratory (OEHL) in April 1980 (Huang, 1980). This report summarized water quality sampling data collected and analyzed during dry weather conditions in the storm sewer systems around Buildings 3001, 3102, 3105, 3108, 3705 and 3703. High concentration of phenols, chromium and zinc were indicated by the sample data in the storm sewer serving Building 3703 (engine test cells). No potential source for these compounds were determined in the report. The storm system discharges to Soldier Creek.

Ordnance Disposal

Ordnance disposal was conducted on base between the early 1960's and 1972 by a detachment of the 2701 EOD Squadron. The ordnance disposal area was located at the southeast end of the North-South Runway (Figure 4.10) and comprised a burn pit with an adjacent igloo-shaped protective bunker. Ordnance burned during this period consisted of outdated small arms munitions, blasting caps, flares, pyrotechnics and

egress items. The frequency of burning operations was less than once per month. Since 1972, all ordnance disposal required by Tinker AFB has been performed at nearby military installations.

Defense Property Disposal Office

The Defense Property Disposal Office (DPDO) has handled the contracting for collection and transportation of resalable waste petroleum products. These products include: waste jet fuel, waste oils, waste synthetic oils and chlorinated hydrocarbon solvents. The contracts are granted by DPDO on a bid basis. DPDO is presently finalizing an agreement with CES concerning collection, transportation and disposal of all chemical waste and nonresalable petroleum product waste materials for the base. Eleven transformers believed to contain PCB materials are currently in storage within the DPDO area (Building 3770).

EVALUATION OF PAST DISPOSAL ACTIVITIES AND FACILITIES

The review of past operation and maintenance functions and past waste management practices at Tinker AFB has resulted in the identification of 14 sites containing hazardous waste materials and having the potential for migration of contamination. Other sites were reviewed and eliminated from further evaluation based on the logic presented in the decision tree shown in Figure 4.1.

The 14 sites have been assessed using a hazardous assessment rating methodology (HARM), which takes into account characteristics of potential receptors, waste characteristics, pathways for migration, and specific characteristics of the site related to waste management practices. The details of the rating procedures are presented in Appendix G and the results of the assessment are summarized in Table 4.7. The HARM system is designed to indicate the relative need for follow-on action. The information presented in Table 4.7 is intended as a guide for assigning priorities for further evaluation of the Tinker AFB disposal areas (Chapter 5, Conclusions and Chapter 6, Recommendations). The rating forms for the individual waste disposal sites on Tinker AFB are presented in Appendix H. Photographs of some of the key disposal sites are contained in Appendix E.

TABLE 4.7

SUMMARY OF HARM SCORES FOR POTENTIAL CONTAMINATION SOURCES

Rank	Site Name	Receptor Subscore	Waste Characteristic Subscore	Pathways Subscore	Waste Management Factor	Overall Total Score
1	Landfill No. 4	57	53	100	1.0	70
2	Industrial Waste Pit No. 2	57	100	46	1.0	68
3	Landfill No. 2	56	40	100	1.0	65
4	Industrial Waste Pit No. 1	54	100	28	1.0	61
5	Landfill No. 3	54	60	65	1.0	60
6	RWDS 1030W	56	20	100	1.0	59
7	Landfill No. 6	59	45	65	1.0	56
8	Fire Training Area No. 1	54	70	42	1.0	55
9	Landfill No. 5	57	40	57	1.0	51
10	RWDS 1022E	54	50	42	1.0	49
11	Fire Training Area No. 2	54	36	50	1.0	47
12	Landfill No. 1	54	40	42	1.0	45
13	RWDS 62598	54	15	42	1.0	37
14	RWDS 2018	53	25	28	1.0	35

CHAPTER 5

CONCLUSIONS

CHAPTER 5
CONCLUSIONS

The goal of the IRP Phase I study is to identify sites where there is the potential for environmental contamination resulting from past waste disposal practices and to assess the probability of contaminant migration from these sites. The conclusions given below are based on the assessment of the information collected from the project team's field inspection, review of records and files, review of the environmental setting, and interviews with base personnel, past employees and state and local government employees. Table 5.1 contains a list of the potential contamination sources identified at Tinker AFB and a summary of HARM scores for those sites.

1) Landfill No. 4 has a high potential for migation of contaminants. This landfill was utilized from 1961 to 1968 and is now a closed site. Leachate has been observed along the west and north banks of Landfill No. 4 despite top soil cover. Results of a leachate sample analysis has indicated the presence of mercury, phenols, and oil and grease. Landfill No. 4 is located 1,500 feet from a drinking water well and 1,300 feet from the base boundary. The distance to ground water is approximately 250 feet and the regional geology information indicates moderately permeable material between the bottom of the landfill and the water level in the aquifer. The landfill received a HARM score of 70.

2) Industrial waste pit No. 2 has a high potential for migration of contaminants due to the types and estimated quantities of hazardous wastes disposed at this location. Waste pit No. 2 is 1,500 feet from the nearest drinking water well and is 1,500 feet from the base boundary. The estimated depth to ground water is 250 feet. The pit was operated from 1958 to 1965 and did not have an impermeable liner. Waste pit No. 2 received a HARM score of 68.

3) Landfill No. 2 has a high potential for contaminant migration. This landfill was operated from 1945 through 1952 and received general refuse from the base and small quantities of industrial waste.

TABLE 5.1

PRIORITY RANKING OF POTENTIAL CONTAMINATION SOURCES

TINKER AFB

Rank	Site Name	Date of Operation or Occurrence	Overall Total Score
1	Landfill No. 4	1961-1968	70
2	Industrial Waste Pit No. 2	1958-1965	68
3	Landfill No. 2	1945-1952	65
4	Industrial Waste Pit No. 1	1947-1958	61
5	Landfill No. 3	1952-1961	60
6	RWDS 1030W	Prior to 1955	59
7	Landfill No. 6	1970-1979	56
8	Fire Training Area No. 1	1950-1962	55
9	Landfill No. 5	1968-1970	51
10	RWDS 1022E	Mid 1950's	49
11	Fire Training Area No. 2	1962-1966	47
12	Landfill No. 1	1942-1945	45
13	RWDS 62598	Early 1950's	37
14	RWDS 201S	Unknown	35

Note: This ranking was performed according to the Hazardous Assessment Rating Methodology (HARM) described in Appendix G. Individual site rating forms are in Appendix H.

The site is closed and has a soil cover with vegetation. The trench areas have settled leaving small depressions in the surface. The southeast section of the site is now a park and recreation area with a small pond built over landfill material. The pond may be acting as a source of infiltration into the landfill. The HARM score for this site was 65.

4) Industrial waste pit No. 1 has a moderate potential for contaminant migration. This pit was used for disposal of industrial waste between 1947 and 1958. Waste pit No. 1 is 1,100 feet from the nearest drinking water well and 2,250 feet from the base boundary. The estimated depth to ground water is 250 feet. Waste pit No. 1 received a HARM score of 61.

5) Landfill No. 3 received general refuse and small amounts of industrial wastes from 1952 through 1961 and poses a moderate potential for contaminant migration. It is believed that some low level radioactive waste was buried by the northwest corner of this landfill. The site is closed with a soil cover and is being used to stockpile surplus fill dirt and rubble (hardfill). Crutcho Creek runs on the north edge of the landfill. The HARM score for Landfill No. 3 was 60.

6) Radioactive waste disposal site (RWDS) 1030W has a moderate potential for contaminant migration primarily because a pond has been constructed over the burial site. The waste is not very toxic (low level radioactive contaminated material) and there may only be a small quantity present. Base reports indicate the waste may have been removed in 1955 during construction of the landfill. The site received a HARM score of 59.

7) Landfill No. 6 poses a moderate potential for migration of contaminants. Landfill No. 6 was operated from 1970 though 1979 and received general refuse and small quantities of miscellaneous industrial wastes and dewatered sludge from the industrial waste treatment plant. The landfill is now closed and has a soil cover and vegetation over most of the surface. No significant erosion was observed at this landfill. The HARM score for Landfill No. 6 was 56.

8) Fire training area No. 1 has a moderate potential for migration of contaminants. Training exercises at area No. 1 may have utilized waste solvents, as well as waste oils and fuels. This pit was unlined during the period of operation (1950 till 1962). Fire training area

No. 1 is 700 feet from the nearest drinking water well and 2,100 feet from the base boundary. This area is about 100 feet from Crutcho Creek. Fire training area No. 1 received a HARM score of 55.

9) Landfill No. 5 has a moderate potential for contaminant migration. This landfill was operated from 1968 through 1970 and received primarily general refuse from the base. Small quantities of chemical and miscellaneous industrial wastes are believed to have been disposed of in this landfill. The site is closed and has a soil cover with vegetation; however, settling in the trench areas has created depressions which retain rainwater runoff. Some seepage streams were observed coming from the base of the landfill on the northeast side. This landfill is adjacent to a drinking water well, a surface stream, and close to the base boundary. The HARM score for Landfill No. 5 was 51.

10) RWDS 1022E has a low potential for contaminant migration. The site was used during the mid-1950's to dispose several containers of low-level radioactive material. Recent radiological surveys by base personnel indicated no radioactivity levels which are hazardous to human health. RWDS 1022E received a HARM score of 49.

11) Fire training area No. 2 has a low potential for contaminant migration. This site was used infrequently as a temporary fire training site from 1962 to 1966. This site received a HARM score of 47.

12) Landfill No. 1 poses a low potential for migration of contaminants and received a HARM score of 45. This landfill is closed and covered. The general refuse disposed in this landfill was burned to reduce volume. Only small amounts of chemicals and industrial wastes were suspected of being disposed in this landfill.

13) RWDS 62598 has a low potential for contaminant migration. The site contains low-level radioactive materials. An Air Force document indicate that the material may have been removed. Recent radiological monitoring has identified no area of increased radioactivity near the site. RWDS 62598 received a HARM score of 37.

14) RWDS 201S also has a low potential for contaminant migration. The site was used for the burial of low-level radioactive contaminated material. Recent radiological monitoring has identified no area of increased radioactivity near the site. RWDS 201S received a HARM score of 35.

15) The surface drainage systems on-base have been sources of contaminant migration since 1942 when the base operation began. This is confirmed by surface water quality data from the U.S. Geological Survey, R.H. Frank, Jr. (1969), and the base Bioenvironmental Engineering monitoring program. The quantity of contaminants discharged from the base was reduced significantly in the 1960's and again in the 1970's when industrial waste treatment facilities were constructed. A sediment sample collected in East Soldier Creek and a soil sample collected from Crutcho Creek were analyzed in July 1981, by the Oklahoma Water Resources Board and indicated high concentrations of chromium and nickel (East Soldier Creek) and COD, oil and grease and total organic carbon (Crutcho Creek). Contaminants may migrate through sediment leaching into the local surface waters and into the ground-water system.

APPENDIX C
SUPPLEMENTAL ENVIRONMENTAL SETTING INFORMATION

BIOLOGICAL RESOURCES

The following information regarding the Tinker AFB biological resources was obtained from Tinker AFB records.

The site of Tinker AFB is situated on a relatively flat expanse of grassland. Prior to the development of the base, the area was characterized by large expanses of agricultural land. At the present time, the base has approximately 1,630 acres of semi-improved and unimproved grounds which are used for the airfield, golf course, housing area, offices and shops. Naturally occurring ecosystems are, therefore, limited on base. The only wooded areas on base are situated along Crutcho Creek and Soldier Creek. No endangered or threatened plants are located within the base. The following list indicates the endangered and threatened animals which, due to their migratory habits, may occasionally visit the area.

Endangered Species:

- Southern Bald Eagle
- Prairie Falcon
- Artic Peregrine Falcon

Threatened Species:

- American Peregrine Falcon
- American Ivory-Billed Woodpecker

SUMMARY OF SURFACE WATER QUALITY DATA

Surface water quality data available from base records, State agencies and private studies are shown in Tables C.1, C.2, C.3, and C.4.

MONITORING DATA COLLECTED BY TINKER AFB BIOENVIRONMENTAL ENGINEERING

Station Number and Location	Date	COD mg/l	B.O.D mg/l	NO_3-N mg/l	NO_2-N mg/l	Ortho-Phosphate mg/l	CN mg/l	Phenol µg/l	Cd µg/l	Cr (Tot) µg/l	Cu µg/l	Fe µg/l	Pb µg/l	Mn µg/l	Hg µg/l	Ni µg/l	Zn mg/l	Cl^- mg/l	TDS mg/l	$SO_4^=$ mg/l	Surfactants[1] mg/l
Soldier Creek 275 Ft. S. Bldg. 02510	5/30/00	2	<0.3	3.3	1.1	0.0	0.04	<10	10	133	<30	100	<50	91	<5	92	<50	30	12	300	0.3
	6/11/00	23	<0.3	3.4	1.6	1.7	0.04	<10	<10	300	33	233	<50	153	<5	300	<50	34	12	15	0.3
	7/15/00	20	1.0	1.5	2.5	2.6	0.03	12	30	1119	30	664	<50	360	<5	882	<50	33	31	25	0.3
	7/25/00	95	1.4	5.0	1.6	0.0	0.03	30	<10	23000	177	7100	303	1343	<5	2099	231	30	170	14	0.34
	7/31/00	30	0.0	9.0	2.3	12.5	<0.01	10	<10	224	44	117	<50	164	<5	355	<50	32	13	16	0.16
	8/16/00	10	1.72	4.0	1.4	0.2	<0.01	10	10	107	56	106	<50	213	<5	329	<50	53	6	273	0.28
	9/23/00	60	1.1	5.0	0.0	1.6	0.02	<10	10	125	40	101	<50	197	<5	250	<50	30	9	14	0.2
	10/14/00	25	0.0	3.0	1.1	0.7	<0.01	<10	<10	101	103	143	<50	135	<2	195	<50	24	<1	230	0.01
West Soldier Ch. (00 Ft. S. Bldg. 2116)	1/10/79	-	-	3.7	0.4	<0.2	<0.01	<10	24	<50	54	170	<50	<50	<5	<50	<50	14	3	6	0.2
	2/13/79	10	<0.3	6.0	1.2	<0.2	<0.01	<10	<10	<50	32	<100	<50	<50	<5	83	60	9	5	9	0.1
	2/27/79	10	<0.3	3.0	0.5	<0.2	<0.01	<10	<10	<50	<30	<100	<50	<50	<5	63	95	10	5	7	<0.1
	3/5/79	50	0.4	<0.2	<0.1	<0.2	<0.01	22	<10	100	52	350	<50	61	<5	<50	140	10	6	17	<0.1
	3/26/79	50	13.2	<0.2	<0.2	<0.2	<0.01	26	<10	<50	130	360	<50	<50	5.2	60	110	16	9	8.0	0.1
	4/5/79	130	0.4	<0.2	0.3	<0.7	<0.01	10	<10	<50	33	240	<50	<50	<5	<50	130	12	25	11	0.2
	4/12/79	120	0.4	<0.2	1.5	<0.2	<0.01	15	<10	<50	50	790	<50	<50	<5	<50	<50	20	<1	8	0.1
	4/26/79	500	50	9.0	<0.1	1.5	26	25	110	<50	110	70	<50	<5	<5	<50	75	20	54	7	0.1
	5/25/79	<10	<0.3	<0.2	0.7	<0.2	<0.01	<10	10	87	<30	100	<50	<50	<5	<50	<50	32	6	16	<0.1
	7/2/79	90	<0.3	<0.2	<0.1	<0.2	<0.01	<10	<10	224	40	104	<50	<50	<5	<50	<50	14	3	20	<0.1
	7/13/79	20	1	0.3	0.4	0.3	<0.01	10	<10	1200	100	530	<50	220	<5	<50	<50	20	8	10	<0.1
	7/31/79	<10	<0.3	<0.2	0.4	<0.2	<0.01	10	10	<50	77	<100	<50	<50	<50	<50	<50	8	3	7	0.1
Shelman Ch. (Central) (330 Ft. S. Bldg. 00001)	3/6/00	<10	<0.3	0.5	1.3	<0.2	<0.01	<10	<10	<50	<30	140	<50	62	<5	<50	<50	00	10	22	<0.1
	3/21/00	30	<0.3	<0.2	1.2	<0.2	<0.01	<10	<10	<50	<30	297	<50	83	<5	<50	<50	36	8	19	<0.1
	4/15/00	20	<0.3	<0.2	1.4	<0.2	<0.01	<10	<10	<50	<30	194	<50	77	<5	<50	<50	52	<1	25	<0.1
	4/21/00	<10	<0.3	<0.2	1.1	<0.2	<0.01	<10	<10	<50	<30	240	<50	77	<5	<50	<50	60	13	30	<0.1
	5/22/00	25	<0.3	0.4	1.0	<0.2	<0.01	<10	<10	<50	<30	164	<50	106	<5	<50	50	40	3	22	<0.1
	5/30/00	22	1.3	<0.2	1.3	<0.2	<0.01	<10	<10	<50	<30	249	<50	229	<5	230	<50	40	9	26	<0.1
	6/11/00	13	1.3	0.3	0.3	<0.2	<0.01	<10	<10	<50	<30	1065	12	1361	<5	<50	<50	64	30	19	<0.1
	7/15/00	<10	0.6	<0.2	1.2	<0.2	<0.01	<10	<10	<50	<30	610	<50	111	<5	<50	<50	80	17	26	<0.1
	7/25/00	20	<0.3	0.3	1.2	<0.2	<0.01	<10	<10	<50	<30	273	<50	90	<5	<50	<50	64	9	23	<0.1
	7/31/00	25	0.72	0.3	1.0	<0.2	<0.01	<10	<10	<50	30	1041	122	319	<5	<50	57	60	25	23	<0.1
	8/16/00	10	0.00	0.2	0.7	<0.2	<0.01	<10	<10	<50	36	323	<50	340	<5	<50	1640	10	1	13	<0.1
	9/23/00	<10	<0.3	<0.2	0.6	<0.2	<0.01	<10	<10	<50	<30	120	<50	<50	<5	<50	620	00	6	590	<0.1
	10/14/00	10	0.7	<0.2	0.5	<0.2	<0.01	<10	<10	<50	37	151	<50	57	<2	<50	304	34	9	9	<0.1
Shelman Ch. (North) (150 Ft. S. Bldg. 0019)	3/6/00	30	<0.3	3.1	0.5	<0.2	<0.01	<10	<10	<50	<30	304	<50	250	<5	<50	<50	60	8	21	0.2
	3/21/00	70	<0.3	1.0	1.1	<0.2	<0.01	12	<10	<50	<30	523	<50	511	<5	<50	<50	216	27	30	0.2
	4/15/00	70	<0.3	1.1	0.2	0.3	<0.01	<10	<10	<50	<30	1061	<50	1317	<5	<50	<50	170	20	23	<0.1
	4/21/00	30	<0.3	0.3	0.1	<0.2	<0.01	10	10	<50	<30	719	<50	1711	<5	<50	<50	152	33	12	0.1
	5/22/00	35	<0.3	0.3	0.7	<0.2	<0.01	<10	<10	<50	<30	839	<50	253	<5	<50	<50	92	67	30	<0.1
	5/30/00	22	<0.3	0.4	0.3	<0.2	<0.01	<10	<10	<50	<30	3056	<50	502	<5	890	<50	64	553	35	<0.1
	6/11/00	30	<0.3	0.2	<0.1	<0.2	<0.01	<10	<10	<50	<30	445	<50	300	<5	<50	<50	300	82	20	<0.1
	7/15/00	25	<0.3	0.3	<0.1	<0.2	<0.01	<10	<10	<50	<30	1635	<50	1010	<5	<50	<50	100	32.9	16	0.13
	7/25/00	30	<0.3	0.3	<0.1	<0.2	<0.01	12	<10	<50	<30	694	<50	1337	<5	<50	<50	140	19	50	0.13
	7/31/00	32	2.04	0.3	<0.1	0.2	<0.01	16	<10	<50	<30	965	<50	6464	<5	<50	<50	160	16	65	1
	9/23/00	<10	1.0	<0.2	<0.1	<0.2	<0.01	<10	<10	<50	30	265	<50	155	<5	<50	57	20	6	24	0.2
	10/14/00	10	0.7	<0.2	0.2	<0.2	<0.01	<10	<10	<50	110	173	<50	<50	<2	<50	30	30	7	11	<0.1
Crosson Ch. (Pickle) (400 Ft. N. Bldg. 0600)	5/30/00	30	<0.3	0.6	0.3	<0.2	<0.01	<10	<10	<50	<30	1611	<50	239	<5	230	<50	72	105	29	<0.1
	6/11/00	20	0.4	0.6	<0.1	<0.2	<0.01	<10	<10	<50	<30	351	<50	342	<5	<50	<50	200	10	25	0.1
	7/15/00	20	-	<0.4	<0.1	<0.2	<0.01	<10	<10	<50	<23	1630	<50	1376	<5	<50	<50				
	7/25/00	60	<0.3	0.4	<0.1	<0.2	<0.01	14	<10	<50	<30	670	<50	1419	<5	<50	<50	170	20	10	0.19
	7/31/00	65	0.60	0.3	<0.1	<0.2	<0.01	10	<10	<50	<30	402	<50	1621	<5	<50	<50	100	6	70	0.13
	9/23/00	<10	<0.3	0.2	<0.1	<0.2	<0.01	<10	<10	<50	<30	405	<50	710	<5	<50	<50	100	30	16	0.1
	10/14/00	15	0.7	<0.2	<0.1	<0.2	<0.01	<10	<10	54	37	202	<50	196	<2	<50	<50	80	3	14	<0.1

[1] Determined as to Methylene Blue Active Substances (MBAS).

TABLE C.2

HISTORICAL WATER QUALITY DATA
U.S. GEOLOGICAL SURVEY

Station No./Location		Date	Parameter			Remarks
USGS 1	NW Stream, near Air Depot Road at SE 29th	6/7/63	Mn	34	µg/l	Surface Water Sample
USGS 2	West Side Creek at Air Depot Blvd.	6/7/63	Cr	129	µg/l	Surface Water Sample
			Mn	26	µg/l	
			Cd	26	µg/l	
USGS 3	Above Sewage O/F at Air Depot & 44th St.	6/7/63	Pb	45	µg/l	Surface Water Sample
			Mn	400	µg/l	
			V	24	µg/l	
USGS 4	Above sewage O/F, 6/7/63 50 yds West Douglas Blvd.	6/7/63	Cd	2,950	µg/l	Surface Water Sample
			Cr	2,180	µg/l	
			Mn	58	µg/l	
			Ni	129	µg/l	
			V	32	µg/l	
USGS 5	TAFB Gate 7 and SE 29th	6/7/63	Al	620	µg/l	Surface Water Sample
			Cd	46,000	µg/l	
			Cr	31,000	µg/l	
			Fe	540	µg/l	
			Mn	1,400	µg/l	
			Ni	242	µg/l	
			Ag	>500	µg/l	Semi-quantitative
*USGS 6	NE 10th, Between Sooner and Air Depot Blvd.	12/12-14/73	Mn (Total)	780	µg/l	Crutcho Creek Surface Water sample
			Mn (Diss.)	730	µg/l	
			Zn (Total)	320	µg/l	
*USGS 7	E. Reno Ave., 1/2 mile E. of Mid-west	12/12-14/73	Mn (Total)	840	µg/l	Soldier Creek Surface Water Sample
			Mn (Diss.)	840	µg/l	
			Zn (Total)	530	µg/l	

*Note: Sampling station located north of Tinker AFB.

TABLE C.3

OKLAHOMA WATER RESOURCES
BOARD DATA

Station No./Location	Date	Parameter			Remarks
E. Soldier Creek at Douglas Boulevard	7/14/81	Cr	20,650	mg/kg	Sediment Sample
		CN	161	mg/kg	
		Ni	6,900	mg/kg	
		Cd	305	mg/kg	
		Rn	153	mg/kg	
		Zn	295	mg/kg	
Crutcho Creek at Fire Training Area	7/14/81	COD	79,530	mg/l	Soil Sample
		Pb	109	mg/kg	
		O & G	106,200	mg/kg	
		TOC	7377	mg/kg	

Source: Thomas H. Maiello
Oklahoma Water REsources Board 16 November, 1981

TABLE C.4

WATER QUALITY DATA COLLECTED FOR THE Ph.D. DISSERTATION
PREPARED BY R. H. FRANK, JR., ENTITLED
"TRACE METAL POLLUTION OF THE NORTH CANADIAN RIVER BASIN,"
1969, UNIVERSITY OF OKLAHOMA

Station # and Location	Date	Parameters (mg/l)						
		Cd	Cr (tot.)	Cu	Fe	Ni	Zn	Ag
Soldier Creek (at Interstate 40, Station III-B)	8/16/67	0.05	0.76	0.15	0.74	22.0	0.13	0.03
	9/15/67	0.07	0.25	0.18	2.80	0.44	0.28	0.01
	10/13/67	0.41	3.50	0.18	5.00	1.10	0.50	0.03
	11/12/67	0.03	0.35	-	2.10	0.15	0.16	0.03
	11/19/67	0.10	3.20	-	0.44	0.22	0.08	0.01
	12/19/67	0.15	0.36	0.15	0.90	0.66	0.05	0.01
	12/24/67	0.30	0.82	0.23	1.95	1.80	0.16	0.01
	12/31/67	0.15	0.70	-	0.90	2.60	0.10	0.03
	1/29/68	0.05	0.88	0.18	0.74	0.22	0.22	0.03
	2/16/68	1.10	0.71	0.34	2.10	0.66	0.28	0.03
	3/27/68	0.15	3.00	0.4	1.95	0.66	0.22	0.07
	3/29/68	0.41	3.40	0.4	14.00	2.0	0.55	2.15
	4/1/68	2.80	1.40	0.5	1.80	0.54	1.10	0.08
	4/2/68	0.12	1.10	0.4	0.90	0.44	0.28	0.02
	4/3/68	0.15	1.90	0.4	0.60	0.44	0.38	0.01
	4/4/68	0.38	1.50	0.34	0.70	0.90	0.35	0.03
	4/5/68	0.90	1.10	0.34	2.25	0.90	0.35	0.17
	4/6/68	0.05	0.98	-	0.60	0.90	0.13	0.01
	5/8/68	1.30	2.50	0.4	5.00	6.50	0.31	0.03
Crutcho Creek (at Interstate 40 Station III-C	9/5/67	0.25	0.90	0.18	4.00	1.10	0.51	0.01
	9/6/67	0.25	0.58	-	2.70	0.22	0.10	-
	12/10/67	0.30	-	0.15	1.20	0.01	0.05	0.01
	2/20/68	0.08	0.05	0.25	0.15	0.10	0.05	-
	3/29/68	0.23	1.80.	0.15	0.60	0.44	1.5	0.01
	4/5/68	0.25	0.05	0.18	0.30	-	0.10	0.01
Industrial Blvd Drainage Ditch to Soldier Creek (at Interstate 40, Station III-D)	4/5/68	2.0	7.2	0.55	3.60	1.80	0.58	0.04
	5/8/68	0.5	1.5	0.25	0.74	0.22	0.45	0.003

APPENDIX D

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Directorate of Distribution				
Petroleum Storage	290	X	X	CES* Contractor
LOX Systems	1050			
Fuel Services Section	240			
Woodworking Support Section	1			
Paint Support Section	1	X	X	CES Contractor
Installation & Repair Section	1	X		
Central Processing Unit	506	X		
Receiving & Processing Section	506	X		
Air Freight Section	260	X		
Packing Section	506	X	X	DPDO
Packaging Services Section	1	X		
Cargo Operations	506			
Rail Operations	24	X	X	
Drum Storage	1121			CES Contractor
Hazardous Storage Unit	16	X	X	DPDO and CES Contractor

* CES - Civil Engineering Squadron

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-si T.S.I
Directorate of Distribution (Con't)				
Directorate of Maintenance				
Aircraft Division				
Cargo Dock Unit	230	X	X	MADE* tracto
Cargo Structural Unit	240	X	X	MADE C tracto
Cargo Systems Unit	240	X		
Cargo Pre & Post Dock Unit	3105			
Cargo Avionics Unit	3105			
Disassembly & Cleaning Unit	2122	X	X	IWTP** MADE Co tractor
Paint Unit	2280	X	X	IWTP an MADE Co: tractor
Servicing Unit	2122	X		
Fighter Aircraft Unit	3001			
Fighter Structural Unit	3001	X		
Fighter Systems Unit	3001			
Sheetmetal Backshop Unit	3001	X	X	MADE Con tractor
Fighter Avionics Unit	3102	X		
Bomber Docks	2121	X	X	MADE Con-tractor

* MADE - Office for Plant Management Division

**IWTP - Industrial Waste Treatment Plant

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Aircraft Division (Con't)				
Bomber Docks	2121	X	X	MADE Contractor
Bomber Ramp	2121	X		
Bomber Landing Gear Shop	2121	X		
Bomber Sealant Shop	2122	X		
Bomber Glass & Rubber Shop	2122	X		
Bomber Structural Unit	2121			
Bomber Systems Unit	2121	X		
Bomber Pre & Post Dock Unit	3102	X	X	MADE Contractor
Bomber Avionics Unit	2121			
Material Control Section	3001	X	X	MADE Contractor
Transient Alert Branch	240/238	X	X	IWTP and DPDO
Plant Management Division				
Mechanical Installation Sect.	3001	X	X	IWTP
Installation Sect.	2129	X	X	IWTP and MADE Contractor
Metal Processing Sect.	2101	X		
AGE Contractor	2101	X		IWTP and MADE Contractor
Area A Equipment Sect.	210	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Plant Management Division (Con't)				
Area B Equipment Sect.	2210			
Area C Equipment Sect.	3001	X		
Elec. & Electrical Repair Unit	3001	X		
Numerical & Computer Control Repair Unit	3001	X		
Mechanical Unit	3001	X	X	MADE Contractor
Pipefitter & Refrig. Unit	3001	X		
B3108 Test Equip Unit	3108	X	X	MADE Contractor
Engine Test Equip Unit	3234	X		
Miscellaneous Services Sect.	101			
Transient & Mat'l Processing Sect.	3001	X	X	DPDO
Propulsion Division				
Parts Inspection Unit	3001	X	X	IWTP and MADE Contractor
Parts Processing Unit	3001	X	X	MADE Contractor
Cleaning Subunit	3001	X	X	MADE Contractor
Blasting Subunit	3001	X	X	IWTP and MADE Contractor
Disassembly Unit	3001			

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Propulsion Division (Con't)				
TF30 Rotor Unit	3001	X	X	MADE Contractor
TF30 Assembly Unit	3001	X	X	MADE Contractor
J57 Rotor Unit	3001	X	X	DPDO
J57 Assembly Unit	3001	X	X	DPDO
J75 Assembly Unit	3001	X	X	MADE Contractor
TF41 Assembly Unit	3001	X	X	MADE Contractor
TF33 Assembly Subunit	3001	X	X	DPDO
TF33 Rotor Subunit	3001	X	X	MADE Contractor
TDR* & EACI** Section	3001	X		
Fan Jet Machining Subunit	3001	X	X	DPDO
Jet Machining Subunit	3001	X	X	DPDO
Lapping & Rework Subunit	3001	X	X	MADE Contractor
Heavy Grinding Subunit	3001	X		
Light Grinding Subunit	3001	X	X	DPDO
Hour Glass Case Subunit	3001	X	X	MADE Contractor
Specialized Machining Subunit	3001	X	X	MADE Contractor

* Tear-down Deficiency Report

** Engine Analysis Condition Report

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Propulsion Division (Con't)				
Heavy Case Subunit	3001	X	X	MADE Contractor
Heavy Grinding Subunit	3001	X	X	MADE Contractor
Component Machining Subunit	3001	X	X	MADE Contractor
Rotor Component Mach. Unit	3001	X	X	MADE Contractor
Turbine Blade Unit	3001	X	X	MADE Contractor
Gear Box Unit	3001	X	X	MADE Contractor
pressor Blade Unit	3001	X		
Chrome Plating Subunit	3001	X	X	IWTP and MADE Contractor
Nickel Plating Subunit	3001	X	X	IWTP and MADE Contractor
Misc. Plating Subunit	3001	X	X	IWTP and MADE Contractor
Solution Maintenance Subunit	3001	X	X	IWTP and MADE Contractor
Heat Treat Subunit	3001	X	X	MADE Contractor
Plasma Spray Subunit	3001	X	X	MADE Contractor
asting Subunit	3001	X	X	IWTP and MADE Contractor
Sermetal Subunit	3001	X	X	MADE Contractor

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Propulsion Division (Con't)				
Coating Subunit	3001	X	X	MADE Contractor
Vane & Shroud Rework Unit	3001	X		
Electric Welding Subunit	3001	X		
Gas Welding Subunit	3001	X		
Resistance Welding Subunit	3001	X		
Material Control Section	3001	X	X	DPDO
Test Section	3234	X	X	IWTP and MADE Contractor
ıtegorization Unit	3703			
Final Preparation Unit	3703	X	X	IWTP and MADE Contractor
Test Section	3703	x	X	IWTP
Reclamation Unit	2101	X	X	MADE Contractor and DPDO
Stripping Unit	2101	X	X	IWTP and MADE Contractor
Quality Division				
Cargo Quality Section	230			
Bomber Quality Section	2121			
ghter Quality Section	3001			

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Quality Division (Con't)				
Chemical Laboratory Section	3001	X	X	IWTP AND MADE Contractor
Non-Destructive Insp. Section	3001	X	X	IWTP and MADE Contractor
Metallurgical Section	3001	X	X	MADE Contractor
Material Testing Section	3001			
Jet Engine Quality Section	3001			
Machining and Special Processes Quality Section	3001			
Flight Control and Accys. Quality Section	230			
Engine Accys & Trans. Qlty. Sect.	3001			
Accessories Division				
Area A Precision Measurement (PME) Section	201	X		
Special Measurement Supt. Sect.	3113	X		
Area C PME Section	3113	X		
Cabin Pressure Regulator and Valve Unit	210	X	X	IWTP
Turbine Powered Accys. and Missile Maintenance Unit	210	X	X	MADE Contractor

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Accessories Division (Con't)				
Oxygen & Assoc. Equipment Unit	1055	X	X	MADE Contractor
Air Accys. Testing Unit	210	X	X	MADE Contractor
Electrical Accys. Unit	3001	X	X	IWTP and MADE Contractor
Electro-Mechanical Accys. Unit	3001	X	X	IWTP
Governor, Misc Engine Accys. Overhaul & Test Unit	3001	X	X	MADE Contractor
Fuel Control Overhaul Unit	3001	X	X	MADE Contractor
Accessories Unit	3001	X	X	IWTP
Machine Unit	3001	X	X	MADE Contractor
Accessories Test Unit	3108	X	X	MADE Contractor
Automatic Pilot Unit	230	X	X	IWTP and MADE Contractor
Engine Instrument Unit	230	X		
Flight Control Unit	230	X	X	IWTP and MADE Contractor
Gen. Trans. Overhaul Unit	2210	X	X	IWTP and MADE Contractor
Specialized Transmission Overhaul Unit	2210	X	X	DPDO
Bearing Unit	3001	X	X	MADE Contractor

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Accessories Division (Con't)				
Machine Shop Unit	2210	X	X	IWTP and MADE Contractor
Manufacture Subunit	3001	X	X	MADE Contractor
Tubing & Cable Mfg. Subunit	3001	X	X	DPDO
Tubing & Cable Repair Subunit	3001	X	X	DPDO
Foundry	2101			
Tank & Cooler Unit	3001	X	X	IWTP and MADE Contractor
General Machine Shop Unit	3001	X	X	MADE Contractor
Numerical Control Unit	3001	X	X	DPDO
Woodmill Subunit	2121	X		
Manufacture and Radome Subunit	230	X	X	IWTP and MADE Contractor
Mfg. & Repair Glass Subunit	230	X		
Parachute Subunit	229	X	X	MADE Contractor
Rubber Subunit	229	X	X	MADE Contractor
Tooling/Tool & Die Subunits	3001	X	X	MADE Contractor
Grinding Subunit	3001	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
Accessories Division (Con't)				
Pattern Shop	3001	X	X	DPDO
Gas and Electron Beam Subunit	3001			
General Welding Subunit	3001	X		
Accessories Welding Subunit	3001	X		
Air Accys. Material Control Sect.	230			
ALC Miscellaneous Shops				
Specialized Eng. Branch	3220	X		
Vocational Technical Training Center	675	X	X	MADE Contractor
2953 Combat Logistic Supp. Sqdn.	3001	X	X	MADE Contractor
2854 Air Base Group				
Printing & Duplicating Sect.	1	X	X	IWTP
Small Arms Marksmanship Br.	1023			
Photo Lab.	4026	X	X	Silver recov. then IWTP
Aircrew Life Support Branch	3102	X		
Restaurant Equip. Maintenance	203	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
2854 Air Base Group (Con't)				
Restaurant Vehicle Maint.	769	X		
Bowling Lanes	5703			
Auto Hobby Shop	6002	X	X	CES Contractor
Ceramics Hobby Shop	6002			
Wood Hobby Shop	6002			
General Purpose Maintenance	2101	X	X	CES Contractor
Special Purpose Vehicle Maintenance	2101	X	X	CES Contractor
Refueling Maintenance	2110	X	X	CES Contractor
2854 Civil Engineering Squadron				
Fire Protection Branch	461	X		
Protective Coating Unit	414	X	X	CES Contractor
Metal Working Unit	414			
Plumbing Unit	414	X		
Structural Unit	414			
Exterior Electrical Unit	414	X	X	CES Contractor
Interior Electrical Unit	414	X	X	CES Contractor
Grounds/Pavements Section	773	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
2854 Civil Engineering Squadron (Con't)				
Golf Course Maintenance	6601	X		
Liquid Fuels System Maint.	246	X	X	CES Contractor
Heating Systems Unit	414	X	X	CES Contractor
Refrigeration/Air Conditioning	414	X	X	CES Contractor
Electrical Power Production	414	X	X	CES Contractor
Entomology Unit	773	X	X	CES Contractor
Water/Waste Unit	62516	X	X	CES Contractor
USAF Hospital				
Dental Clinic	5801	X	X	CES Contractor
Clinical Lab	5801	X		
Radiology	5801	X		
Medical Maintenance	5801	X		
Surgery	5801			
Veterinary Services	702	X		
3 Combat Communications Group				
Electrical Power Production	1010	X	X	CES contractor

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
3 Combat Communications Group (Con't)				
Refrig./Air Conditioning Maint.	1010	X		
Navigational Aids Maintenance	900			
Radar Maintenance	7001	X		
Radio Maintenance	7003			
Longhaul Maintenance	7003			
Ground/Air Maintenance	7003			
Wideband Maintenance	904	X		
DSTE Maintenance	7003	X		
Teletype Maintenance	7003	X		
Cryptographic Maintenance	7003			
Inside Plant	7003	X		
Outside Plant	7003			
Vehicle Maintenance	1001	X	X	CES Contractor
6 Weather Squadron				
Vehicle Maintenance	2101	X	X	CES Contractor, oil/water separator and IWTP
507 Tactical Flighter Group				
Flight Line Maintenance	1070	X		

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
507 Tactical Flighter Group (Con't)				
Jet Engine Shop	1070	X	X	CES Contractor
Communications/Navigation Shop	1030	X		
Auto Pilot/Instruments	1030			
Inertial Navigation Shop	1030			
Electronic Countermeasures	1072			
Weapons Control System	1030			
Welding	1030			
Structural Repair	1030			
Machine Shop	1030			
Survival Equipment	1030			
Pneudraulics	1030	X	X	CES Contractor
Mechanical Accys.	1041	X	X	CES Contractor
Electric Shop	1030	X		
Non-Destruct. Inspect.	1030	X		
Powered Aircraft Ground Equip. (AGE)	1041	X	X	CES Contractor
Inspection	1030			
Corrosion Control	1030	X	X	CES Contractor

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
507 Tactical Flighter Group (Con't)				
Fuel System Repair	1030	X	X	CES Contractor
Repair & Reclamation	1037			
Egress	1030	X		
Loading/LSC		X		
Armament/Gun Shop	1030	X	X	CES Contractor
Life Support	1048	X		
Munitions Storage	1030	X		
552 Aircraft Warning and Control Wing				
Acft. Gen. Sqdn. (AGS) E3A Aircraft Maint. Unit (AMU)	230	X	X	CES Contractor
AGS-C135 AMU	230	X	X	CES Contractor
Component Repair Sqdn. (CRS)-Comm. Shop	230			
CRS-Nav/Instrum Shop	230			
CRS-Computer Shop	230			
CRS-Radar Shop	230	X		
CRS-Corrosion Control	289	X	X	CES Contractor

MASTER LISTS
INDUSTRIAL SHOPS

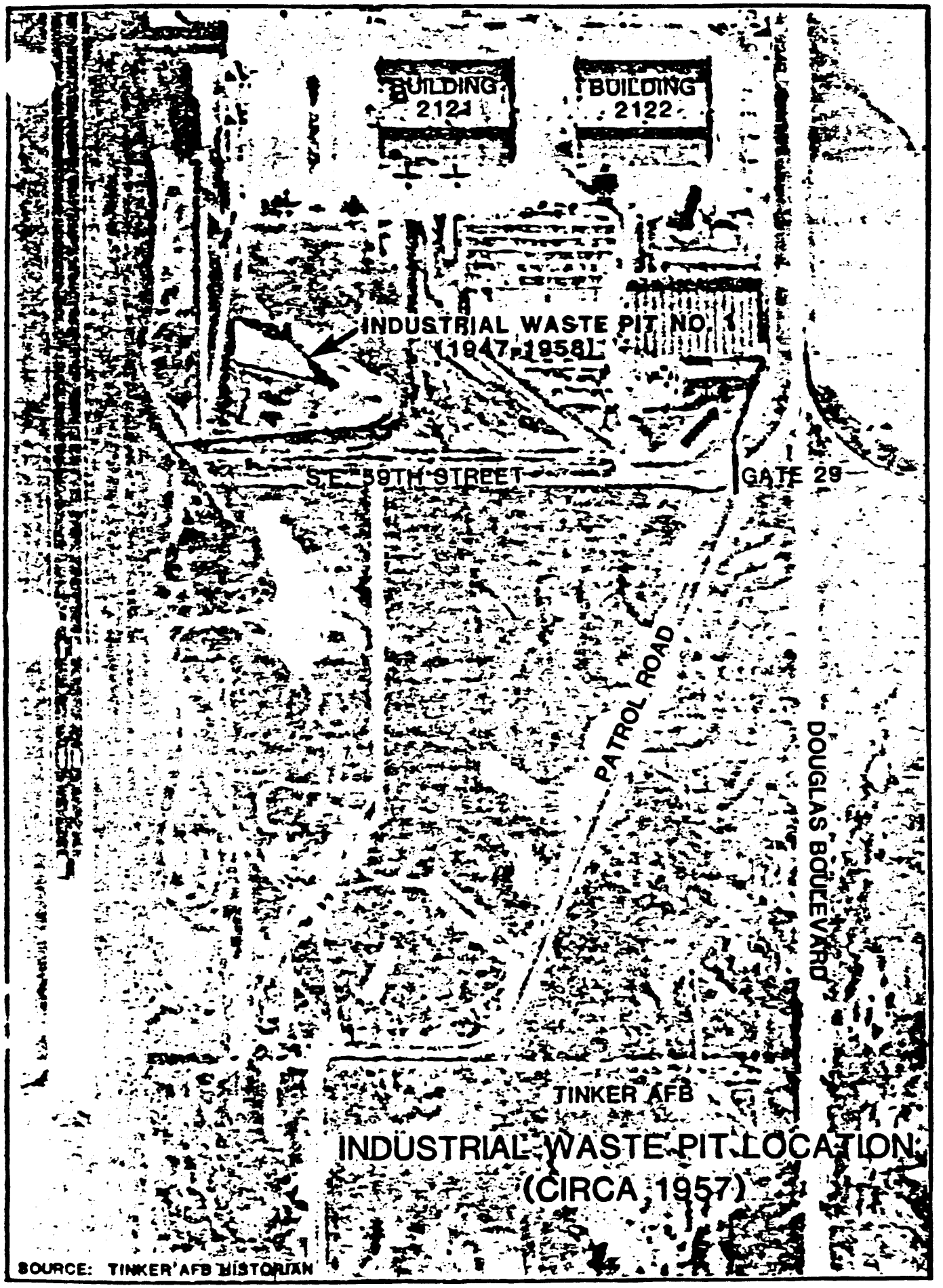
Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
552 Aircraft Warning and Control Wing (Con't)				
CRS-Fuel Cell Section	230	X	X	CES Contractor
CRS-Maintenance Inspection	230	X	X	CES Contractor
CRS-Repair & Reclamation	230			
CRS-Flight Simulator	283	X		
CRS-AGE Branch	228	X	X	CES Contractor
CRS-Electric Shop	230	X		
CRS-Environ. Control Systems Shop	230	X	X	CES Contractor
CRS-Hydraulic Shop	230	X	X	CES Contractor
CRS-Jet Engine Shop	228	X	X	CES Contractor
CRS-Sheet Metal/Machine Shop	230	X		
CRS-Welding Shop	228			
Wing Life Support	221			
1985 Communications Squadron				
Power Production	3001	X	X	DPDO
Navigational Aids Maintenance	18			

MASTER LISTS
INDUSTRIAL SHOPS

Name	Present Location (Bldg. No)	Handles Hazardous Materials	Generates Hazardous Wastes	Past On-site T.S.D
1985 Communications Squadron (Con't)				
Radar Maintenance	249			
Weather Maintenance	219			
Radio Maintenance	18			
TV Maintenance	18			
Centralized Repair Activity	2101			
Teletype Maintenance	18			
Crypto Maintenance	3001			
Defense Property Disposal Office	3767	X	X	DPDO Contractor Disposal

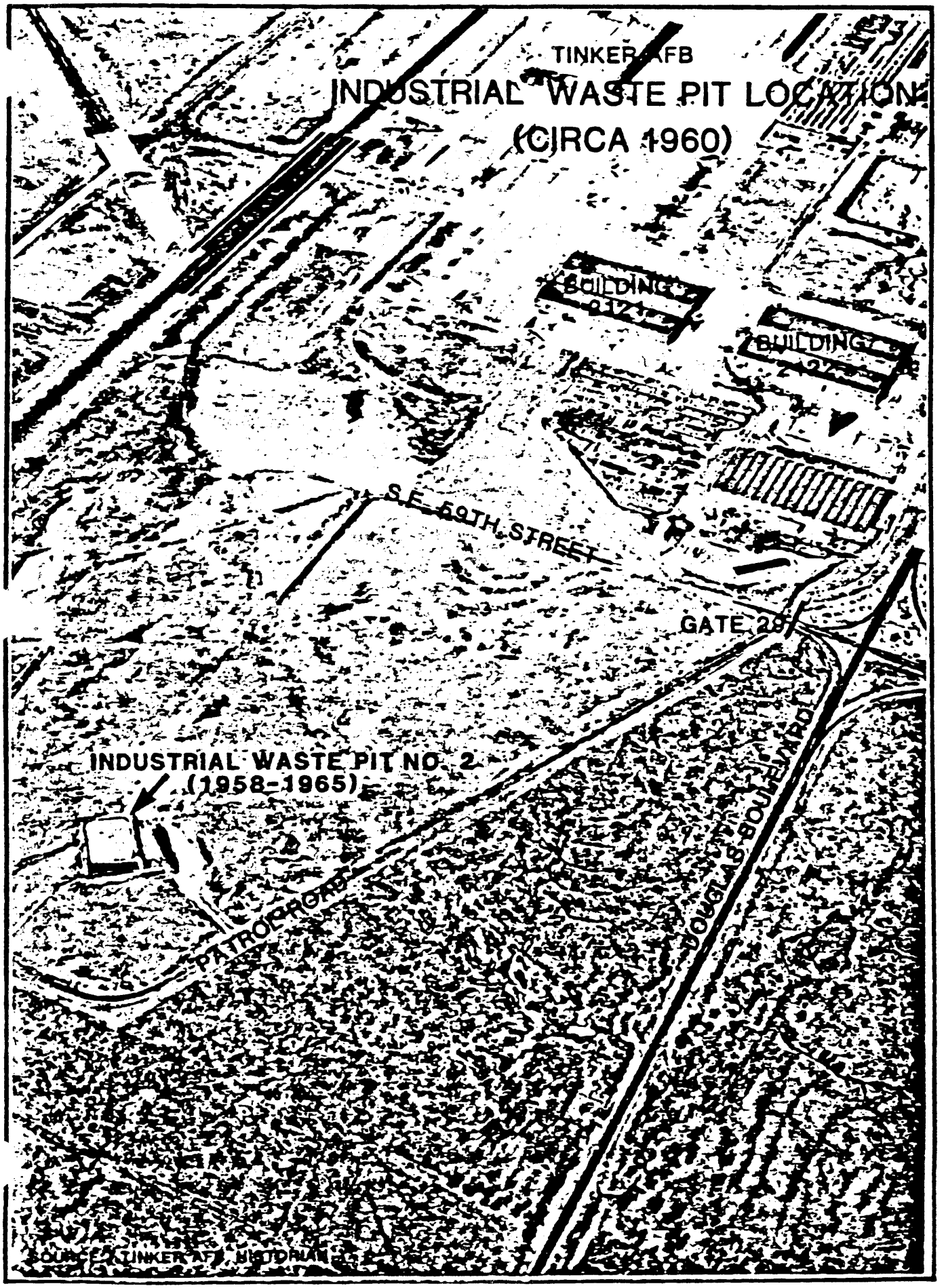
APPENDIX E

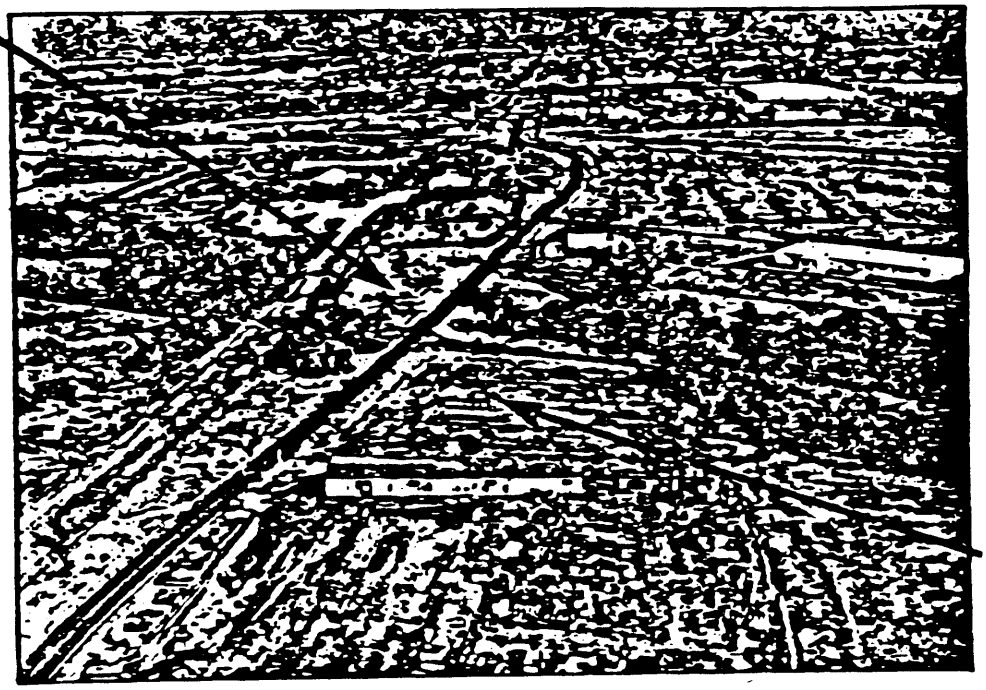
PHOTOGRAPHS



INDUSTRIAL WASTE PIT LOCATION (CIRCA 1957)

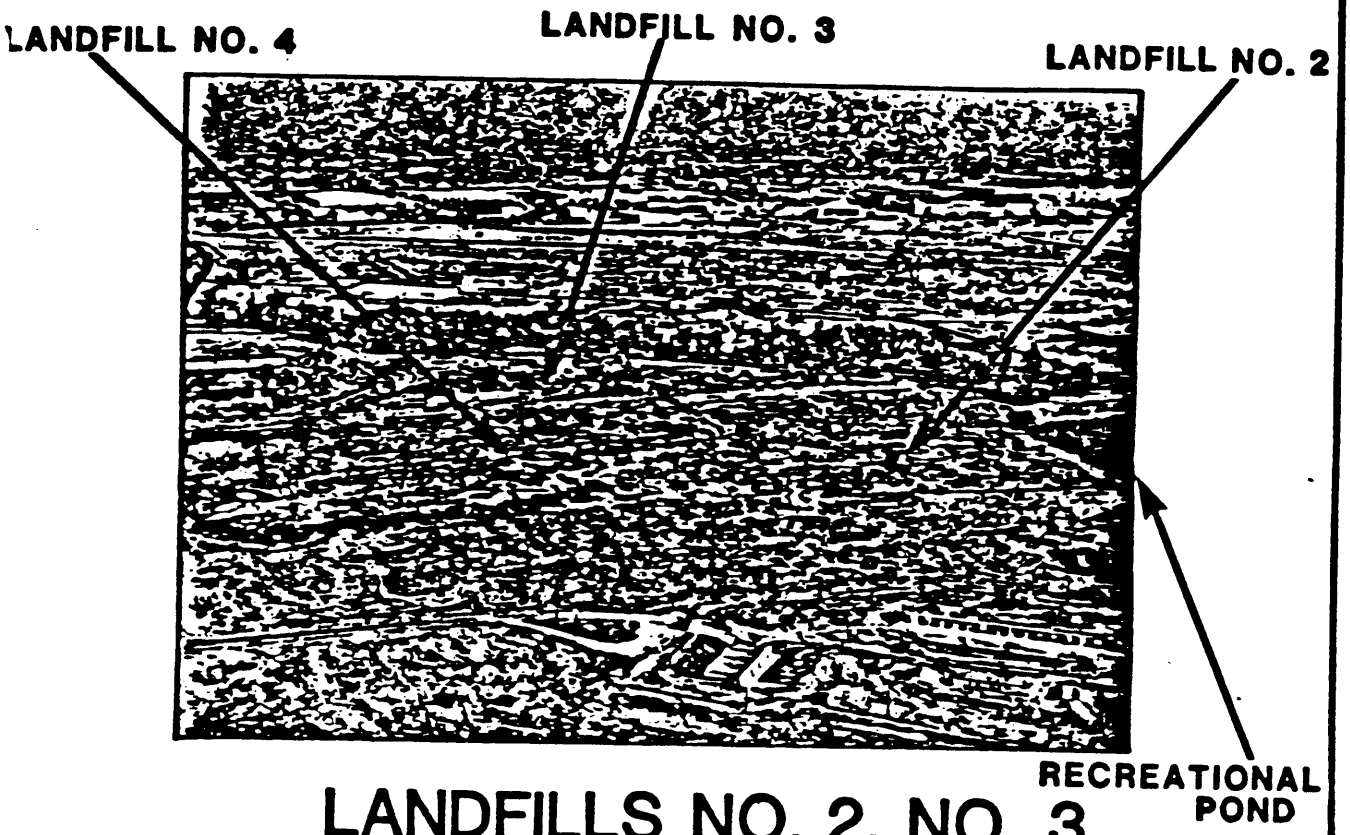
SOURCE: TINKER AFB HISTORIAN


TINKER AFB
INDUSTRIAL WASTE PIT LOCATION
(CIRCA 1960)
BUILDING
BUILDING
S.E. 59TH STREET
GATE 29
INDUSTRIAL WASTE PIT NO. 2
(1958-1965)
PATROL ROAD
DOUGLAS BOULEVARD
SOURCE: TINKER AFB, HISTORIAN

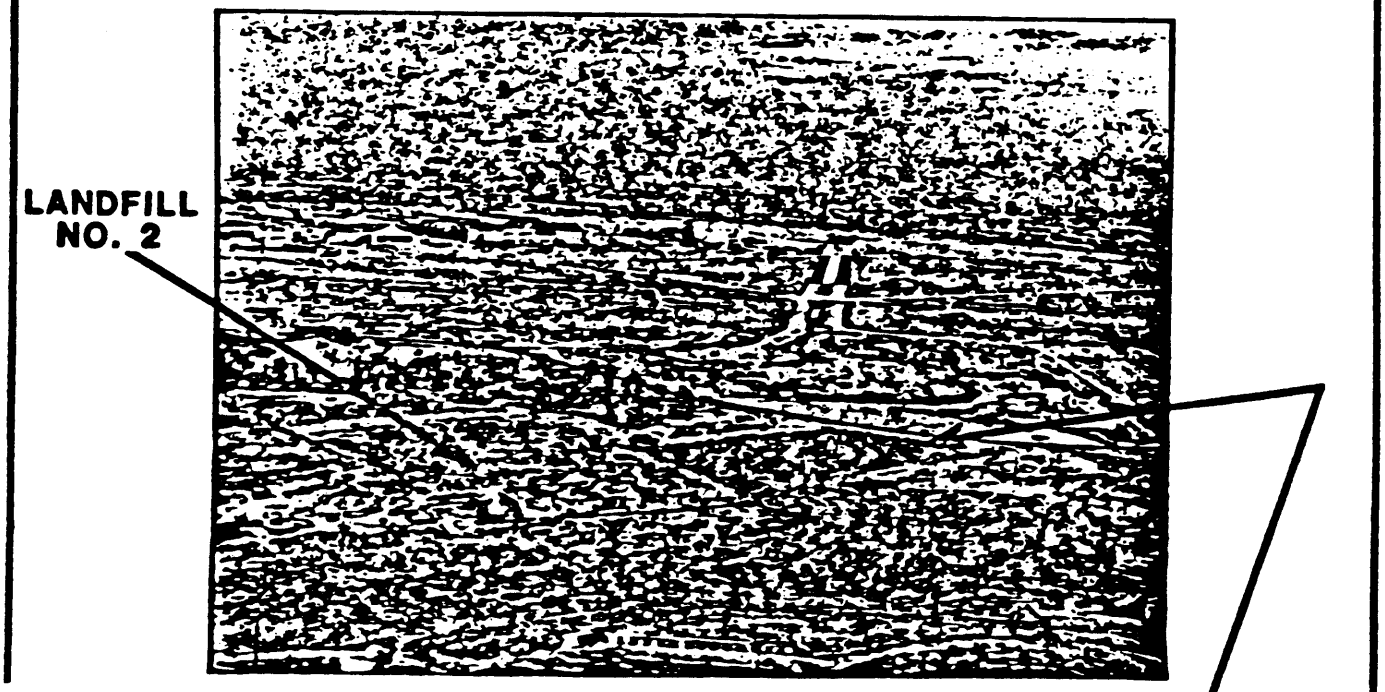


LANDFILL NO. 1

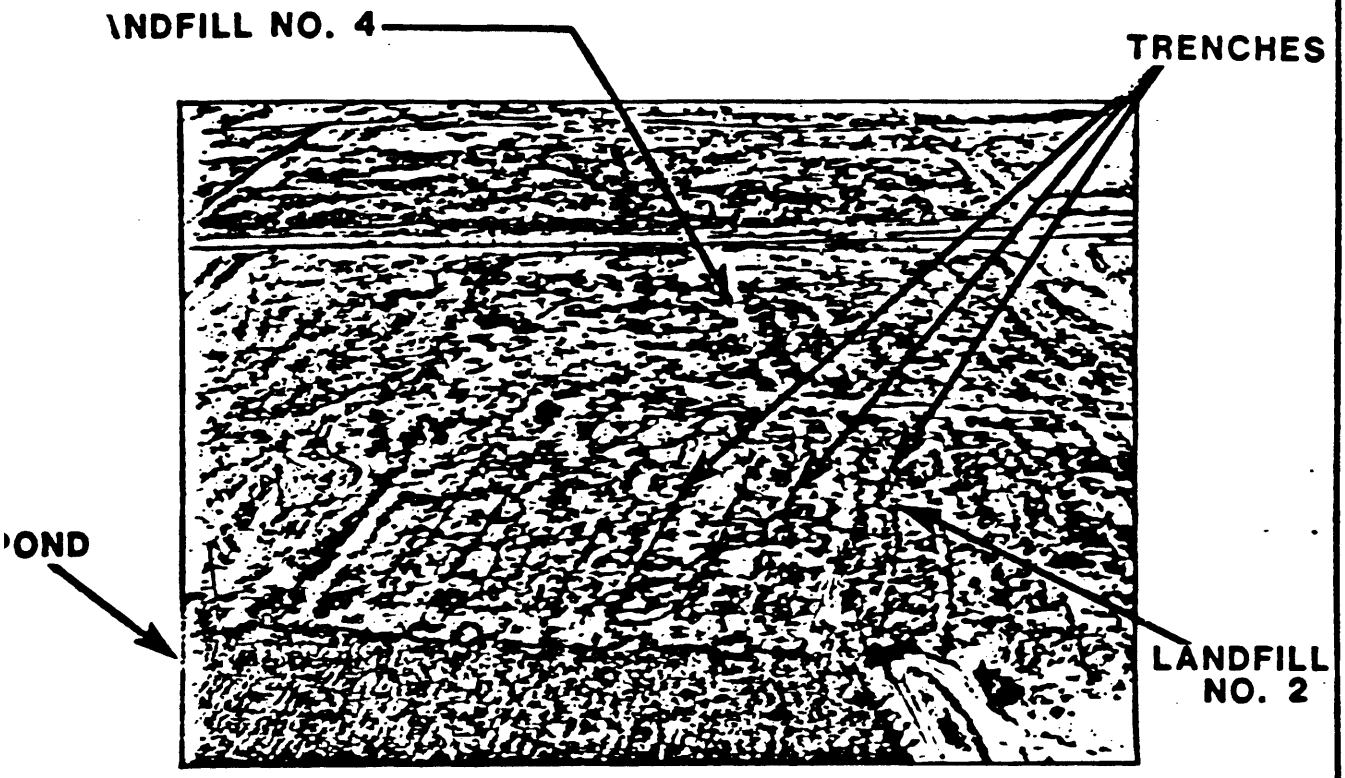
LANDFILL NO. 1



LANDFILLS NO. 2, NO. 3 & NO.4



LANDFILL NO. 2 & RECREATIONAL POND



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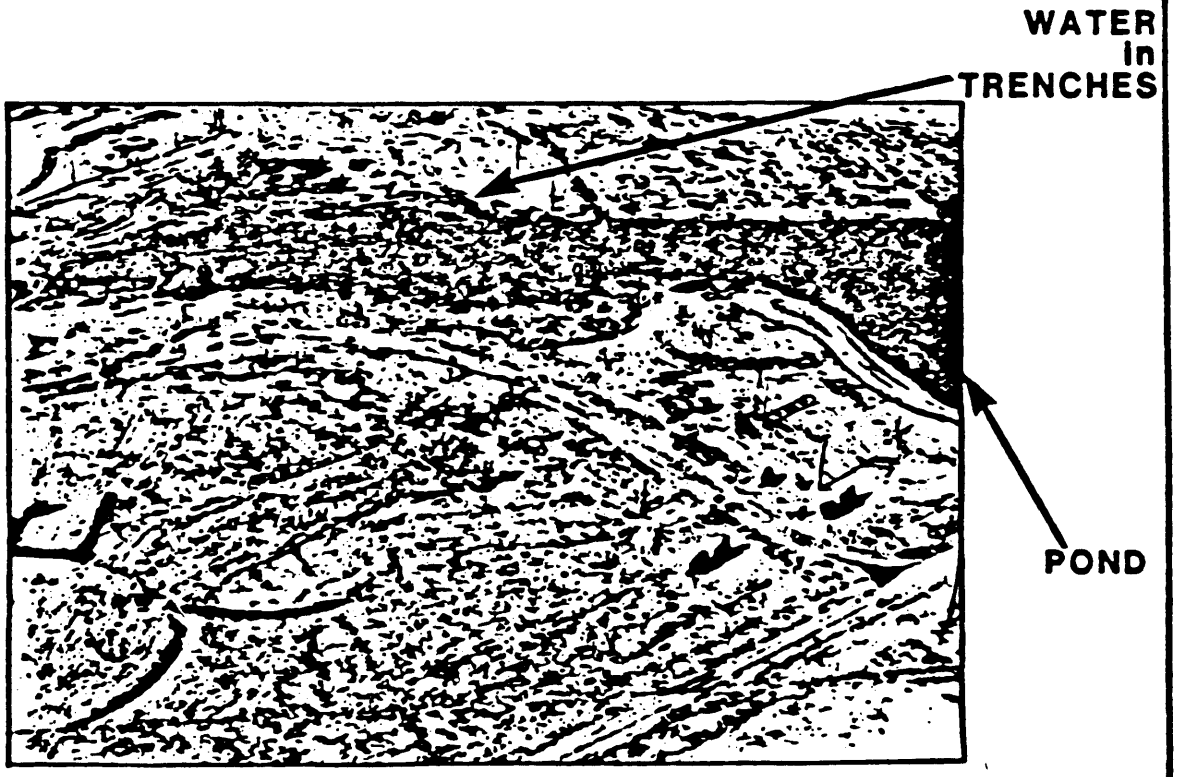

POND at LANDFILL NO. 2

APPENDIX F

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RADIAN CORPORATION

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DCN 84-212-027-04-02

Volume I

INSTALLATION RESTORATION PROGRAM
PHASE II - FIELD EVALUATION
STAGE 1

DRAFT FINAL REPORT

FOR

TINKER AFB, OKLAHOMA

AIR FORCE SYSTEMS COMMAND
HEADQUARTERS AERONAUTICAL SYSTEMS DIVISION

NOVEMBER, 1984

PREPARED BY

RADIAN CORPORATION
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SUMMARY

Background and Purpose

The Department of Defense (DOD) is conducting a nation-wide program to evaluate waste disposal practices on DOD property, control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Initial Assessment/Record Search; Phase II, Problem Confirmation; Phase III, Technology Base Development; and Phase IV, Remedial. The United States Air Force (USAF) has initiated an IRP investigation at Tinker Air Force Base near Oklahoma City, Oklahoma.

Phase I studies for the Tinker AFB Installation Restoration Program were completed in April 1982. The purpose of the Phase I study was to conduct a records search for the identification of past waste disposal activities which may have caused ground-water contamination and the migration of contaminants off-base.

Fourteen individual sites at Tinker AFB were identified as possibly containing hazardous waste. The potential for adverse environmental consequences of each site was evaluated with a rating or scoring system. This system took into account such factors as the site environmental setting, the nature of the wastes present, past waste disposal practices and the potential for contaminant migration.

Of the fourteen individual sites identified, eight sites, comprising four zones, were selected for Phase II studies. Two additional problem areas, not addressed in Phase I, were added to the list of sites for Phase II studies. These are the Base water supply wells and the wells in Building 3001. Radian Corporation performed the Phase II (Stage 1) Field Evaluation under USAF Contract No. F33615-83-D-4001, Delivery Order 0004.

waste, and covering with soil. The depth of the trenches has not been accurately recorded; it is probable that the depth is largely related to the ease of excavation of the shallow soil above shale bedrock, generally 10 to 15 feet below land surface. The landfills are visible today as features slightly elevated above the surrounding topography, with a hummocky surface corresponding to the former trenches that have undergone differential compaction. Most waste deposited in the landfill consisted of general base refuse, paper, trash, construction debris, and garbage. Table 1 identifies the features of each landfill and lists the probable contents at each site.

Liquid wastes and sludges generated during the period 1947-1965 were directed to industrial waste pits located in the southeast portion of the Base. These sites, Industrial Waste Pits 1 and 2, were used for the disposal of waste streams originating from the various aircraft maintenance shops at Tinker AFB. The streams were thought to contain high levels of heavy metals, and a variety of organic compounds (solvents and cleaners). The pits were probably unlined, with the materials in the pits periodically burned (Engineering Science, 1982).

Site Descriptions

The Phase II (Stage 1) Field Evaluation was organized by zones; each zone consisting of one or more waste disposal sites grouped together geographically or functionally. Zone 1 consists of four landfills, Landfills 1, 2, 3 and 4, located on the southwest part of the Base. Zone 2 consists of two landfills (Landfills 5 and 6) on the south side of the Base on opposite sides of the N-S runway. Zones 3 and 4 are the sites of Industrial Waste Pits Nos. 2 and 1, respectively, on the southeast part of the Base. Zone 5 consisted of the activity involved in the sampling of all water-supply wells at Tinker; and Zone 6 consisted of the evaluation of trichloroethylene in water-supply wells 18 and 19 located in Building 3001. The locations of the zones of investigation are shown on Figure 1.

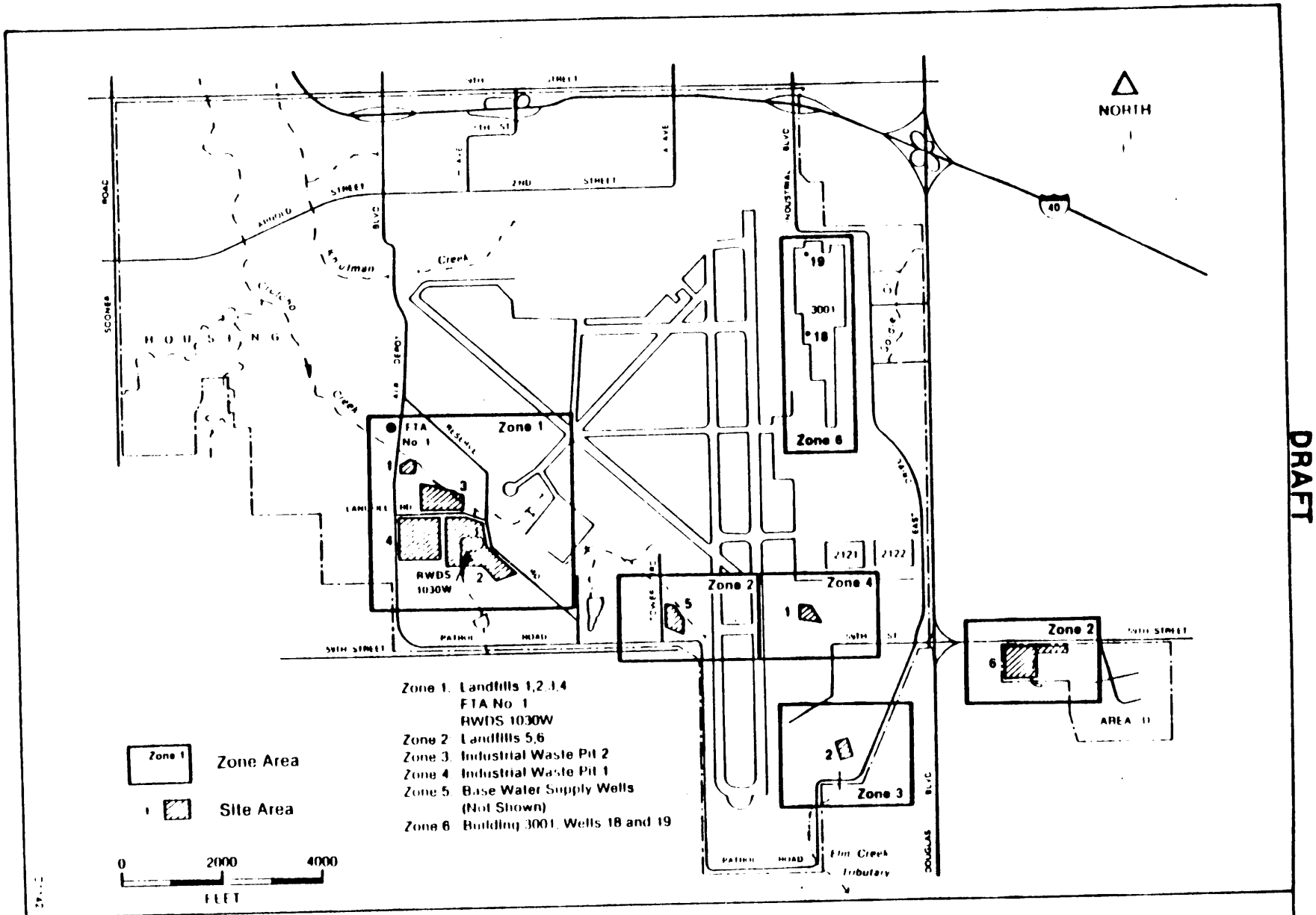

Figure 1. Zones of Investigation, Tinker, AFB.

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Zone 3

Zone 3 is the former site of a surface impoundment located north of Patrol Road (betwen the main N-S runway and Douglas Boulevard) on the south side of the Base. The impoundment, Industrial Waste Pit 2, was in operation from 1958 to 1965. The pit received large quantities (i.e., more than 85 55-gallon drums) of waste oils, cyanides, chromates, phenols, solvents and waste acids and alkalies. No data are available concerning construction of the pit. It has been closed and the land surface regraded to approximate original contours. Grass now covers the site, obscuring the original limits of the pit.

Zone 4

Zone 4 encompasses Industrial Waste Pit 1 at Tinker AFB. The site is located in the south-cental portion of the Base. This pit, in operation from 1947 to 1958, received industrial wastes similar to those in Industrial Waste Pit No. 2 (Zone 3).

Zone 5

Activities in Zone 5 consisted of sampling all Base water supply wells. Tinker AFB presently obtains water supplies from a system of 27 water wells constructed along the east and west Base boundaries. All Base wells are completed in the Garber-Wellington Aquifer. Base wells range from 700 to 900 feet in depth, with yields ranging from 205 to 250 gallons per minute. The wells incorporate multiple screens, deriving water supplies from sand zones that vary in thickness from 103 to 184 feet (Wickersham, 1979).

Zone 6

Activities in Zone 6 consisted of evaluating the occurrence of trichloroethylene in Tinker AFB water supply wells 18 and 19 located in Building 3001.

TABLE 2. ANALYTICAL SCHEDULE FOR SOIL AND WATER SAMPLES, TINKER AFB

Parameter	Zones
Barium	2
Iron	1, 2
Manganese	1
Total Organic Halogen (TOX)	1, 2, 3, 4
Oil and Grease	1, 2, 3, 4
Total Organic Carbon (TOC)	1, 2, 3, 4
Cyanide	1, 2, 3, 4
Metals (Cd, Cr, Ni, Cu, Zn, Pb, Hg)	1, 2, 3, 4
Volatile Hydrocarbons (EPA 601)	5
Phenol	1, 2, 3, 4
Pesticides and Herbicides	1, 2
Trichloroethylene and tetrachloroethylene (EPA 601)	6
Acid Neutral Extractable Organic Priority Pollutants (modified EPA 625)	
- selected wells	1, 2, 3, 4, 5
- selected soils	3, 4
Volatile Organic Priority Pollutants (EPA 624)	
- selected wells	5

Other Sampling: In addition to the monitor well sampling, selected surface water samples were also collected. Leachate seeps were sampled by excavating a small trench at the site of the seep and allowing water to accumulate. The surface impoundment at Landfill 2 was sampled by compositing grab samples from four randomly selected locations within the pond. Samples were submitted for the same chemical analyses as were the ground-water samples. An aliquot of the composited pond sample was also provided to the Base Bioenvironmental Engineering staff for radiochemical analysis.

Results of Analysis

In general, the Phase II (Stage 1) investigation documented only limited contaminant movement from the waste sites investigated. However, analytical data supplied by the State of Oklahoma suggest that volatile organic priority pollutants may be important species at all waste disposal sites. A summary of the analytical data for Zones 1 through 4 is provided in Table 3.

With the exception of wells in the vicinity of Building 3001, all Base water supply wells appear to be unaffected by contaminant migration from Base waste disposal sites.

Based on the results of the Phase II (Stage 1) investigation, conditions at Zone 6 consist of a zone of contamination, dominantly trichloroethylene, of unknown source and extent, in the vicinity of Building 3001. The occurrence of contamination is limited to relatively shallow zones.

Recommendations

Based on the findings of this study, Radian recommends certain follow-up investigations to resolve remaining issues. These recommendations and issues addressed are listed in Table 4, in order of priority. The selection and prioritization criterion is the verification of impacts on possible receptors.

TABLE 4. RECOMMENDATIONS

Problem Area or Site No.	Recommended Action	Rationale
Zone 6	Investigate hydrogeologic conditions and contaminant occurrence in the vicinity of Building 3001, as provided in Delivery Order 21.	Occurrence of TCE in Well 18 suggests shallow source/occurrence. Need to document area of contamination and movement.
Zone 2 (Landfill 6)	Investigate hydrogeologic conditions and contaminant occurrence in the vicinity of Landfill 6, as provided in Delivery Order 21.	Hydrocarbon contamination reported by Oklahoma State Department of Health in a private well, immediately northeast of Landfill 6. Possible source is Landfill 6.
All Zones	Investigate the occurrence of volatile halocarbons and aromatics in all monitor wells by resampling and analysis by EPA Methods 601 and 602 (double column).	Oklahoma State Department of Health data suggest existence of volatile contaminants in ground water.
Zone 1	Investigate the seasonal variations in water quality in the existing monitor wells along Crutcho Creek by conducting a quarterly sampling program for a period of one year. Analyses should be for total organic carbon, total organic halogen, and the metals on the parameter list in the current Statement of Work, Fe, Mn, Cd, Cr, Ni, Cu, Zn, Pb and Hg.	Data from original investigation do not agree with Phase II (Stage 1) data.

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1.0 INTRODUCTION

The Department of Defense (DOD) is conducting a nation-wide program to evaluate waste disposal practices on DOD property, control the migration of hazardous contaminants, and to control hazards that may result from these waste disposal practices. This program, the Installation Restoration Program (IRP), consists of four phases: Phase I, Initial Assessment/Record Search; Phase II, Problem Confirmation; Phase III, Technology Base Development; and Phase IV, Operations. The United States Air Force (USAF) has initiated an IRP investigation at Tinker Air Force Base near Oklahoma City, Oklahoma; Radian Corporation has performed the Phase II (Stage 1) Field Evaluation under USAF Contract No. F33615-83-D-4001, Delivery Order 0004.

1.1 Purpose of the Investigation

The purpose of the Phase II (Stage 1) investigation was to determine if environmental contamination has resulted from waste disposal practices at Tinker AFB. In addition, the purpose of the investigation included an estimate of the magnitude and extent of contamination, the identification of environmental consequences of migrating pollutants, and the recommendation of additional investigations to identify the magnitude, extent and direction of movement of discovered contaminants.

1.2 Duration of the Program

Authorization to proceed on the Tinker AFB Phase II (Stage 1) program was given on 12 September 1983. Following the initial site visit conducted on 29 September 1983, field activities were initiated during November 1983. A second field season was completed during February-March, 1984. The field work consisted of the installation and sampling of ground-water monitoring wells, electromagnetic surveys of two waste disposal sites, coring and sampling of shallow soils at suspected waste disposal sites, sampling and analysis of ground water from Tinker AFB water supply wells, and the investigation of trichloroethylene contamination in two water supply wells.

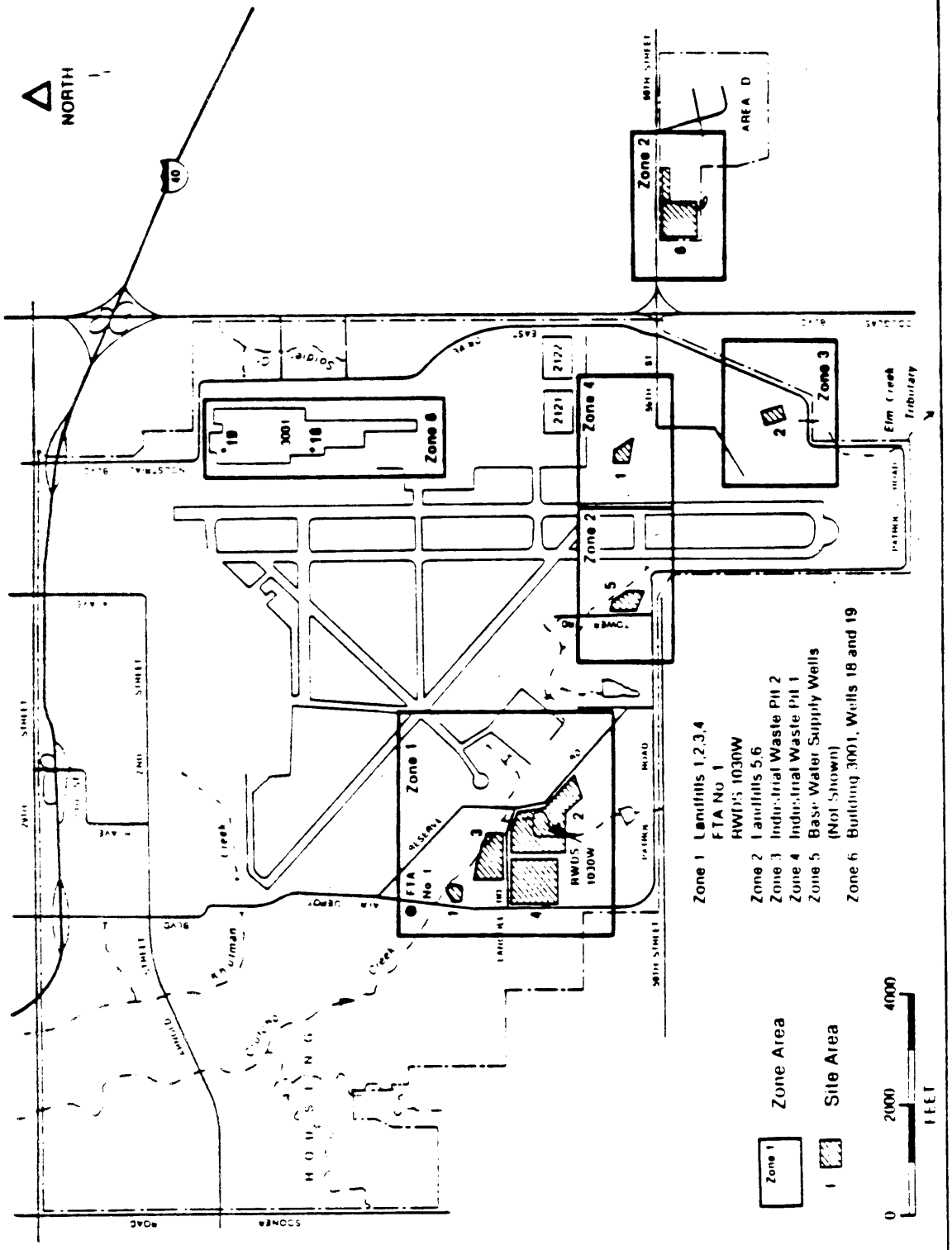

Figure 1-1. Locations of Waste Disposal Areas, Tinker AFB.

1.4 Site Descriptions

The Phase II (Stage 1) Field Evaluation was organized by zones; each zone consisting of one or more waste disposal sites grouped together geographically or functionally. Zone 1 consists of four landfills, Landfills 1, 2, 3 and 4, located on the southwest part of the Base as well as Fire Training Area No. 1 and Radiological Waste Disposal Site (RWDS) 1030W. Zone 2 consists of two landfills (Landfills 5 and 6) on the south side of the Base on opposite sides of the N-S runway. Zones 3 and 4 are the sites of industrial waste pits Nos. 2 and 1, respectively, on the southeast part of the Base. Zone 5 consisted of the activity involved in the sampling of all water-supply wells at Tinker; and Zone 6 consisted of the evaluation of trichloroethylene in water-supply wells 18 and 19 located in Building 3001. The locations of the zones of investigation are shown on Figure 1-2.

Zone 1

Zone 1 consists of four individual landfills on the southwest side of the Base. The landfills, numbered from 1 to 4, were active from 1942 to 1968; all are closed, covered with soil, and vegetated. The landfills are clearly visible from the ground and are characterized by elevated (3-8 feet above the surrounding land), irregular surfaces with elongate depressions corresponding to former trenches, areas of patchy vegetation, and isolated zones of leachate emergence at the surface margins of the fills. Also included within Zone 1 are Fire Training Area No. 1 and Radiological Waste Disposal Site 1030W.

Prior to the Phase II (Stage 1) work, a series of ground water monitoring wells had been installed near Zone 1, primarily on the northeast side of the zone along Crutcho Creek. These wells are shallow, averaging approximately 25 feet in depth and are completed in deposits influenced by conditions in the creek. Conditions along the creek are adequately monitored by these wells.

Zone 2

Zone 2 consists of Landfills 5 and 6 at Tinker; these widely-separated sites are located at the southern end of the Base. Landfill 5 is near the intersection of Patrol Road and Tower Road; it is bordered on the northeast by Crutcho Creek, on the west by Tower Road, and on the south by Building 1141. Three ground-water monitoring wells completed in the shallow alluvium exist along Crutcho Creek; these wells provide ample coverage of ground-water conditions on the northeast side of the landfill.

Landfill 6 is approximately one-half mile east of the main Base (on AF leased property), south of 59th Street. Shallow ground-water monitoring wells have been installed at two locations along 59th Street, north of the landfill. Additional ground-water data are available from several wells located north of 59th Street and south of Interstate 40.

Zone 3

Zone 3 is the former site of a surface impoundment located north of Patrol Road (between the main N-S runway and Douglas Boulevard) on the south side of the Base. The impoundment, Industrial Waste Pit 2 (IWP2) was in operation from 1958 to 1965. The pit received large quantities of waste oils, cyanides, chromates, phenols, solvents and waste acids and alkalies. No data are available concerning construction of the pit. It has been closed and the land surface regraded to approximate original contours. Grass now covers the site, obscuring the original limits of the pit.

Zone 4

Zone 4 encompasses Industrial Waste Pit 1 at Tinker AFB. The site is located in the south-central portion of the Base. This pit, in operation from 1947 to 1958, received industrial wastes similar to those in Industrial Waste Pit No. 2 (Zone 3).

TABLE 1-2. ANALYTICAL SCHEDULE FOR SOIL AND WATER SAMPLES, TINKER AFB.

Parameter	Zones
Barium	2
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Manganese	1
Total Organic Halogen (TOX)	1, 2, 3, 4
Cyanide	1, 2, 3, 4
Metals (Cd, Cr, Ni, Cu, Zn, Pb, Hg)	1, 2, 3, 4
Volatile Hydrocarbons (EPA 601)	5
Phenol	1, 2, 3, 4
Pesticides and Herbicides	1, 2
Trichloroethylene and tetrachloroethylene (EPA 601)	6
Acid Neutral Extractable Organic Priority Pollutants (Modified EPA 625)	
- Selected wells	1, 2, 3, 4, 5
- Selected soils	3, 4
Volatile Organic Priority Pollutants (EPA 624)	
- Selected wells	5

2.0 ENVIRONMENTAL SETTING

This discussion of the Tinker AFB environmental setting was principally derived from the Installation Restoration Program Phase I Records Search report (Engineering-Science, 1982). Information developed from that report is supplemented by the literature and the general findings of this study. The following sections describe the environmental setting of Tinker AFB. Basic features and history of the sites investigated in this study are also discussed here.

2.1 General Geographic Setting and Land Use

Tinker AFB is located in central Oklahoma, within the corporate limits of Oklahoma City and adjacent to the suburbs of Midwest City and Del City (Figure 2-1). Tinker AFB is bordered by Interstate 40 to the north, Douglas Boulevard to the east, Sooner Road to the west, and industrial and undeveloped land near S.E. 59th Street to the south. The general features of Tinker AFB are illustrated in Figure 2-2.

The Base lies within an area representing a transition from residential and industrial/commercial land use on the west to agricultural land on the east and south. The principal industrial use of the area southwest of the Base is the General Motors installation south of S.E. 59th Street.

2.2 Physiographic and Topographic Features

Tinker AFB is located within the Central Redbed Plains section of the Central Lowland Physiographic Province, an area characterized by nearly level to gently rolling hills, broad flat plains and well-entrenched main streams. Surface elevations in the Oklahoma City area range from 1,070 to 1,400 feet MSL; at Tinker AFB the elevations range from 1,210 feet MSL (at Crutcho Creek, near the northwest portion of the Base) to about 1,320 feet

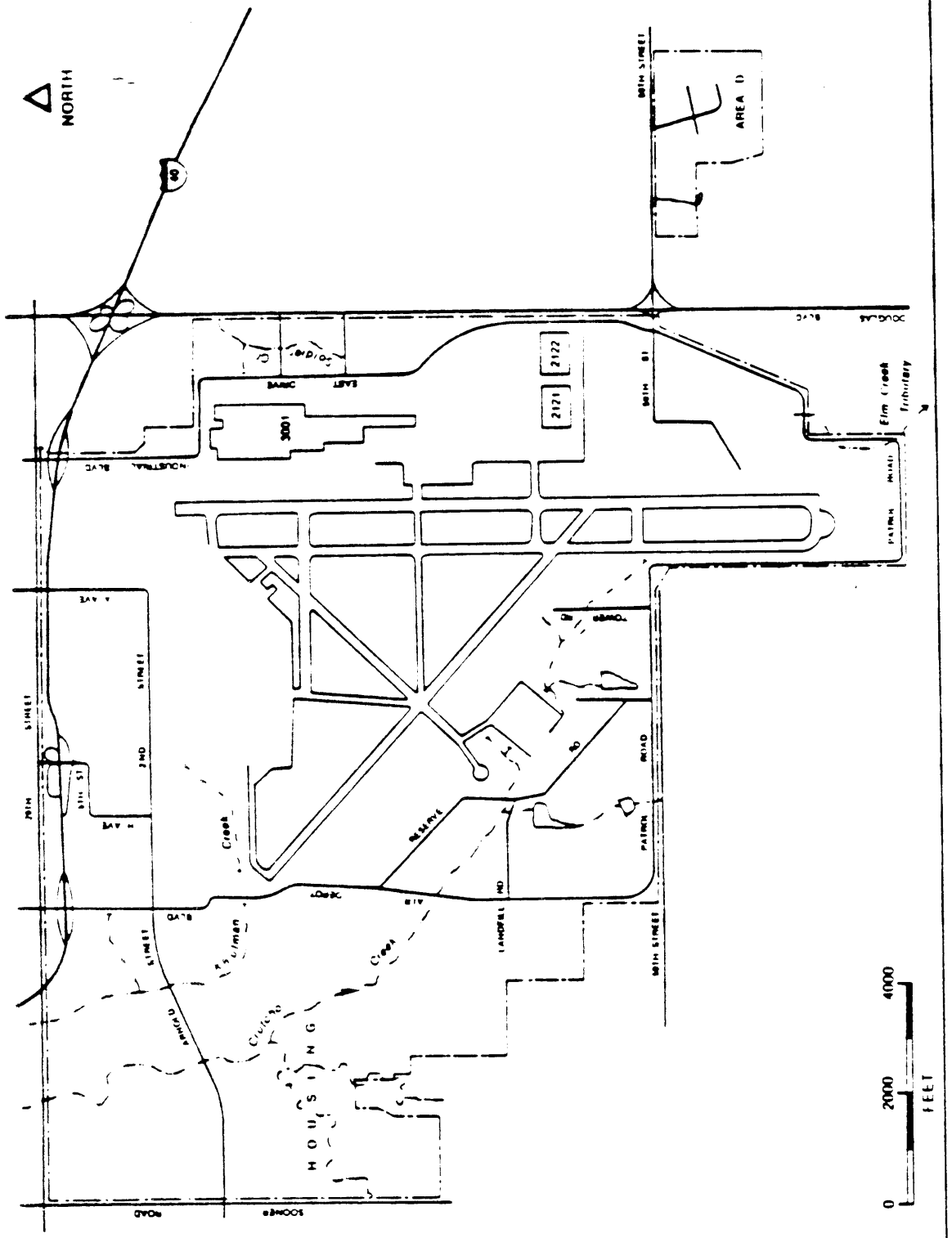

Figure 2-2. General Features of Tinker AFB.

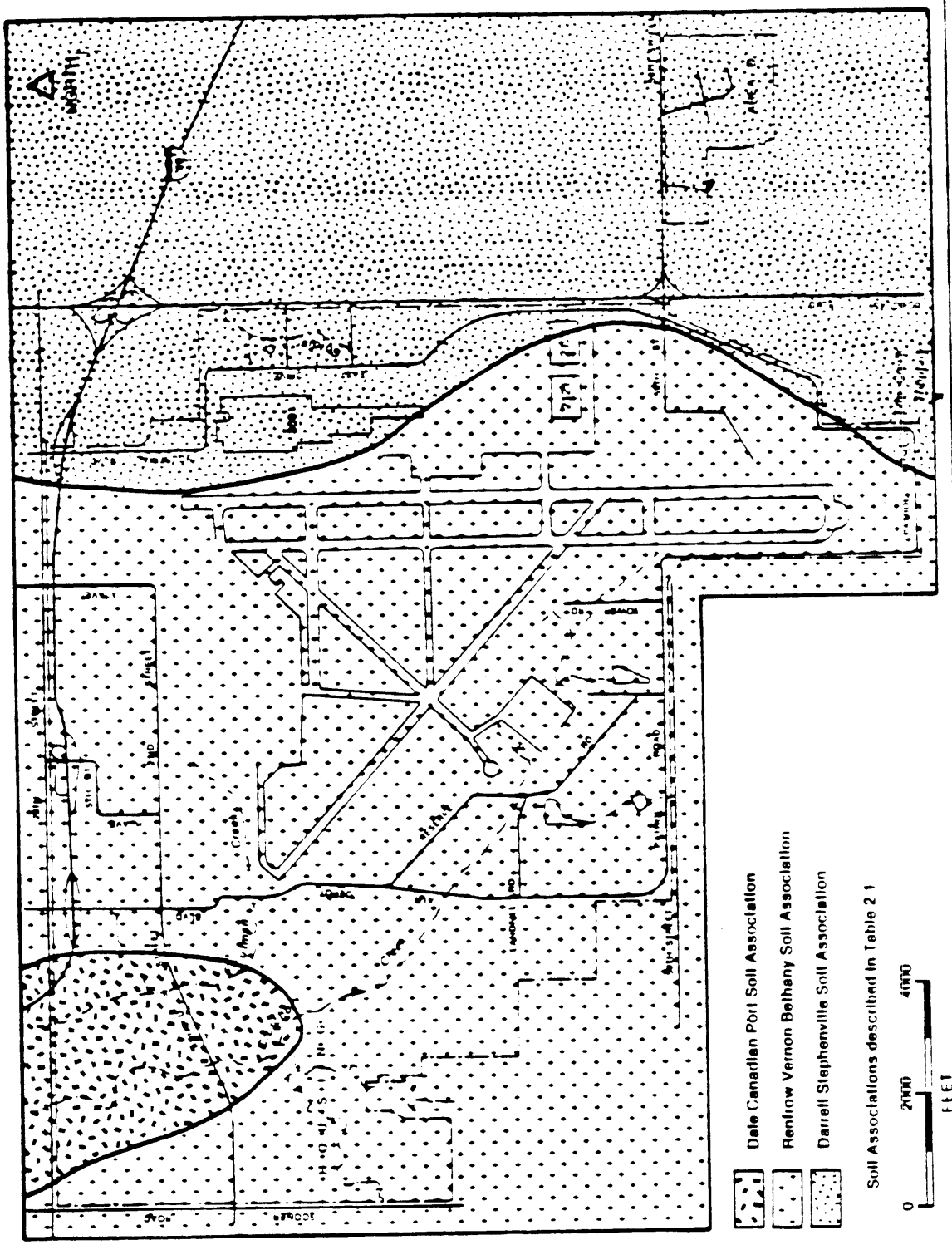

Figure 2-3. Soil Associations, Tinker AFB (USDA, Soil Conservation Service, 1969).

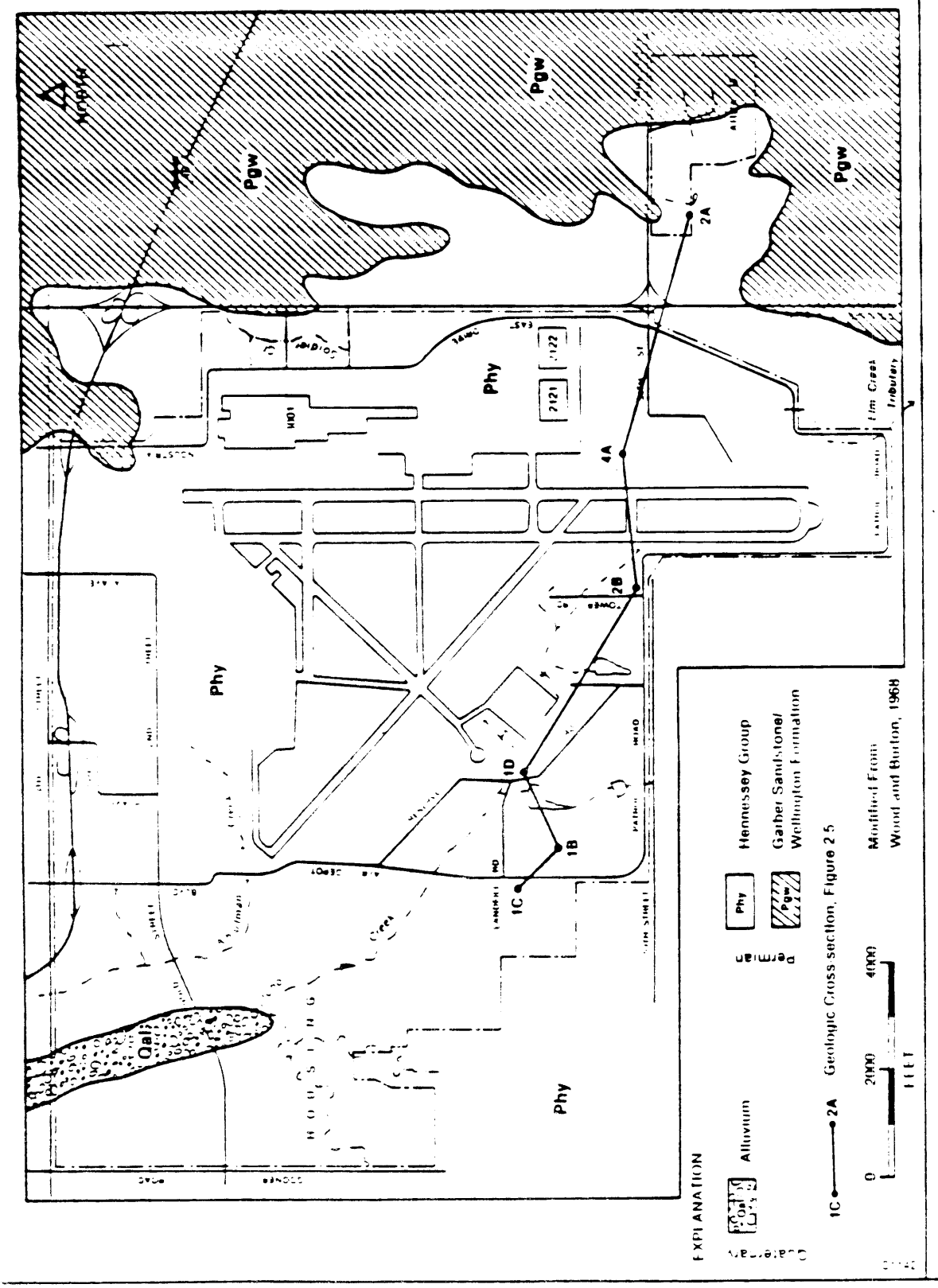

Figure 2-4. Geologic Map of Tinker AFB.

Siltstone and the Fairmont Shale, as indicated on geologic maps by Miser (1959) and Bingham & Moore (1975) and confirmed by drilling in Phase IIB. The Fairmont Shale (Hennessey Group) strata, consisting predominantly of shale, are difficult to distinguish from upper portions of the underlying Garber Sandstone, which is reported to be shaly. The contact between the Fairmont Shale and Garber Sandstone is gradational throughout the Oklahoma City area. Published geologic maps differ in the interpretation of the surface geology at Tinker AFB; Wood and Burton (1968) extend the Fairmont Shale (Hennessey Group) over most of the Base, but Bingham and Moore (1975) map the Garber Sandstone over most of the Base and show the contact with the Fairmont Shale to lie, for the most part, south of S.E. 59th Street. Figure 2-5 is a shallow cross section across the southern portion of Tinker AFB, based on Phase IIB drilling. This cross section is supportive of the Wood and Burton (1968) map, in that it shows the Fairmont Shale occurring north of S.E. 59th St. However, no geologic mapping, per se, was done to support or refute either interpretation. In either event, the significant observations are the occurrence of shale and sandstone beds, whether they be Fairmont or Garber. Results of drilling are discussed further in Section 4.0.

Structure

Tinker AFB lies within a tectonically stable area. No major faults or fracture zones have been mapped near the base. Most of the consolidated rock units of the Oklahoma City area are nearly flat-lying. The reported regional dip is forty feet per mile in a generally westward direction (Bingham and Moore, 1975).

Ground Water

Shallow Aquifer - Shallow, ephemeral aquifers exist temporarily within the study area where zones of alluvium border streams or where shallow sandy residual soils collect precipitation. At Tinker AFB, sandy residual soils overlying bedrock at shallow depths form such an ephemeral aquifer. Soil aquifers are typically recharged directly by precipitation, gradually

running dry seasonally as base flow to local streams and recharging of underlying rock aquifers deplete limited supplies. The significance of the shallow aquifer is that it may facilitate the contamination of important lower aquifers or surface waters by leachate generation and mobilization of wastes. It is not useable from a water-supply standpoint.

Garber-Wellington Aquifer - Tinker AFB lies within the limits of the Garber-Wellington Ground-Water Basin. The Garber Sandstone and the Wellington Formation are considered to be a single aquifer and provide the most significant source of ground-water supplies in the Oklahoma City area. At the present time, Tinker AFB derives most of its water supplies from this aquifer and supplements the supply by purchasing from the Oklahoma City Water Department. The nearby communities of Midwest City and Del City derive water supplies from both surface sources and wells tapping the aquifer. Industrial operations, individual homes, farm irrigation, and small communities not served by a municipal distribution systems also depend on the Garber-Wellington Aquifer. Communities presently depending upon surface supplies such as Oklahoma City also maintain a well system drilled into the Garber-Wellington as a standby source of water in the event of drought. The aquifer area is depicted in Figure 2-6.

The Garber Sandstone and the Wellington Formation are considered to be a single aquifer. They were deposited under similar conditions and consist of lenticular beds of sandstone, siltstone and shale that tend to vary in thickness over relatively short horizontal distances (Wood and Burton, 1968). The sediments constituting the aquifer tend to be loosely cemented and have a maximum thickness of some 1,000 feet. In the area of outcrop, ground water occurs under water table (unconfined) conditions and may occur at relatively shallow depths below ground surface (100 to 150 feet). In areas overlain by younger geologic units, ground water occurs in the aquifer under artesian (confined) conditions and wells must be drilled deeper (200-250 feet) in order to encounter it (Wickersham, 1979). Ground water can occur under either water table or artesian conditions in the vicinity of Tinker AFB.

The Garber-Wellington aquifer is exposed at ground surface or mantled by a thin soil over the northern two-thirds of Tinker AFB. As noted above, the aquifer is probably overlain by a thin, discontinuous sequence of Hennessey Group sediments (Kingman Siltstone and Fairmont Shale) over the southern portion of the base. Water in useable quantities from productive zones in the Garber-Wellington is encountered at depths of approximately 100 feet at Tinker AFB, although the top of the saturated, but poorly productive, zone delineated by Phase II (Stage 1) drilling was usually less than 50 feet. A geologic cross-section of base wells developed by Wickersham (1979) is presented as Figure 2-7. This figure graphically depicts the lenticular nature of the sandy zones. Although most of the aquifer is believed to be saturated, multiple screened wells are usually constructed in order to obtain water from the more productive zones.

Recharge of the Garber-Wellington Aquifer is accomplished principally by rainfall infiltration and by percolation of surface waters crossing the area of outcrop. Because most of Tinker AFB is located in an aquifer outcrop area, it is therefore assumed that the base is situated in a recharge zone (Havens, 1981). The aquifer is therefore susceptible to contamination in the study area. Ground-water levels and flow directions (1976 data) are presented as Figure 2-8. It is important to note that Figure 2-8, a verbatim transcript from Wickersham (1979), is based on generalized data from throughout the area shown. It is "true" in only a regional sense. Results of detailed investigations in any one small portion of the area are likely to be at variance with the regional data. The maps show Tinker AFB to be within a roughly 10-mile long zone, trending northeast-southwest which makes up a regional ground-water "high" - i.e., a recharge zone. Superimposed on this is a local "low" or saddle surface, perhaps reflective of the ground-water withdrawals by the Base wells. According to the indicated hydraulic gradients, ground-water flow at Tinker AFB is presently directed to the west and northwest over most of the Base and to the south in the southeast part of the Base.

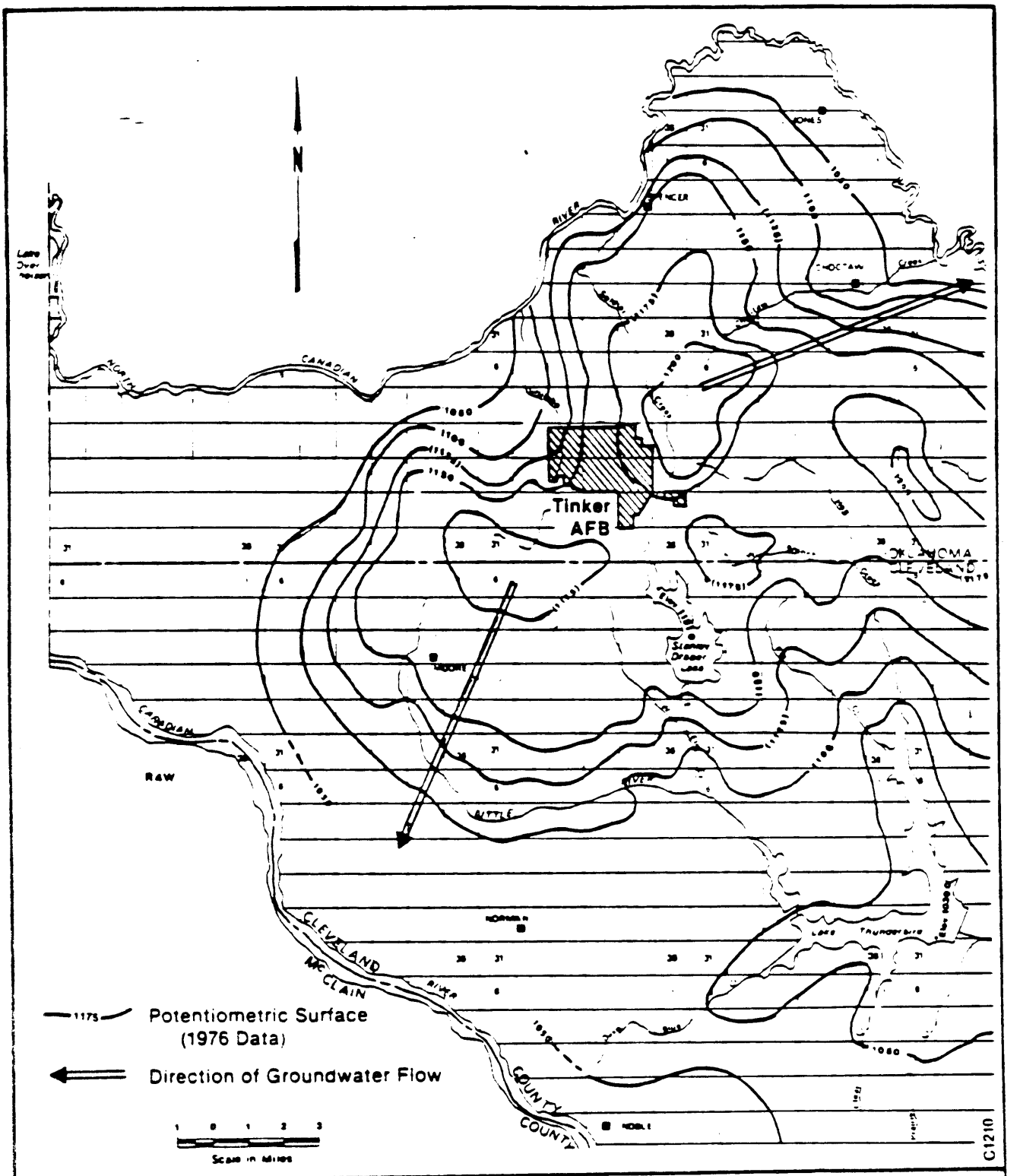

Figure 2-8. Ground-Water Levels and Flow Directions in the Garber-Wellington Aquifer (from Wickersham, 1979).

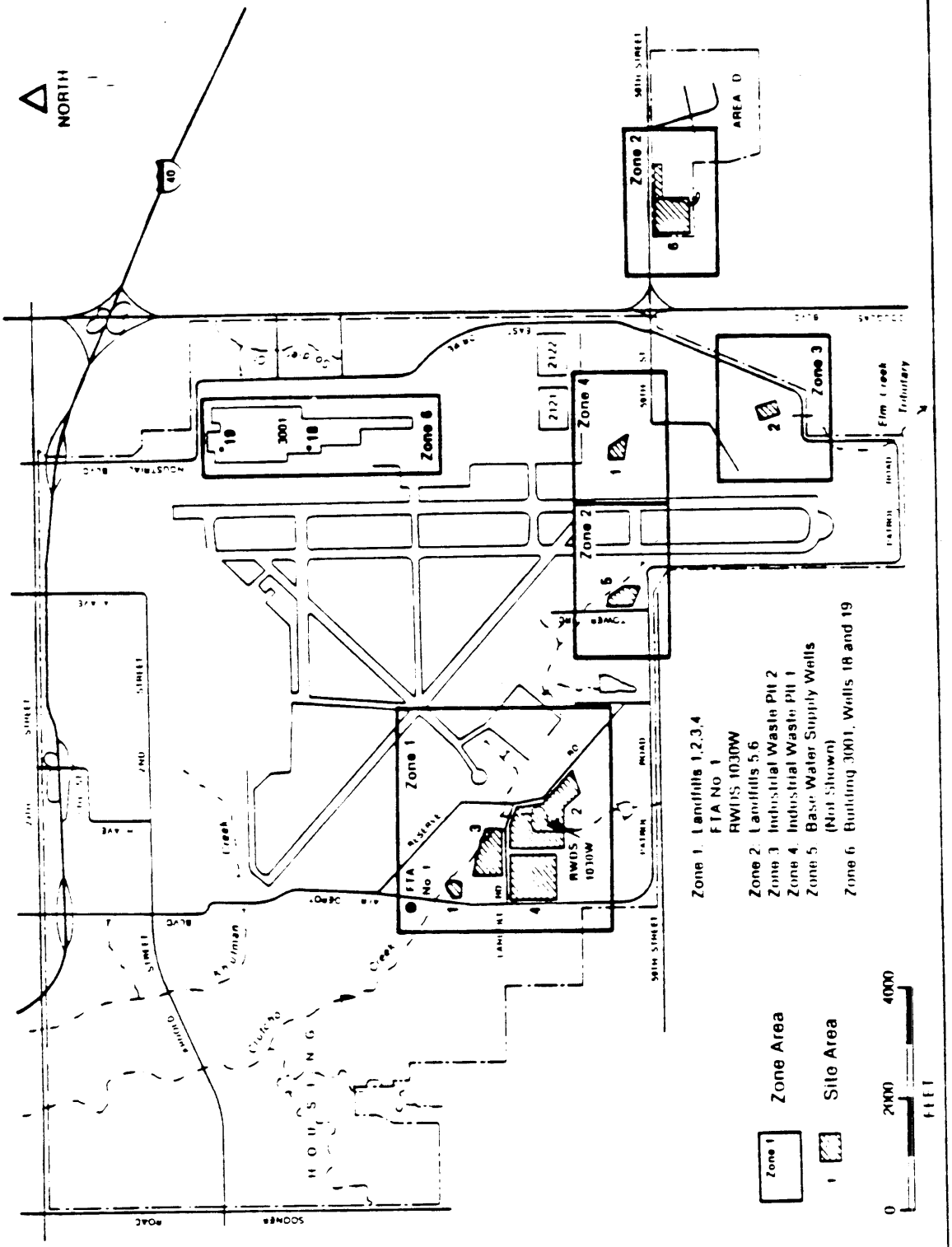

Figure 2-9. Zones of Investigation, Tinker AFB.

No. 2. The pond was constructed in the mid-1960s either partly on top or adjacent to the landfill area. From the air, the outlines of trenches can be seen along the boundary of the pond where the water level is high enough to inundate portions of the trenches. Overflow from the pond enters the upper reaches of Crutcho Creek. It is presently unknown to what extent the pond waters percolate through the landfilled material.

During the time period 1952-1961, wastes were disposed of in an eight acre area designated as Landfill No. 3. This area is located adjacent to Landfill No. 2 north of Landfill Road and south of Crutcho Creek. Crutcho Creek crosses the northeast corner of Landfill No. 3. The type of waste disposed of and disposal methods were similar to previous landfills. The landfilled material consisted primarily of general refuse, but did include paint buckets, insecticide cans, and empty barrels. A number of vacuum tubes which contained low levels of radioactivity were also disposed of at this site. Landfill materials were disposed of in trenches running the length of the landfill. Trenches were approximately 25 feet deep, and extended through a surface clay layer into a sand/rock layer. The refuse was covered daily, and a final cover of 3 to 4 feet of excavated material was placed on completed trenches.

Additional radioactive material was reported to have been disposed of in a deep pit adjacent to the northwest corner of landfill No. 3. The area was formerly posted with radioactivity warning signs, which have been destroyed.

Landfill No. 3 shows no evidence of erosion along the creek or elsewhere around the landfill. At present, additional dirt and hardfill are being stored on top of the landfill. This practice has been in effect for approximately 5 years.

After closure of the Landfill No. 3, a 16-acre site south of Landfill Road between Landfill No. 2 and Air Depot Boulevard was utilized for

the trenches has resulted in surface depressions which collect and hold rain water. A small area of seepage is noticeable on the northeastern edge of the landfill adjacent to West Crutcho Creek. Recent (1984) construction activities have disrupted a portion of the landfill surface.

Landfill No. 6 was used for the disposal of refuse from 1970 to 1979. This landfill is located in Area "D" approximately 1/2 mile east of Tinker AFB along S.E. 59th Street on land leased from Oklahoma City. Although 40 acres are available at the site, only about 20 acres on the western half of the landfill were used prior to the closing of the site during 1979. Base refuse since that time has been disposed of off-site by private contractor.

Materials disposed in Landfill No. 6 consisted primarily of general refuse with small quantities of industrial waste materials such as paint buckets, insecticide cans, etc. Industrial wastewater treatment plant sludge was also intermittently disposed of in this landfill. The refuse was covered daily with 6 to 8 inches of compacted soil, and several feet of compacted cover was used as a final trench covering. Highly permeable river sand was used for daily cover for several years, although other areas had a cover of excavated clay and sand/rock. After closure, the site was revegetated with grasses. Field reconnaissance of the site indicated moderate surface erosion and no observed leachate.

2.4.2 Waste Disposal Pits

Prior to the establishment in 1963 of an industrial wastewater collection and treatment system, some of the industrial wastes were disposed of in large, open pits. Two waste disposal pit areas were located on the east side of the base south of the aircraft maintenance area. The pits were used for the disposal of industrial wastes between 1947 and 1965.

Industrial Waste Pit No. 1 (Zone Four of the Phase II (Stage 1) study) was located southwest of Building 2121. Waste disposal occurred during the period 1947-1958. During the Base records search, no written information

Zone 5 (Base Water Supply Wells)

Zone 5 consists of the 27 Base Water Supply Wells, a system of wells located along the east and west Base boundaries. All wells are completed in the Garber-Wellington Aquifer. Base Wells range from 700 to 900 feet in depth, with yields ranging from 205 to 250 gallons per minute. The wells incorporate multiple screens, deriving water supplies from sand zones that vary in thickness from 103 to 184 feet (Wickersham, 1979).

Zone 6 (Building 3001 Wells)

Zone six consists of two Base water supply wells (Wells 18 and 19) located within Building 3001 (The Oklahoma City Air Logistics Center manufacturing complex) in the northeast portion of the Base (Figure 2-9). An Air Force monitoring program had discovered both trichloroethylene (TCE) and tetrachloroethylene in these wells, so both were taken out of service. Radian was tasked with a preliminary assessment of the contamination in these wells.

Both Wells 18 and 19 are deep (>1,000 feet), high capacity water supply wells, pumping directly into the distribution system, which supplies both industrial and potable uses. The wells were drilled in 1942 and incomplete construction records remain. No driller's or geophysical logs were available, but partial casing and perforation records were found.

3.0 FIELD PROGRAM

Various field activities were performed at Tinker Air Force Base in support of the IRP Phase II (Stage 1) investigation. The activities consisted of the completion of eleven deep and four shallow ground-water monitor wells, performance of two ground conductivity (electromagnetic) surveys, and soil coring of two waste sites. The periods of performance of the field activities were November 1983 and February-March 1984.

3.1 Field Techniques

The following paragraphs contain descriptions of the various field techniques used in the Tinker AFB Phase II investigation. These techniques included geophysical surveying, hollow-stem augering and air rotary drilling, monitor well installation, and soil and ground-water sampling.

3.1.1 Geophysical Surveying

Geophysical surveying was performed in order to accurately define the area of investigation at two buried industrial waste pits (Zone 3 - Industrial Waste Pit No. 2 and Zone 4 - Industrial Waste Pit No. 1). The two sites are currently vacant land; no surface remnants of the waste disposal facilities are visible. The geophysical technique selected for the investigation consisted of an electromagnetic survey using two devices: the Geonics EM31 and the EM34-3 ground conductivity sensors. Both ground conductivity sensors are designed for rapidly obtaining data over large areas. The meters employ magnetic dipoles or magnetic induction loops for transmission and reception of low-frequency electromagnetic waves. The effective depth sampled by the EM31 is 6 meters; the depth sampled by the EM34-3 depends on the coil separation and orientation, applied frequency, and to some extent on the conductivity profile of the subsurface (McNeill, 1980). Geophysicon, Inc., of Lakewood, Colorado, performed the ground conductivity surveys at Zones 3 and 4. Operating procedures and specifications of the EM31 and EM34-3 are provided in Appendix L.

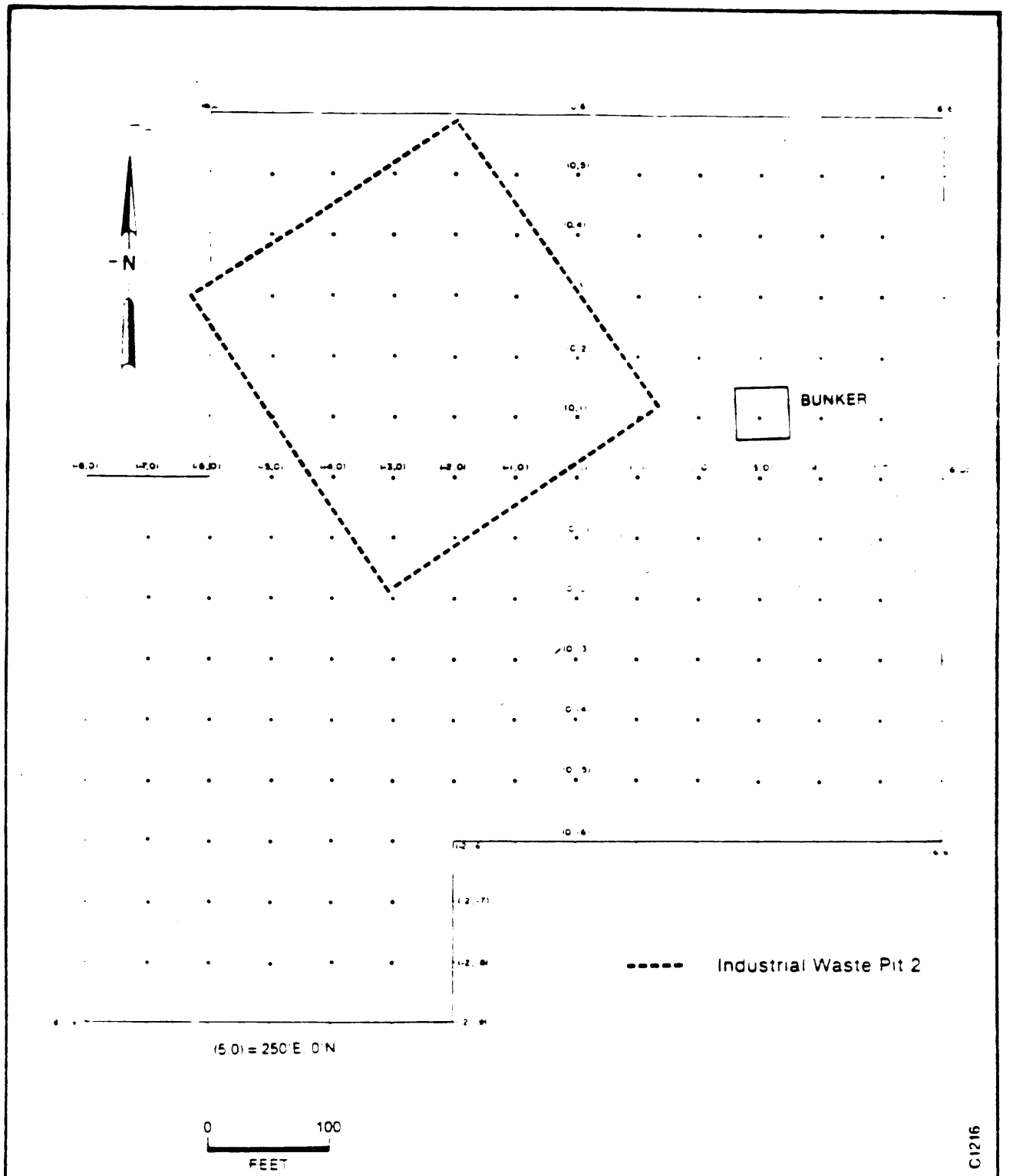

Figure 3-1. Data Point Grid for Geophysical Survey - Zone 3.

depth of 10 feet below the first ground water encountered. No drilling fluids or additives were used in the drilling program. As the bore hole was advanced, the cuttings discharged at the surface were examined for lithology, moisture, and other features to describe the geologic section. Drilling conditions, such as relative rate and ease of penetration, were noted by the driller. Water encountered during drilling was noted with respect to depth of occurrence and rate of production; if needed, drilling was suspended temporarily to allow for recovery of water in the borehole. The decision to complete the borehole and install the screen and casing for the monitor well was made on the basis of relative water level (with respect to the approximate predicted regional water level), the likelihood of perched water above a regional water table, and the representativeness of the water table in terms of evaluating the impact of the waste disposal site on the quality of ground water.

The method of introduction of contaminants is by dissolved constituents moving with downward migrating infiltration. Once these contaminants reach the ground-water body they are entrained in the flow and move with it. So long as no density effects operate, there will be no tendency for contaminants to plunge or sink in the ground-water system. Common causative agents of density effects, concentrated brines or nearly pure streams of dense industrial chemicals (such as TCE) do not exist at Tinker AFB, so this phenomena may safely be ignored. As was discussed in Section 2, there is a downward component of flow, so some contaminants would be expected to move down in the aquifer. However, they would also be diluted, so detection is less likely. Contaminants of interest are expected to be at their highest concentrations at the water table, so all wells were completed as near the water table as practicable.

Hollow-Stem Augering

A hollow-stem auger drilling rig, the Mobile B-50, was used at Zones 3 (Industrial Waste Pit 2) and 4 (Industrial Waste Pit 1) to perform shallow coring in the vicinity of the pits. The hollow-stem method allowed for an

TABLE 3-1. MONITOR WELL CONSTRUCTION SPECIFICATIONS

- Casing: 2-inch or 4-inch diameter, flush joint, Schedule 80 PVC.
- Screen: 2-inch or 4-inch diameter, flush joint, Schedule 80 PVC, 0.010-inch mill slot. Normal screen length was 10 feet, reduced to 5 feet at the discretion of the supervising geologist.
- Gravel pack: 8-12 mesh silica, emplaced from bottom of hole to 2 feet above top of screen.
- Bentonite seal: 2 feet above top of sand pack.
- Grout: neat cement (Type I Portland cement) grout from the top of the bentonite seal to the land surface.
- Surface completion: the PVC casing was cut off to provide a 2 to 3 foot stickup and solid cap placed on the casing. A 6-inch diameter guard pipe, 4 feet in length, was placed over the exposed casing, and seated in the cement. A locking cap lid was installed on the guard pipe.
- Guard pipes or posts: 3-inch diameter steel posts, 6 feet in length, with a minimum of 2 feet below ground, 3 each installed radially 4 feet from the wellhead.
- After each well was installed, it was developed by air lifting or bailing until a clear stream was produced, or until the supervising geologist determined that development was complete.
- The split-spoon sampler was washed between samples (water, acetone, water) and the drill pipe, bit, and augers cleaned (pressure water wash) between corings.

Water Level Determination

As the first step of ground-water sampling operations at each monitor well, water level measurements were taken using a Soiltest Model 762A electrical probe. The probe and associated electrical line were washed with laboratory deionized water between each well to preclude the possibility of cross-contamination. Measurements were taken to the nearest 0.01 foot with respect to the top of the protective steel well casing. The elevation point was surveyed as discussed in Section 3.1.9. Water level measurements taken prior to each sampling operation are listed in Appendix E.

Water level measurements were not taken at the base supply wells since the readings would reflect levels influenced by pumping.

Well Purging

Following the completion of well construction activities, each monitor well was purged using a 1.75-inch diameter submersible gas-driven pump. The pump, manufactured by ISCO, Inc. (Model 2600) delivered water to the surface by means of the rapid inflation and deflation of the pump's silicone rubber bladder. Gas (compressed air from a cylinder) did not contact the sample; water comes into contact with stainless steel, polycarbonate, medical-grade silicone rubber, Teflon, polypropylene, Delrin acetal, polyethylene, and the PVC well casing. The pump was operated in the following way: after the pump was set at the appropriate position in the well, the gas supply and pump gas lines were attached to the control box, controls were adjusted to compensate for the bladder inflation rate at varying lifts and gas supply pressure, and the gas valves were opened to begin operation of the pump. Some of the eight existing monitor wells were purged and sampled with a 1.1 liter bottom-discharge Teflon bailer due to low water or poor yields.

Each well was purged either immediately prior to sample collection or within 1 day of sample collection (for low-yield wells) to ensure that fresh formation water was collected as the sample. Purging operations were conducted using a 1.1 liter bottom-discharge Teflon bailer. Purging operations were considered complete when 3 wetted well volumes had been evacuated.

TABLE 3-2. ANALYTICAL SCHEDULE, TINKER AFB

Parameter	Zones
Barium	2
Iron	1, 2
Manganese	1
Total Organic Halogen (TOX)	1, 2, 3, 4
Oil and Grease	1, 2, 3, 4
Total Organic Carbon (TOC)	1, 2, 3, 4
Cyanide	1, 2, 3, 4
Metals (Cd, Cr, Ni, Cu, Zn, Pb, Hg)	1, 2, 3, 4
Volatile Hydrocarbons (EPA 601)	5
Total Phenol	1, 2, 3, 4
Pesticides and Herbicides	1, 2
Trichloroethylene and tetrachloroethylene (EPA 601)	6

A representative of the Oklahoma State Department of Health accompanied the Radian team during most of the sampling effort and split samples from selected monitor wells. A report of all available State data is provided in Appendix H. Analytical results are discussed in Section 4.0.

3.1.5 Geologic Sampling

Geologic sampling consisted of two distinct activities. The first consisted of the routine collection of samples from the air rotary discharge during well drilling. Geologic samples were collected at variable intervals during monitor drilling or where significant changes in lithology occurred. At coring operations (Zones 3 and 4), samples were collected through hollow-stem augers with the use of split-spoon sampler in accordance with ASTM Method D-1586. Grab samples from shallow depths were collected from the auger flights where conditions warranted. All split-spoon samples collected were described, logged, and placed in glass jars with screw-on lids. These samples were labeled and retained by Radian for future reference. Selected samples (ten each from Zones 3 and 4) were frozen and submitted for chemical analysis.

3.1.6 Sampling Schedule

A total of 38 wells were sampled for ground water during Phase II (Stage 1) field activities (February-March 1984). Generally, sufficient sample was obtained during a single sampling round to satisfy the volume requirements for all analytical tests to be performed. However, in some cases, well recovery or leachate production was very slow and sample sets from the same sampling point were collected on more than one occasion. Details of the sampling schedule, including well identification, sample type, date collected, date delivered to the laboratory, and sampler are provided in Appendices E and G.

3.2 Zone Activities

The field program at Tinker AFB consisted primarily of the installation and sampling of ground-water monitor wells. Other activities, such as geophysical surveying, soil coring and sampling, and leachate and pond sampling, were also conducted. The conduct of the field program is presented in narrative form in the following subsections. For each of the zones of investigation, a similar sequence of events was followed, as described in Section 3.1. Each zone of investigation (Figure 3-3) is discussed separately, below.

3.2.1 Zone 1 (Landfills 1 through 4)

This section contains a description of the field activities that occurred at Zone 1, consisting of Landfills 1 through 4. Zone 1 is located at the southwest corner of Tinker AFB; bordered by Patrol Road on the west, Crutcho Creek on the northeast, and Storage Road area on the south. The activities that took place at Zone 1 included; completion of 4 boreholes, installation of 3 ground-water monitor wells, sampling of a series of existing ground-water monitor wells near Crutcho Creek, sampling of the newly-installed monitor wells, and sampling of the leachate from Landfill 4 and water from the recreational pond.

Monitor Well Installation

The locations of the drilling sites are illustrated on Figure 3-4. These locations were selected in order to provide complete coverage of the hydrogeologic conditions at Zone 1. The anticipated ground-water flow direction was to the west and southwest. Well 1A, located on the northwest portion of the zone, is the shallowest boring; borehole 1D, located east of the zone, was intentionally drilled as the deepest boring for the purpose of investigating the subsurface to at least 150 feet below the land surface. Wells 1B and 1C, south and west of the zone, respectively, were drilled to intermediate depths. Each boring encountered a weathered zone of residual soil, underlain

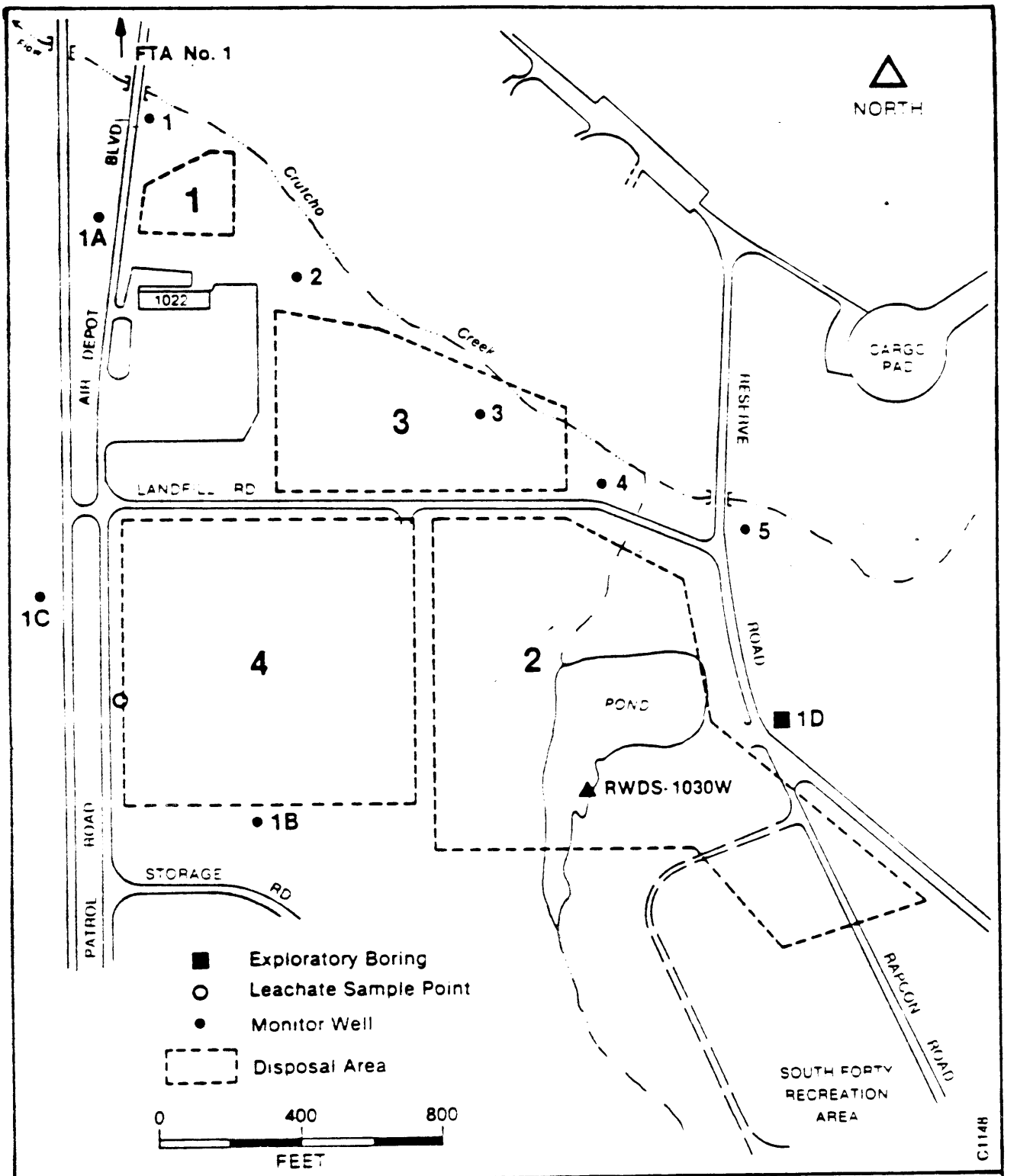

Figure 3-4. Drilling Locations - Zone 1.

TABLE 3-4. GENERAL SPECIFICATIONS FOR ZONE 1 MONITOR WELLS AND CORES

Monitor Well or Core	Measuring Point Elevation[1]	Measuring Point Height	Ground Level Elevation[2]	Screened Interval[3]	Screen Elevations[4]	Total Depth[5]
1A	1223.09	3.00	1220.09	25-35	1195-1185	35
1B	1256.03	2.58	1253.44	65-75	1191-1181	75
1C	1242.49	2.91	1239.59	45-55	1197-1187	55
1D	1238[7]	0	1238[7]	grouted	N/A	150
1[6]	1219.16	2.90	1216.26	37.8-41.8	1178-1174	42.8
2	1222.09	2.95	1219.14	35.8-39.8	1183-1179	42.6
3	1223.37	2.58	1220.79	28.0-32.0	1193-1189	34.3
4	1225.10	3.25	1221.85	29.0-32.5	1193-1189	41.9
5	1227.78	2.95	1224.83	24.0-29.0	1201-1196	32.2
6	1243.63	2.95	1240.68	24.4-28.4	1216-1212	32.2
7	1247.63	2.66	1244.97	18.5-22.5	1226-1222	25.8
8	1254[7]	2.54	1251[7]	16.2-20.2	1235-1231	22.9

[1] Top of PVC casing for monitor wells; ground level for cores; surveyed, except as noted.
[2] Feet, msl to nearest 0.1 foot.
[3] Feet below ground level.
[4] Feet, msl.
[5] Feet below ground level.
[6] Wells 1-8, pre-existing monitor wells.
[7] Ground level elevations taken from Base topographic map.

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3.2.2 Zone 2 (Landfills 5 and 6)

Zone 2 consisted of two widely-separated landfills: Landfill 5 west of the main runway and southwest of Crutcho Creek, and Landfill 6 east of Tinker AFB and south of S.E. 59th Street near Area "D". These landfills represent the most recent on-base landfilling operations, with the period of activity ranging from 1970 to 1979. Earlier ground-water investigations at these sites have resulted in the placement of monitor wells near Crutcho Creek at Landfill 5 and near an unnamed tributary of Soldier Creek near Landfill 6 along S.E. 59th Street.

Monitor Well Installation

Drilling for the emplacement of monitor wells at Zone 2 was conducted from 17 to 20 November 1983. Two wells were installed; 2A at Landfill 6, and 2B at Landfill 5. Both wells were installed in boreholes drilled using the air rotary method. Locations of the wells are shown on Figures 3-5 and 3-6. Prevailing ground-water flow was determined to be generally south on the basis of published information (Figure 2-8) (Wichersham, 1979). Therefore, well 2A was located on the south margin of Landfill 6 in order to monitor conditions hydraulically downgradient from the landfill. Regional ground-water flow in the vicinity of Landfill 5 is believed to be to the south or southwest; well 2B was therefore placed on the south side of Landfill 5 to monitor downgradient conditions and provide complementary coverage to the existing 3 monitor wells located to the north and east of the landfill. Appendix D contains detailed descriptions of the log of borings and well completion data. Table 3-6 provides a summary of monitor well data.

Monitor Well Sampling

After the completion and initial development of the monitor wells each one was purged and sampled. Field sampling was conducted by Radian personnel during the period 12-18 February 1984. Details of the field sampling procedures are presented in Section 3.1.4. The ground-water samples were analyzed for the parameters specified in the Statement of Work as shown on Table 3-7. Results of all analyses are discussed in Section 4.2.2.

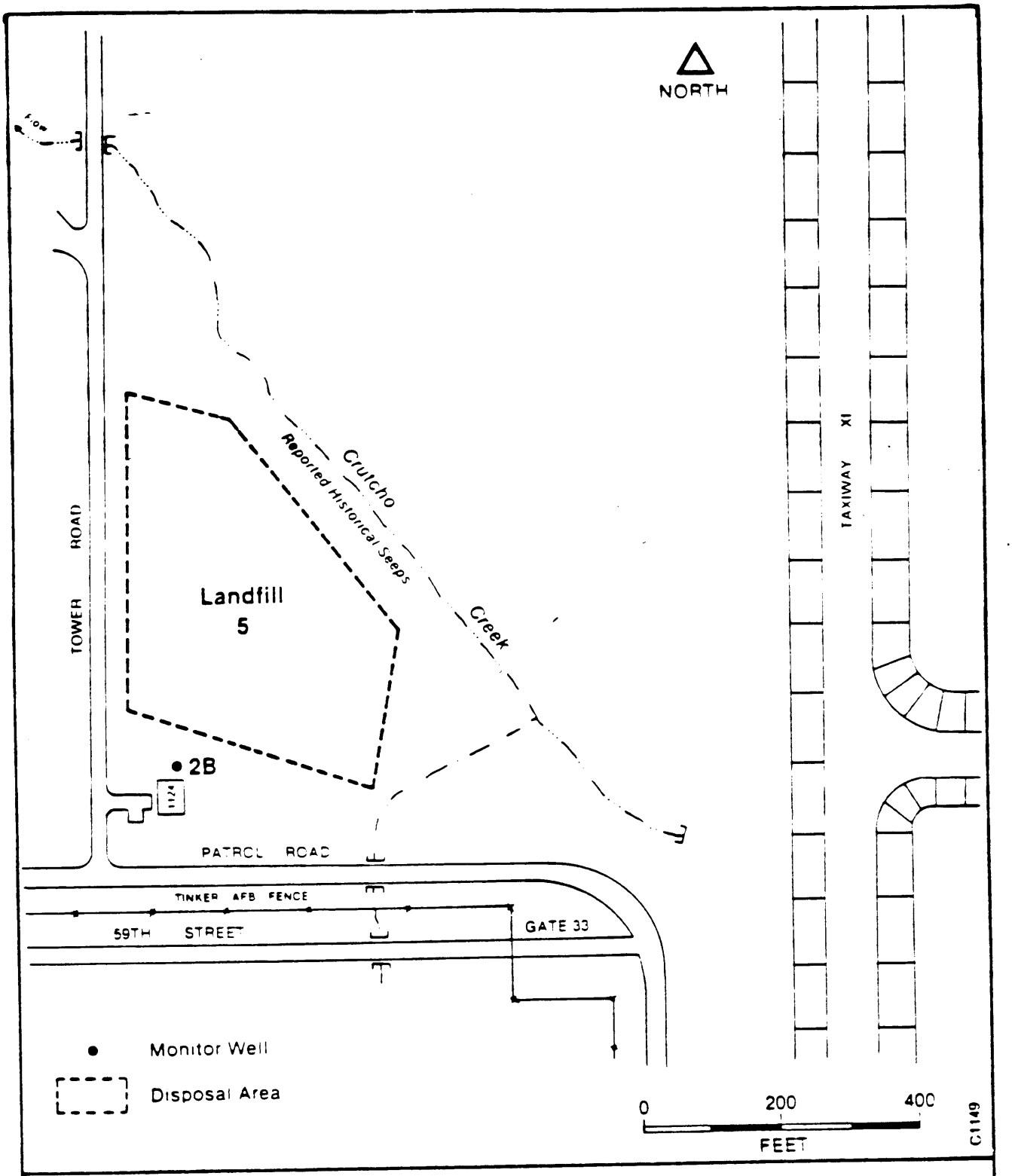

Figure 3-6. Location of Well 2B - Zone 2, Landfill 5.

TABLE 3-7. ANALYTICAL SCHEDULE, ZONE 2

Barium
Cadmium
Cyanide, total
Chromium
Copper
Iron
Herbicides
2,4-D
2,4-5TP (Silvex)
Mercury
Nickel
Oil and Grease (IR)
Lead
Pesticides (EPA Method 608)
DDT Isomers
aldrin
dieldrin
lindane
methoxychlor
heptachlor
heptachlor epoxide
Total Organic Carbon
Total Organic Halogen
Total Phenol
Zinc
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)

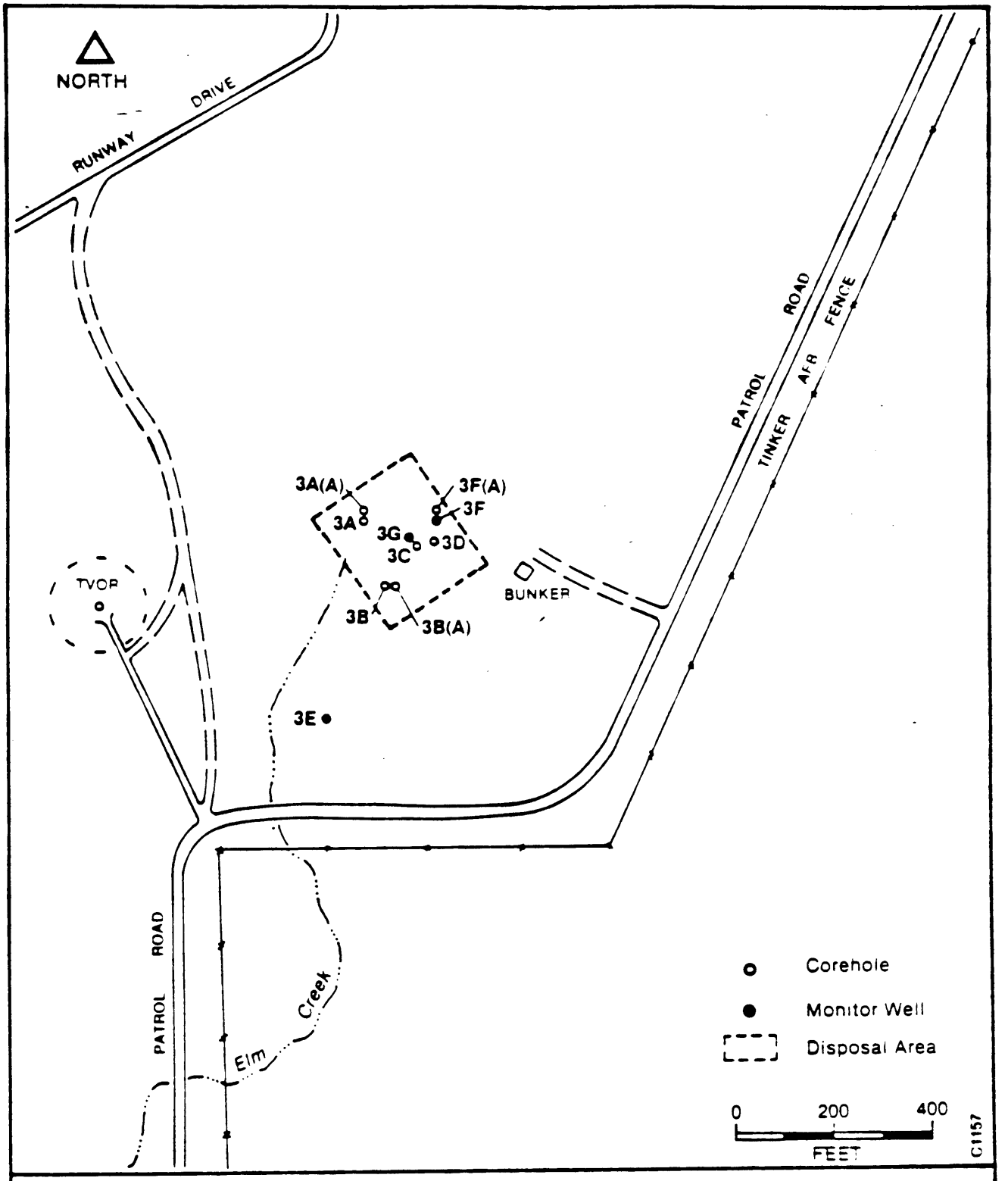

Figure 3-7. Drilling Locations, Zone 3 - Industrial Waste Pit No. 2.

TABLE 3-8. GENERAL SPECIFICATIONS FOR ZONE 3 MONITOR WELLS AND CORES

Monitor Well or Core	Measuring Point Elevation[1,2]	Measuring Point Height	Ground Level Elevation[2]	Screened Interval[3]	Screen Elevations[4]	Total Depth[5]
3A	1305	0.0	1305	grouted	N/A	10
3A(A)[6]	1305	0.0	1305	grouted	N/A	5
3B	1303	0.0	1303	grouted	N/A	11
3B(A)[6]	1303	0.0	1303	grouted	N/A	21
3C	1305	0.0	1305	grouted	N/A	10
3D	1305	0.0	1305	grouted	N/A	10
3E	1297.6	2.6	1295	64.5-74.5	1230.5-2330.5	74.5
3F	1309.9	2.9	1307	15.4-30.3	1291.6-1276.6	30.4
3F(A)	1307	0.0	1307	grouted	N/A	6
3G	1302	2.3	1305	3.0-8.0	1302-1297	8.0

[1]Top of PVC casing for monitor wells; ground level for cores.
[2]Feet, msl taken from Base topographic map.
[3]Feet below ground level.
[4]Feet, msl.
[5]Feet below ground level.
[6](A) = alternate.

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TABLE 3-9. ANALYTICAL SCHEDULE, ZONE 3

Cadmium
Cyanide, total
Chromium
Copper
Mercury
Nickel
Oil and Grease (IR)
Lead
Total Organic Carbon
Total Organic Halogen
Total Phenol
Zinc
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)[1]

[1]Ground-water samples and one selected soil sample only.

at other zones in order to monitor the first significant occurrence of ground water. The shallow wells (Wells 4F and 4G) were installed in boreholes drilled using hollow-stem auger equipment as part of the effort to define subsurface conditions directly over the buried industrial waste pit. In total, six boreholes were drilled using the hollow-stem auger, revealing a wide range of subsurface conditions in a relatively small area. Small diameter wells (consisting of 2-inch PVC as described in Section 3.1) were installed in two adjacent boreholes. The shallow borehole (4G) collected a significant amount of water within a few hours; the deeper borehole (4F) remained dry but was converted to a monitor well in order to observe the possible accumulation of ground water in the shale bedrock. Appendix D contains detailed descriptions of the logs of borings and well completion data. Table 3-10 provides a summary of the cores and monitor well data.

Soil Sampling

During the coring operations, samples were collected through the hollow-stem augers with the use of split-spoon sampler in accordance with ASTM Method D-1586. All split-spoon samples collected were described, logged, and containerized in glass jars with Teflon-lined screw-on lids. These samples were labeled and retained by Radian for future reference. Ten selected samples were frozen and submitted for chemical analysis. Results of chemical analysis are discussed in Section 4.2.4.

Monitor Well Sampling

After the completion and initial development of the monitor wells each one was purged and sampled. Field sampling was conducted by Radian personnel during the period 12-18 February 1984. Details of the field sampling procedures are presented in Section 3.1.4. The ground-water samples were analyzed for the parameters specified in the Statement of Work as shown on Table 3-11. Results of all analyses are discussed in Section 4.2.4.

TABLE 3-11. PARAMETERS FOR WATER AND SOIL ANALYSES - ZONE 4

Cadmium
Cyanide, total
Chromium
Copper
Mercury
Nickel
Oil and Grease (IR)
Lead
Total Organic Carbon
Total Organic Halogen
Total Phenol
Zinc
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)[1]

[1]Ground-water samples and one selected soil sample only.

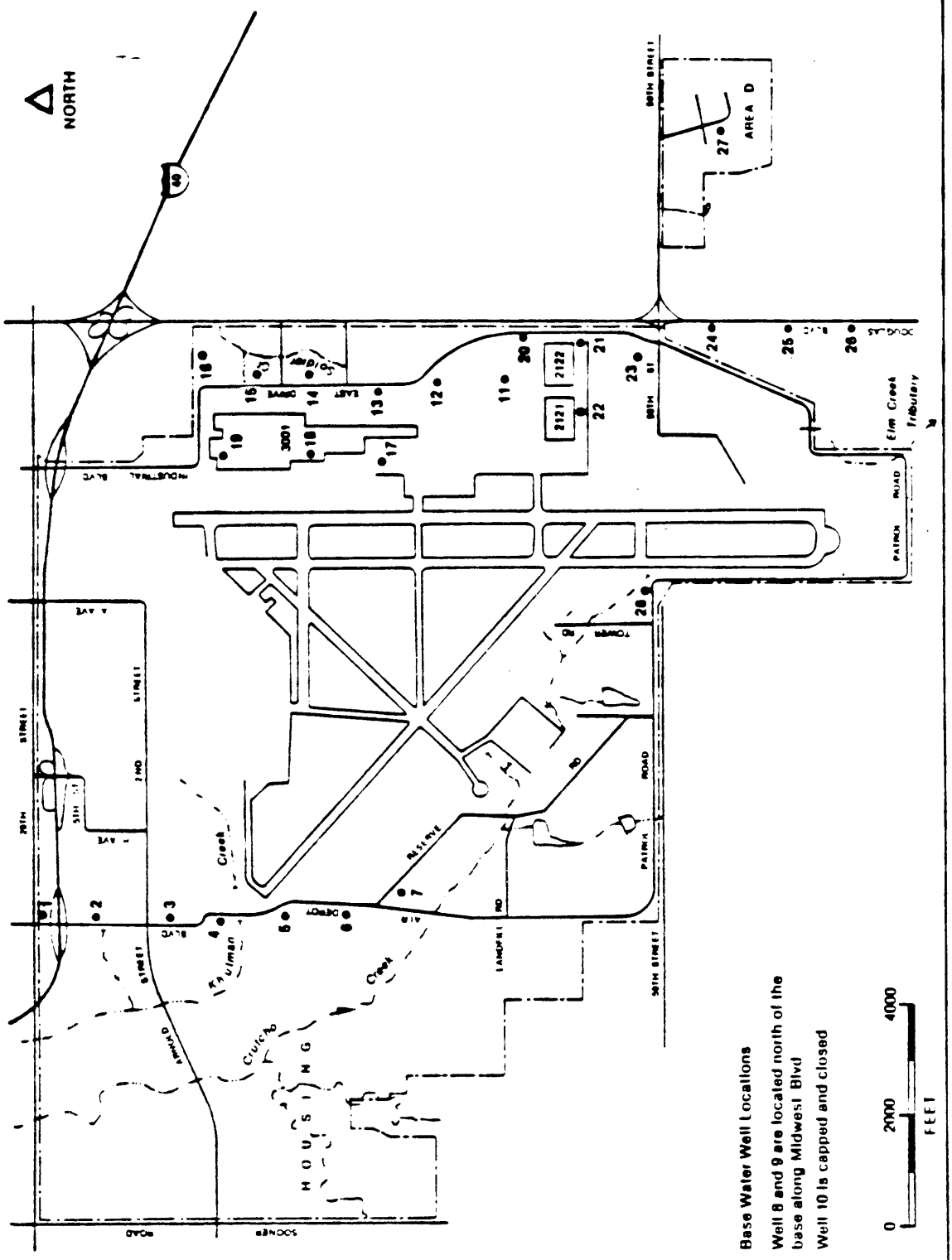

Figure 3-9. Zone 5 - Base Water Supply Wells.

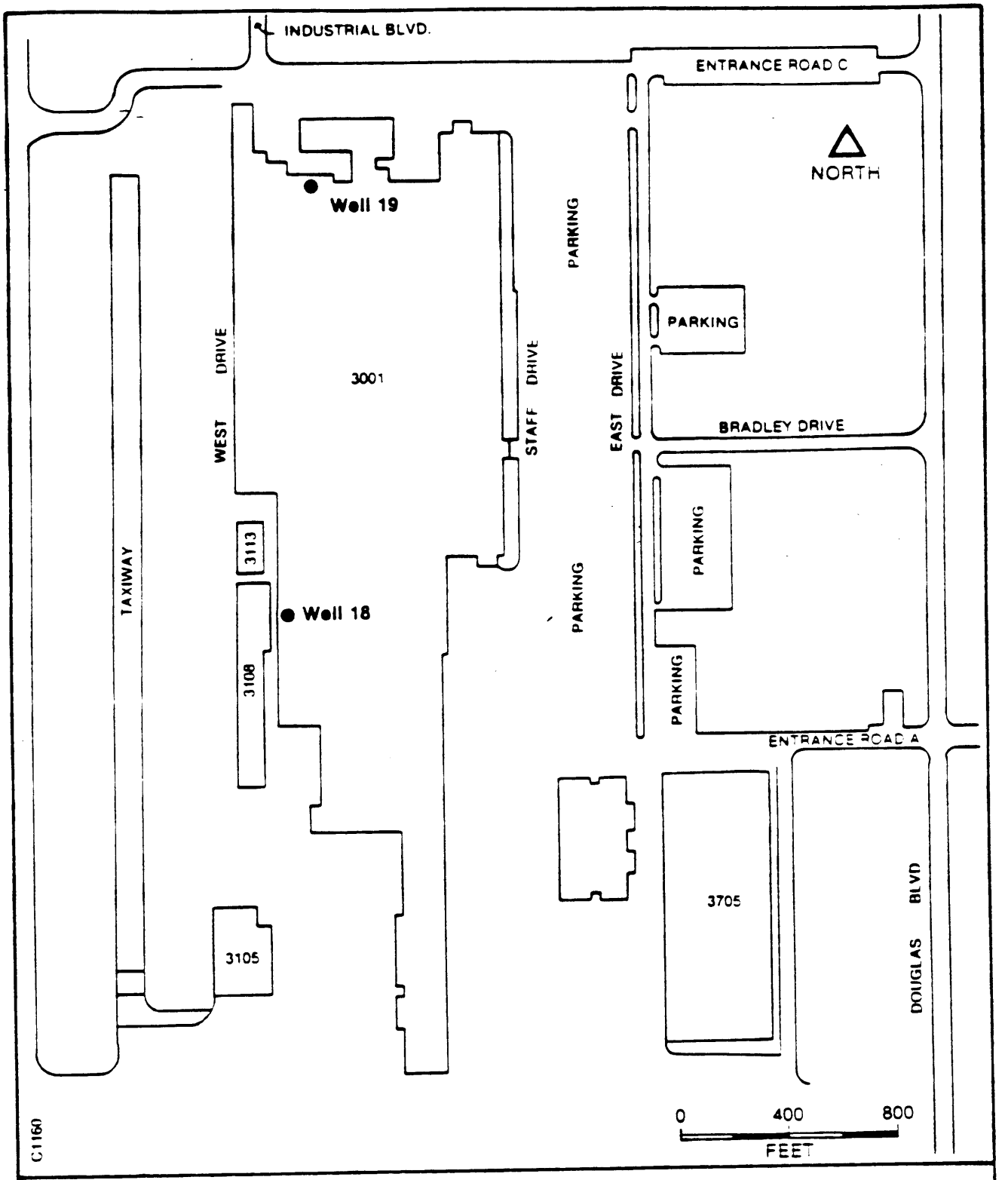

Figure 3-10. Zone 6 (Building 3001 Wells).

- Occurrence (i.e., quantity) of contaminants in the deeper aquifer.
- Mechanism for introduction of contaminants into well bore.
- Occurrence of contaminants in shallow zone.
- Movement of contaminants in shallow zone.
- Source of contaminants.

Radian determinated that the most effective means of addressing the highest priority issues was to conduct a protracted pump test with periodic sampling for contaminants of interest. If contaminants were shown to decline with continued pumping, this could be taken as evidence for limited contamination within the deeper zones of the aquifer. If, on the other hand, contaminant concentrations showed a constant or increasing trend, this would be evidence for widespread contamination. Corrollary issues (occurrence of contaminants in shallow zones, etc.) would be addressed after the results of the preliminary investigation were available.

The original plan, as specified in the modified Statement of Work, was to test-pump wells 18 and 19 for a period of up to eight hours each, collecting samples periodically for analysis by Method 601 for trichloroethylene (TCE) and tetrachloroethylene. However, as long as these wells remain connected to the water distribution system, neither could be pumped for more than approximately five minutes. Since test-pumping remained the method of investigation most likely to yield the required data in a timely and cost-effective manner, the method of investigation was modified. The test-pumping was limited to a single, 16-hour test of Well 18, only, which was disconnected from the distribution system with temporary plumbing installed to allow the well to discharge to the industrial sewer inside Buiding 3001. The test took place on 5 March 1984. Results are discussed in Section 4.2.6.

4.0 DISCUSSION OF RESULTS AND SIGNIFICANCE OF FINDINGS

In this section, the hydrogeologic observations and chemical analytical data are discussed on a zone-by-zone basis. Hydrogeologic interpretations are made on the basis of the available data. Analytical chemistry data are discussed within the context of available regulatory standards and criteria. After an introduction section dealing with available standards and criteria, the discussion of results and significance of findings are each discussed zone by zone in separate sections.

4.1 Regulatory and Human Health Criteria and Standards

In order to determine possible water quality impacts on the local ground-water systems, the organic and inorganic compounds detected in the ground-water samples were compared to various criteria. These criteria were drawn from federal drinking water regulations, standards and guidelines. Table 4-1 shows parameters detected, along with the corresponding primary or secondary drinking water standard. These standards provide a stringent comparison for human health considerations.

The second column of Table 4-1 lists EPA toxicity values for chemicals detected. These human health criteria are also available for most of the other organic chemicals detected, as summarized on Table 4-2. Although these criteria do not have the force of standards, they do provide a valid means of assessing properties of chemicals of concern. Many of the compounds are proven or suspected animal carcinogens where zero consumption is recommended for the protection of human health. Many are also regulated as hazardous waste under RCRA (40 CFR Parts 262 and 263). For each zone, parameters detected are evaluated in comparison with these standards and criteria.

The use of human health criteria and standards for comparison of ground-water contamination at Tinker AFB provides stringent evaluations of observed concentrations. Since the shallowest zones of the aquifer are not used as water supply sources, contaminants in-situ have neither human health

TABLE 4-2. GUIDELINES FOR ORGANIC COMPOUNDS DETECTED IN GROUND WATER

Compound	EPA Toxicity[1,2] ppb unless noted
EPA Method 601 (Purgeable halocarbons)	
Methylene Chloride	0 (1.9)[3]
1,1-Dichloroethene	0 (0.33)
trans-1,2-Dichloroethene	n.c.[4]
1,1-Dichloroethane	0 (9.4)
1,2-Dichloroethane	0 (9.4)
1,1,1-Trichloroethane	18.4 ppm
Trichloroethylene	0 (27)
Chlorobenzene	488
Chloroform	0 (1.9)
Bromodichloromethane	0 (1.9)[3]
Tetrachloroethylene	0 (8)
Modified EPA Method 625 (Acid/Neutrals)	
1,2-Dichlorobenzene	400
1,3-Dichlorobenzene	400
1,4-Dichlorobenzene	400
di-n-butyl phthalate	34 ppm
Isophorone	5.2 ppm
butyl benzyl phthalate	n.c.

[1]Footnote 2, Table 4-1.

[2]EPA has recommended human health effects criteria of zero (0) for carcinogens, but notes that this level may currently be infeasible. The Agency provides criteria for achieving various levels of protection on an interim basis. The levels which may result in a 10^{-5} incremental increase of cancer risk over a lifetime are presented in parentheses in ppb unless noted. These figures would permit one case of cancer per 100,000 people exposed.

[3]Criterion for "halomethanes".

[4]n.c. -- denoted no criteria set for human health due to insufficient data.

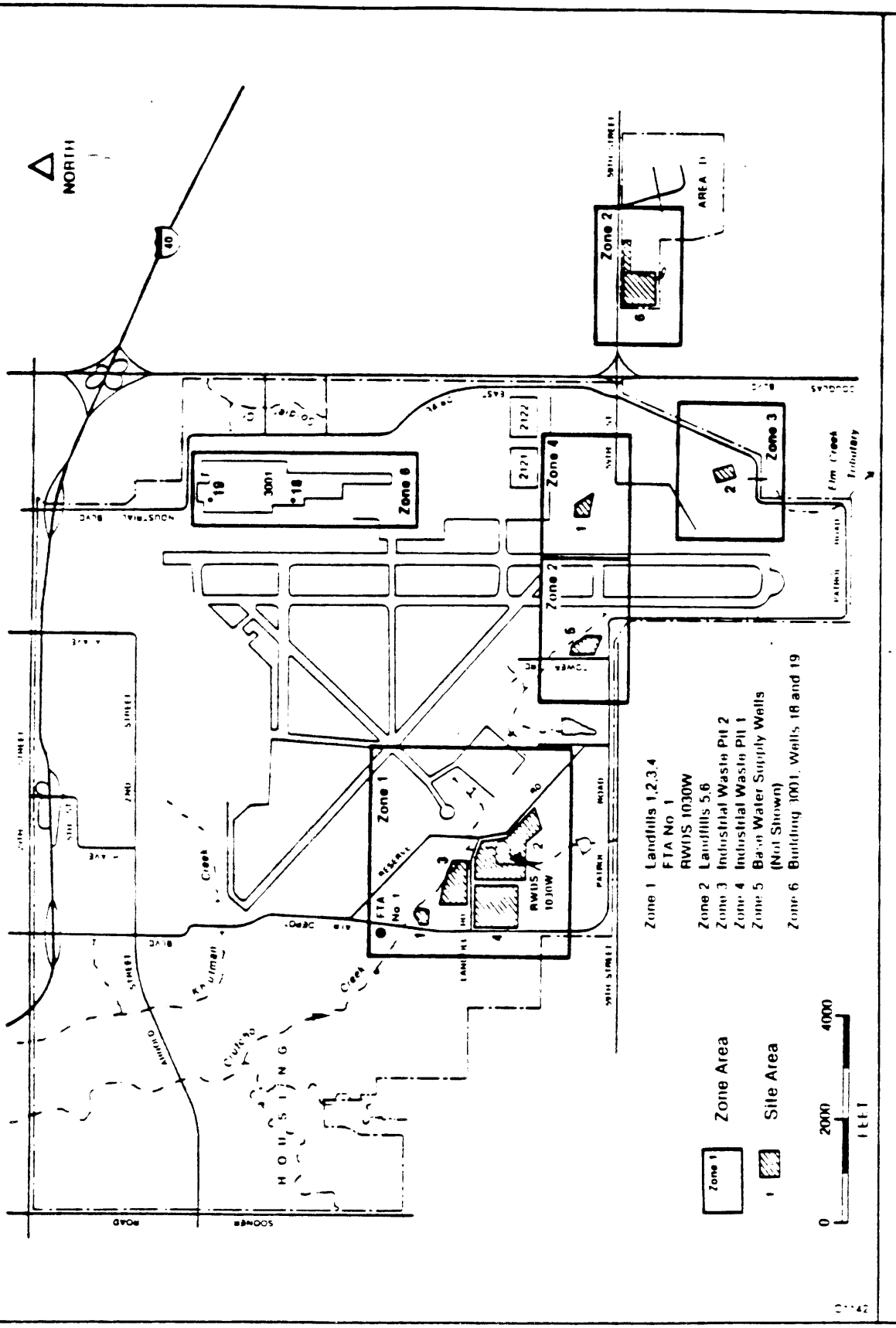

Figure 4-1. Zones of Investigation, Tinker AFB.

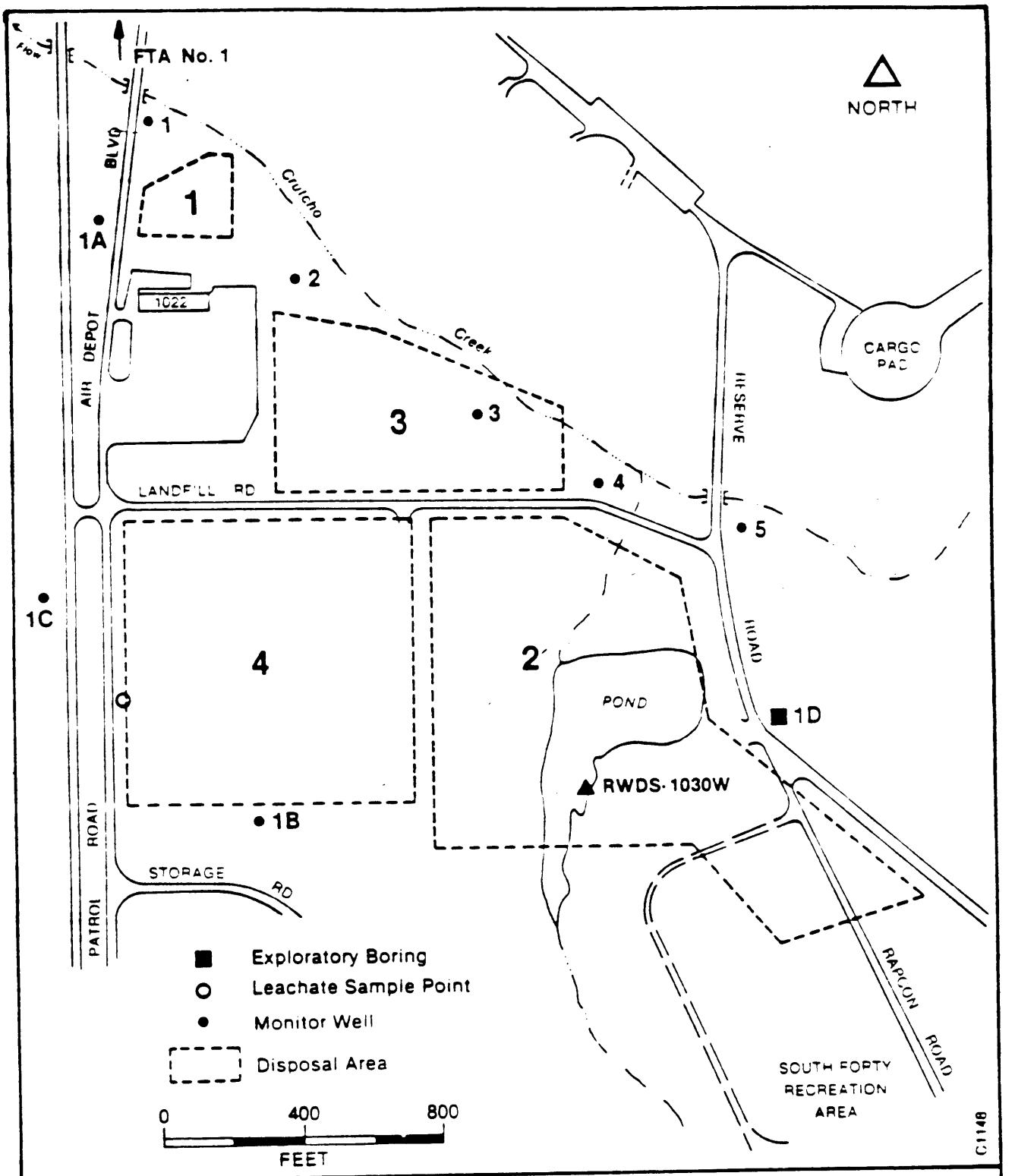

Figure 4-2. Location of Sample Points, Zone 1.

Perched ground water also exists within Landfill 4 (and possibly other landfills), emerging as both discrete seeps and broad zones of seepage along the margins of the landfill. The volume of seepage at the land surface is correlatable with rainfall events; for example, active seeps were observed at the west side of Landfill 4 within several weeks of heavy rainfall that occurred in October 1983, but these seeps were nearly dry in February 1984 following a relatively dry spell. Landfill leachate that emerges at the surface collects in roadside ditches and flows to the north to Crutcho Creek.

Ground-water flow, as inferred from water-level elevations in wells away from the influence of Crutcho Creek, is generally to the west. The results of water level interpretations for Zone 1 are consistent with the results obtained in other zones, indicating a hydrogeologic picture consistent with the regional flow patterns observed in the Oklahoma City area.

Ground-Water Quality

After installation, each of the Phase II (Stage 1) monitor wells was sampled for chemical analysis. The eight existing monitor wells (numbered one through eight) were also sampled at this time. The results of analyses are given on Table 4-3. Samples from monitor wells 1A, 1B, and 1C were analyzed for acid/neutral extractable organic priority pollutants (modified EPA Method 625). Samples from monitor wells 2 and 4 were resubmitted for modified Method 625 analysis, based on the results of total organic carbon analyses performed in the specific parameter schedule. No additional compounds were detected by modified Method 625. Complete reports of all analyses are provided in Appendix H. These data are discussed in Section 4.3.

Other Samples

In addition to the monitor well samples, selected surface water samples were also collected. The recreation pond overlying Landfill 2 was sampled by compositing grabs from randomly selected points. The leachate seep on the west fence of Landfill 4 was sampled, but leachate seeps at other landfills remained dry throughout the period. Results of analyses are also shown on Table 4-3. These data are also discussed in Section 4.3.

4.2.2 Zone 2 (Landfills 5 and 6)

Work performed at Zone 2 consisted of the installation of two groundwater monitor wells (one at Landfill 6 and one at Landfill 5) and the sampling and analysis of water from the monitor wells. The results and significance of the hydrogeologic and chemical data are discussed in the following paragaphs.

Topography

Zone 2 is separated into two distinct areas with over 1 mile of separation (Figure 4-1). It exhibits the same types of topograhic features that occur in other zones. Landfill 5 (Figure 4-3), located just southwest of Crutcho Creek and upstream of Zone 1, is built up on the order of 5 to 10 feet above the surrounding land, which slopes gently to the northeast toward Crutcho Creek. Similarly, Landfill 6 (Figure 4-4) is higher than the surrounding land as it is located on the crest of a low hill just south of S.E. 59th Street and east of Douglas Boulevard. Both landfills are relatively recent features, having been active within the last 5 to 15 years. Accordingly, there is patchy vegetatiou on both fill surfaces. There is also recent disruption of the surface of Landfill 5 due to nearby construction.

Geologic Features

Results of monitor well installation show that the geologic setting at sites in Zone 2 is essentially the same as the geologic setting at Zone 1. A near-surface zone of soil and weathered shale, normally 3 to 5 feet thick, is underlain by dry, red Fairmont Shale. The shale is in turn underlain by fine-grained sandstone of the Garber Sandstone. Logs of borings (Appendix D) for wells 2A (at Landfill 6) and 2B (at Landfill 5) include detailed descriptions of the geologic section. Figure 2-5, a geologic cross-section of the southern part of the base, illustrates the continuity of geologic strata from zone to zone. The dip of the strata is to the west at a shallow angle, which is consistent with the regional geologic framework of Permian-age strata in central Oklahoma.

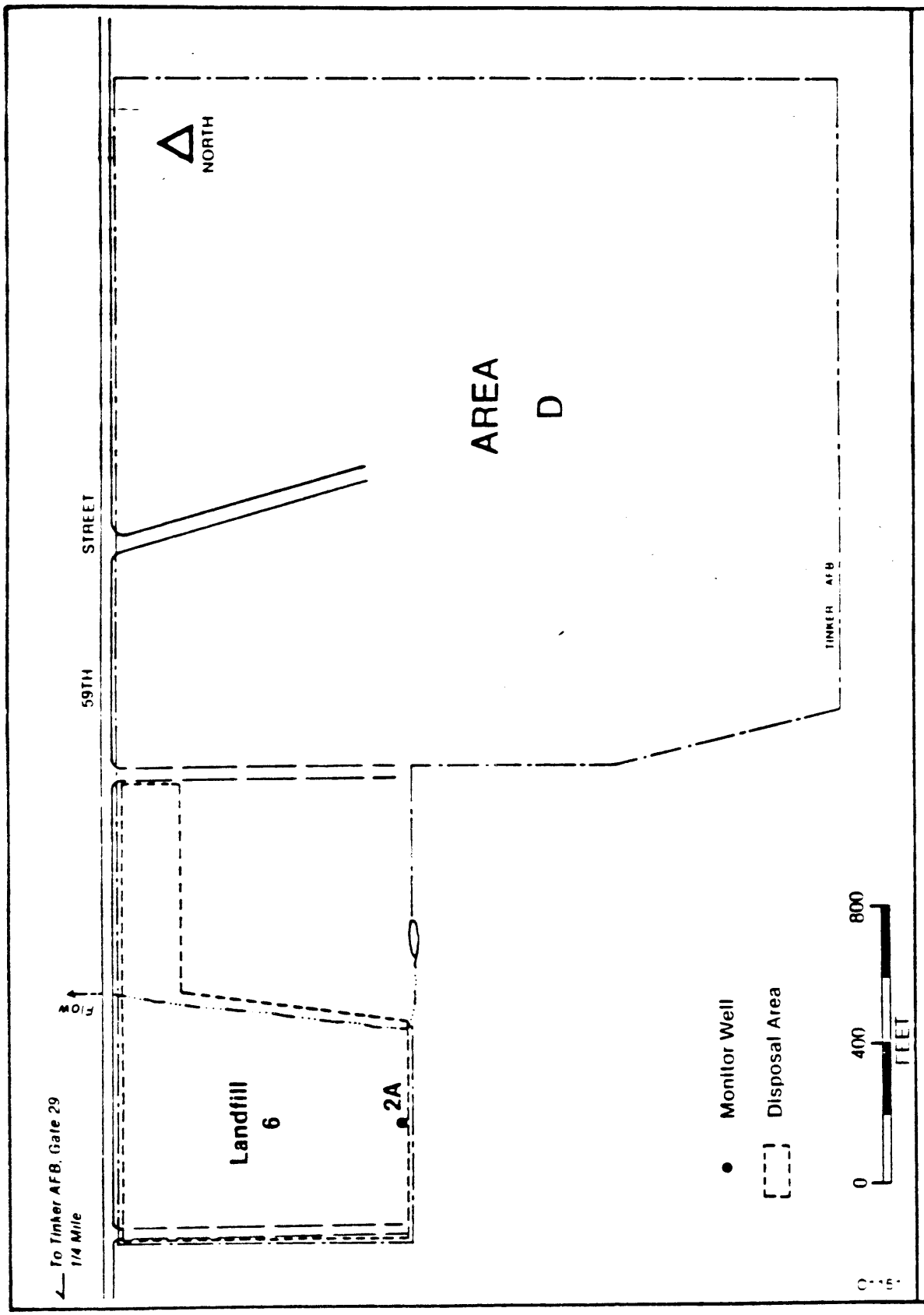

Figure 4-4. Location of Sampling Points, Zone 2 (Landfill 6), Tinker AFB.

TABLE 4-4. RESULT OF CHEMICAL ANALYSES, ZONE 2, TINKER AFB

Parameter mg/l (except as noted)	Well 2A	Well 2B
Barium	0.21	0.45
Cadmium	0.006	<.002
Cyanide	<.01	<.01
Chromium	<.001	<.001
Copper	<.001	<.001
Iron	0.23	<.008
Mercury	0.0004	<.0005
Nickel	<.003	<.003
Oil & Grease	<0.10	<0.10
Lead	<.002	<.002
Phenol	<.005	<.005
Total Organic Carbon	<1	9
Total Organic Halogen	<.01	<.01
Zinc	0.34	<.003
Herbicides		
2,4-D	ND	ND
2,4,5-TP (silvex)	ND	ND
Pesticides (EPA Method 608)	ND	ND
Acid/Neutral Extractable Organic Priority Pollutants (Modified EPA Method 625)		
butyl benzyl phthalate	ND	2.3 µg/L

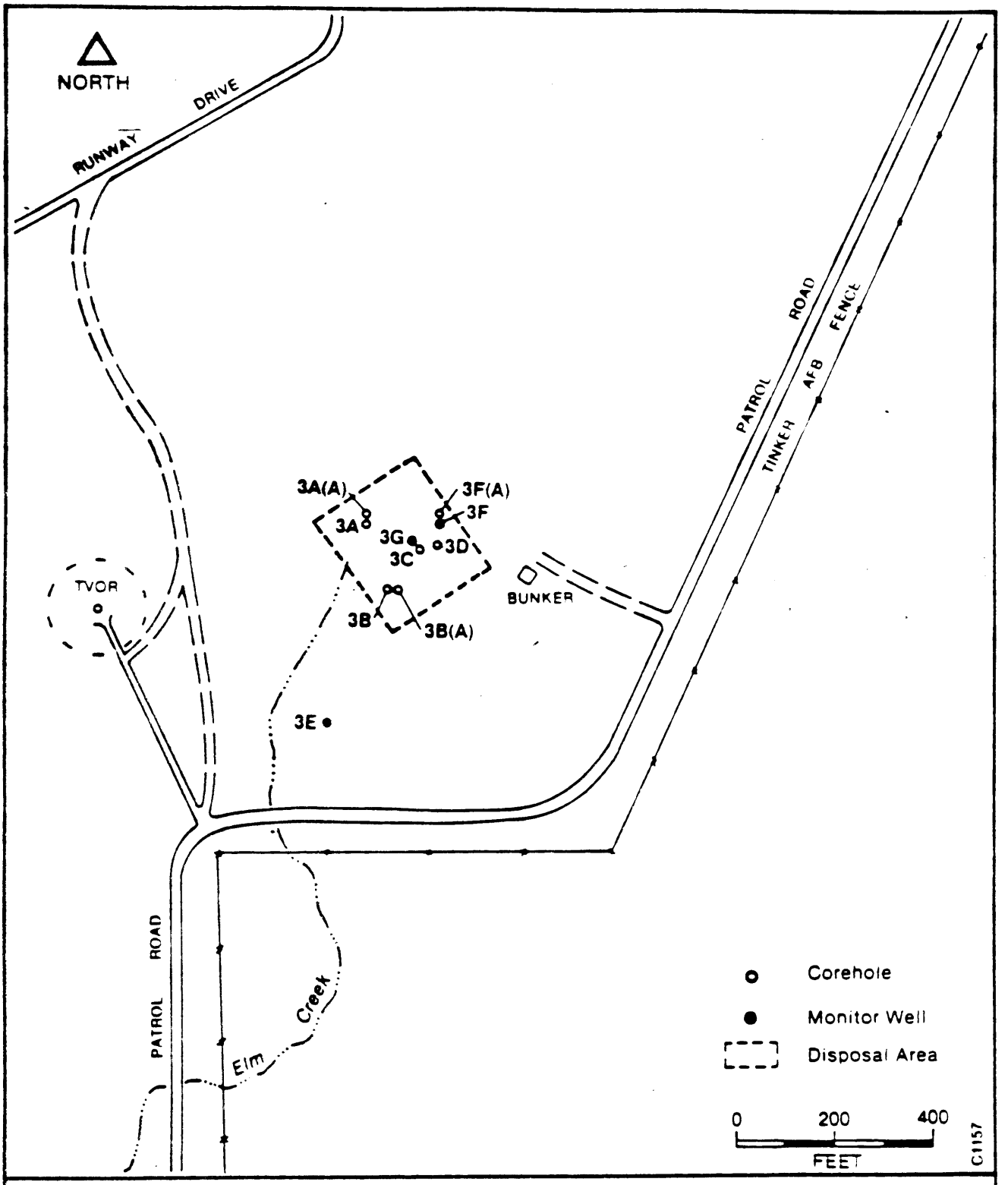

Figure 4-5. Location of Sampling Points, Zone 3, Tinker AFB.

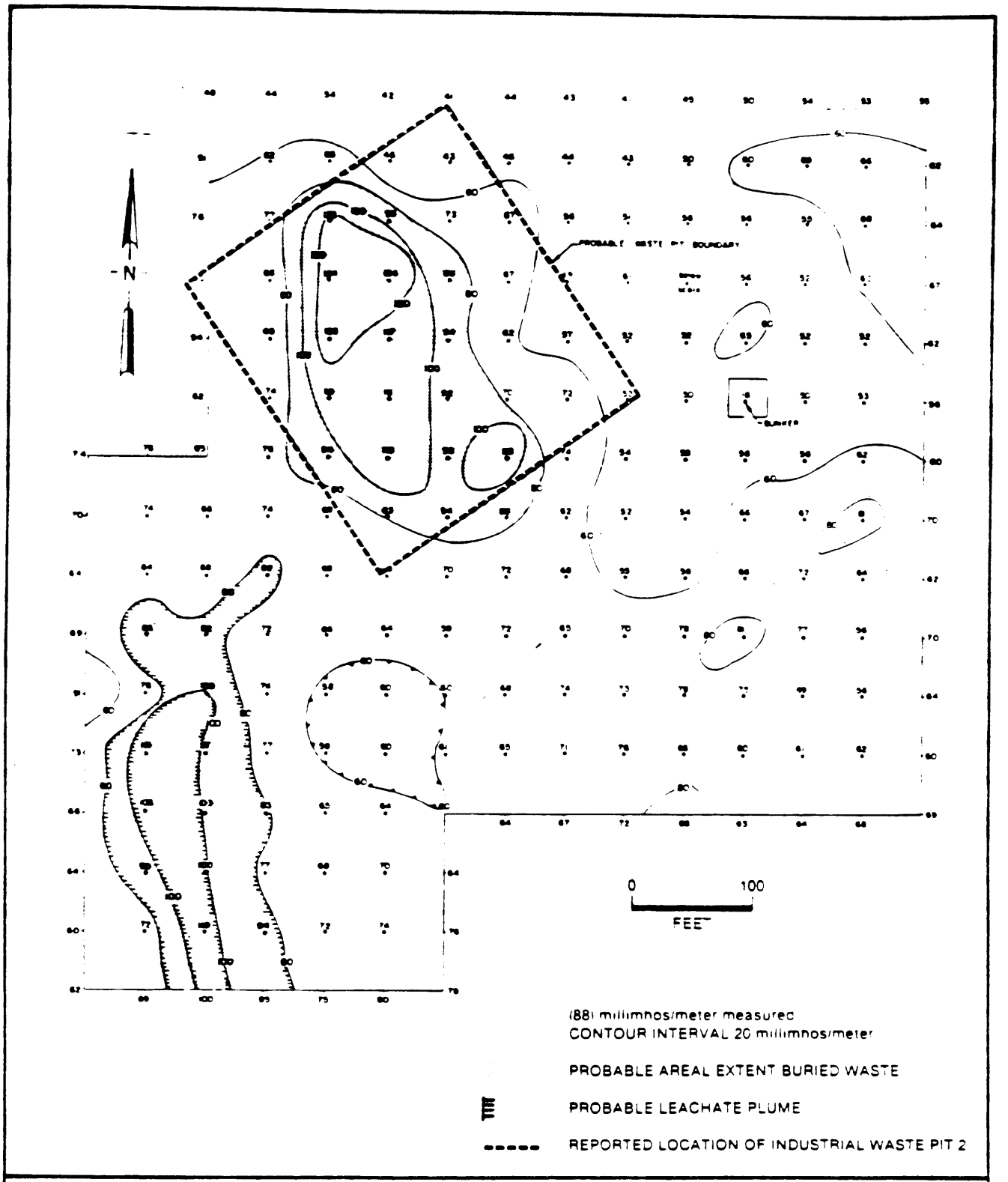

Figure 4-6. Geophysical Survey Results, EM31, Zone 3, Tinker AFB.

Soil Sampling

Shallow soil sampling operations (described in Section 3.1.2) were conducted at the conclusion of the field geophysical survey. Results of the geophysical survey were used as an aid in selecting the locations of the cores so as to investigate the area of the waste pit. Sampling was performed at five locations in order to directly observe soil conditions at the waste pit and to provide for the installation of two shallow ground-water monitor wells.

The geologic materials varied considerably within the area of investigation. For the most part, the subsurface consisted of soil and fill, underlain by weathered and unweathered shale. Augering and sampling were quite difficult in unweathered shale, with refusal typically at or slightly below the weathered shale - unweathered shale contact. Split-spoon samples from directly over the conductivity anomalies generally yielded near-surface samples of soil with a contaminated appearance: dark brown, moist, clayey fill-like material. The logs of borings for Zone 3 (Appendix D) provide additional and specific details. It is believed that the fill-like material simply represents soil that was pushed or placed into or over the waste pit during reclamation in the mid-1960s.

Rotary Drilling

Sampling of deeper stratigraphic horizons (at monitor wells 3E) southwest of the waste pit revealed a sequence essentially identical to the geologic setting at Zones 1 and 2. No evidence of soil or ground-water contamination was observed during the driling of 3E.

Occurrence of Ground Water

Ground water at Zone 3 was found to occur under three different conditions: in a shallow, saturated interval extending from just below the land surface to the top of the unweathered shale; in a sandstone body isolated in a dominately shale section directly below the waste site; and in the regional water-table aquifer continuous within the base.

of selected metals, total organic carbon, total organic halogen, and phenols. The samples selected for analysis were chosen such that the vertical and horizontal distribution of chemical species in geologic materials within and below the pit could be evaluated, as shown on Table 4-5. Based on the results of these analyses, one sample (the sample with the highest level of total organic carbon) was resubmitted for modified EPA Method 625 analysis. Results of these analyses are provided on Tables 4-6 and 4-7.

After installation, each of the monitor wells was sampled for chemical analysis. The results of analyses are shown on Table 4-8. Samples were analyzed for acid/neutral extractable organic priority pollutants (modified EPA Method 625); only compounds detected are shown. Complete reports of all analyses are provided in Appendix H. These data are discussed in Section 4.3.

4.2.4 Zone 4 (Industrial Waste Pit No. 1)

Work performed at Zone 4 consisted of geopysical (EM) survey, shallow soil coring at six locations, installation of two shallow ground-water monitor wells within the boundary of the disposal area, installation of 1 deep ground-water monitor well away from the disposal area, and sampling and analyses of soil and ground water. The results of the hydrogeologic, geophysical, and chemical data are discussed in the following paragraphs.

Topography

Zone 4 is located in the southeastern portion of Tinker AFB, just east of the main north-south runway and southwest of maintenance buildings 2121 and 2122. The area is nearly flat, with a gentle slope to the southwest toward Crutcho Creek. The topographic relief is about 20 feet, with elevations ranging from 1270 feet to about 1290 feet across the site.

Figure 4-8 illustrates the suspected disposal area, as well as the locations of the cores, monitoring wells, and the limits of the geophysical survey.

TABLE 4-6. RESULTS OF SOILS ANALYSES, ZONE 3, TINKER AFB

Parameter (µg/g, except as noted)	Soil Sample									
	3Aa	3Aa (alt)	3Ab	3Bb	3Bd	3Be	3Ca	3Cb	3Fb	3Fc
Cadmium	3.2	2.0	0.49	0.25	0.20	<.15	23	1.2	0.25	<.020
Cyanide	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Chromium	8.9	6.2	4.5	3.8	2.9	4.0	750	5.7	15	4.0
Copper	7.1	4.1	11	5.6	5.6	5.7	130	13	5.1	2.3
Mercury	4.0	4.5	4.1	3.5	3.4	4.0	3.5	3.5	3.8	3.8
Nickel	38	13	13	7.2	5.4	6.0	40	11	7.9	5.7
Oil & Grease (mg/g)	2	5	2	0.5	1.5	0.5	6	1	1.5	1
Lead	5.2	2.5	2.9	2.5	1.8	1.9	41	3.3	9.2	1.6
Phenol	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Total Organic Carbon (%)	0.11	0.32	0.02	0.02	0.02	0.04	0.52	0.03	0.19	0.02
Total Organic Halogen	<1	12	<1	<1	<1	<1	14	<1	<1	<1
Zinc	9.2	3.0	12	5.9	5.0	8.2	36	7.6	16	5.7

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TABLE 4-8. RESULTS OF GROUND-WATER SAMPLE ANALYSES, ZONE 3, TINKER AFB

Parameter (mg/L, except as noted)	Well 3E	Well 3F	Well 3G
Cadmium	<.002	<.002	2.2
Cyanide	<.01	<.01	<.01
Chromium	<.001	<.001	12
Copper	<.001	<.001	0.15
Mercury	0.0004	0.0006	<.0005
Nickel	<.003	<.003	82
Oil & Grease	<0.10	<0.10	70
Lead	<.002	<.002	3.3
Phenol	<.005	<.005	80[1]
Total Organic Carbon	<1	3	4000
Total Organic Halogen	<.01	<.01	3.4
Zinc	0.016	0.024	29
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)			
1,2-dichlorobenzene	ND	ND	20
phenol	ND	ND	220

[1]Probable low bias due to interferences with colorimetric procedure, large dilution required for analysis.

Topography

Zone 4 is located in the southeastern portion of Tinker AFB, just east of the main north-south runway and southwest of maintenance buildings 2121 and 2122. The area is nearly flat, with a gentle slope to the southwest toward Crutcho Creek. The topographic relief is about 20 feet, with elevations ranging from 1270 feet to about 1290 feet across the site.

Figure 4-8 illustrates the suspected disposal area, as well as the locations of the cores, monitoring wells, and the limits of the geophysical survey.

Geologic Features

Geologic data developed for Zone 4 resulted from three primary activities: geophysical (EM) surveying, geologic sampling during coring and drilling operations, and observations of water levels during and after coring and monitor well installation.

The geologic picture at Zone 4 is virtually the same as at other zones. The major geologic units are a thin soil cover, underlain by dry, red Fairmont Shale, in turn underlain by sandstone of the Garber Sandstone. Logs of boring and drilling operations (Appendix D) provide additional details of the geologic section. The major geologic feature of interest in the investigation of Zone 4 are the near-surface phenomena (conductivity anomalies and disturbed earth materials) associated with the former Industrial Waste Pit No. 1. The purpose of the geophysical survey and shallow coring efforts was to investigate in detail the near-surface geologic conditions in view of the potential for ground-water contamination.

Geophysical Survey

Ground conductivity was read directly using the Geonics EM31 and EM34-3. By using both the EM31 and EM34-3 (10m and 20m of separation) the

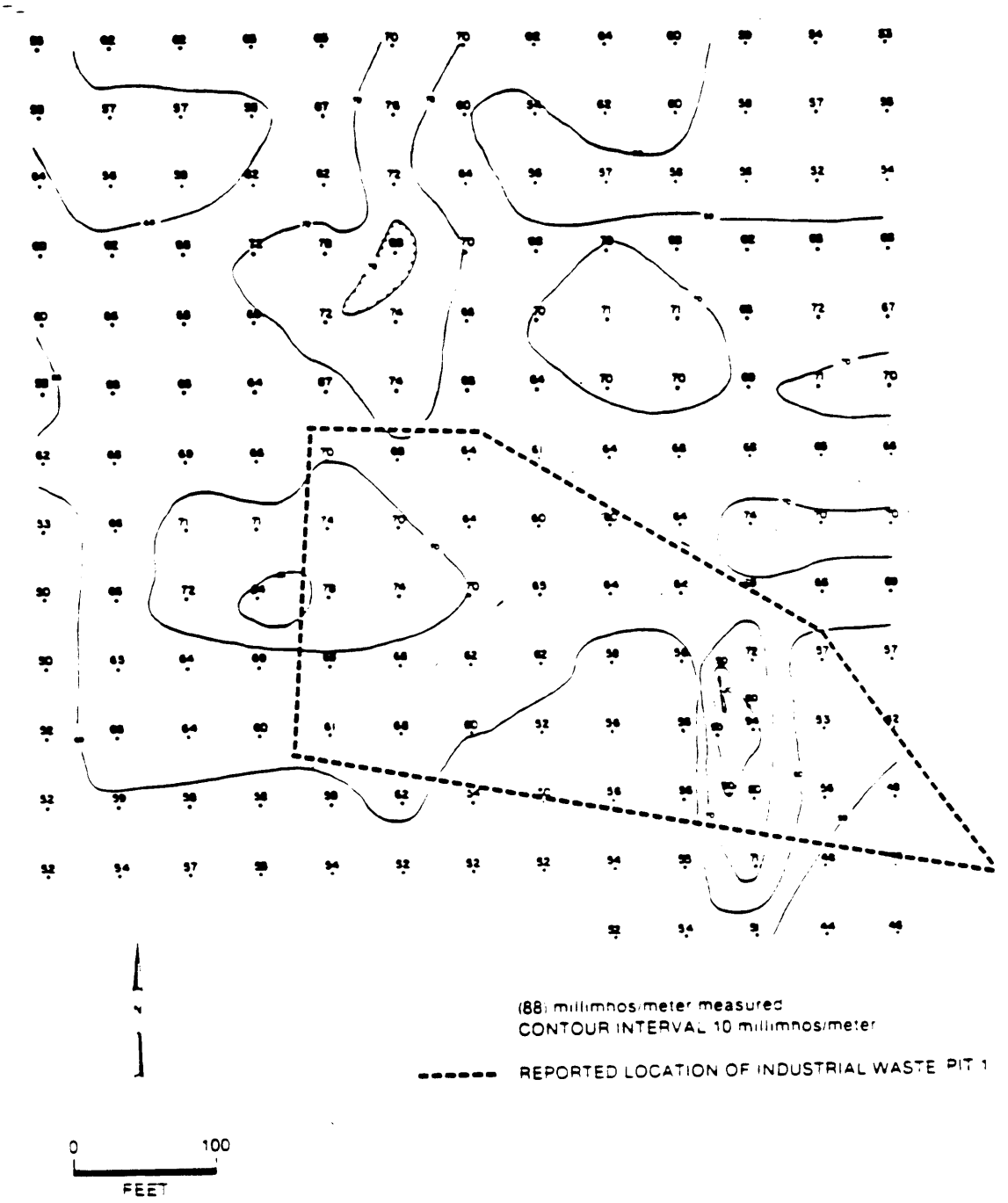

Figure 4-9. Geophysical Survey Results, EM31, Zone 4, Tinker AFB.

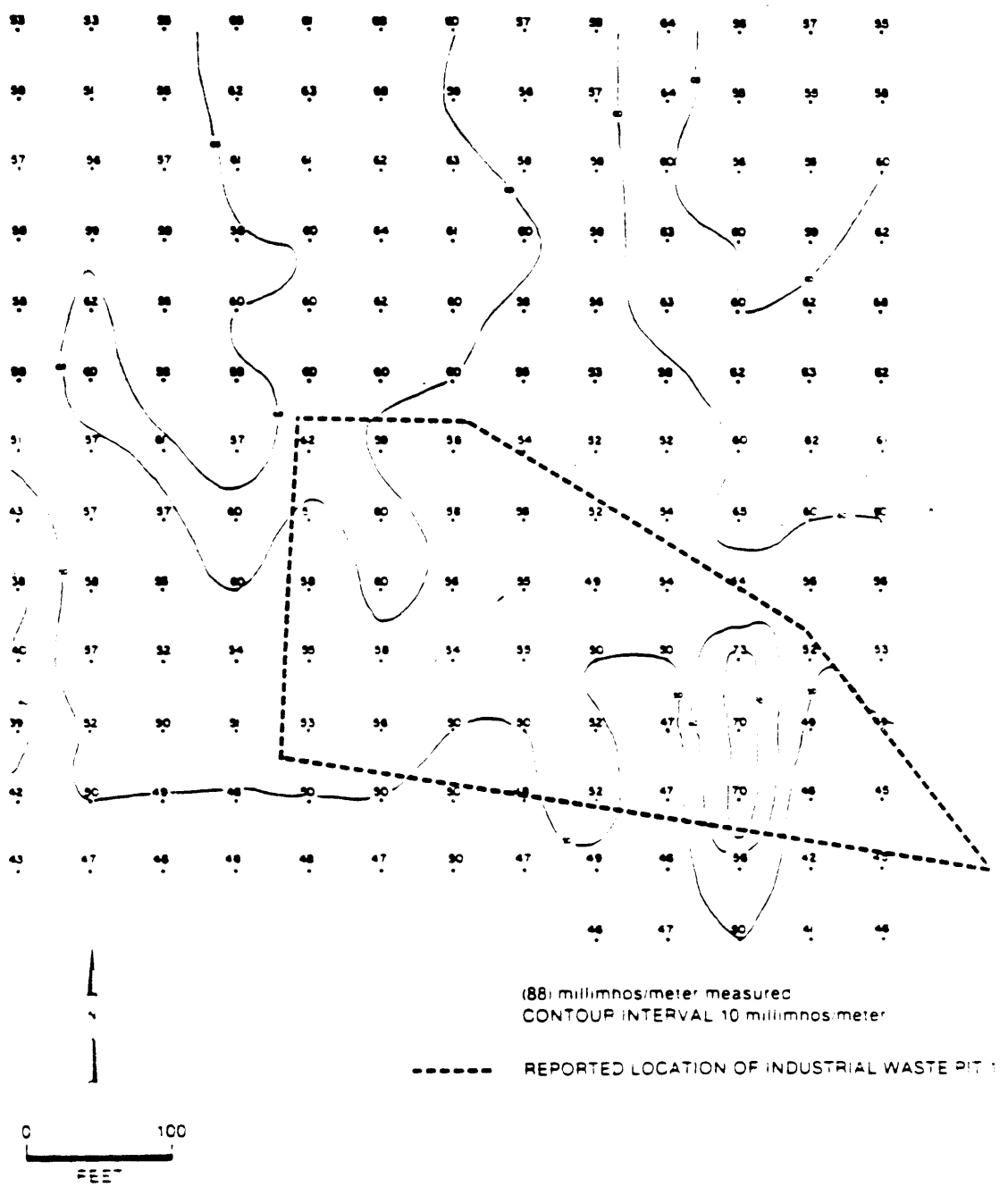

Figure 4-11. Geophysical Survey Results, EM34-3 (20m spacing), Zone 4, Tinker AFB.

Soil Chemistry and Ground-Water Quality

Split-spoon samples collected in the coring operations were retained and examined for evidence of contamination. Based on the apparent geometry of the pit, ten samples of soil were selected for detailed analysis, consisting of selected metals, total organic carbon, total organic halogen, and phenols. The samples selected for analysis were chosen such that the vertical and horizontal distribution of chemical species in geologic materials within and below the pit could be evaluated, as shown on Table 4-9. Based on the results of these analyses, one sample (chosen to be the sample with the highest level of total organic carbon) was resubmitted for modified EPA Method 625 analysis. Results of these analyses are provided on Table 4-10.

After installation, each of the monitor wells was sampled for chemical analysis. The results of the analyses are shown on Table 4-11. Samples were analyzed for acid/neutral extractable organic priority pollutants (modified EPA Method 625); only compounds detected are shown. Complete reports of all analyses are provided in Appendix H. These data are discussed in Section 4.3.

4.2.5 Zone 5 (Base Water Supply Wells)

Zone 5 consists of 27 Base Water Supply wells, as shown on Figure 4-12. Each of the 20 operational wells was sampled during 7-17 Februay 1984. Samples were submitted to the laboratory for screening analyses (Total Organic Carbon and EPA Method 601). Sampling results are shown on Tables 4-12 and 4-13. Based on the results of these tests, five samples were resubmitted for analysis by EPA Methods 624 (Volatile Organic Priority Pollutants by GC-MS) and modified 625 (Acid/Neutral Organic Priority Pollutants by GC-MS). No additional compounds were discovered by these analyses. Complete reports of results are contained in Appendix H. Of the 20 wells sampled, only six displayed any trace of chlorinated organic contaminants. Observations concerning the contamination in each well are provided in Section 4.3.

TABLE 4-10. RESULTS OF SOILS ANALYSES, ZONE 4, TINKER AFB

Parameter (µg/g, except as noted)	Soil Sample									
	4B.5	4B.6	4C.5	4D.2	4E.2	4E.3	4E.4	4E.5	4F.2	4F.3
Cadmium	<.21	<.20	1.7	17	1.7	340	<.20	1.5	2.7	5.0
Cyanide	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Chromium	4.9	8.5	11	42	9.1	78	5.6	6.3	230	32
Copper	4.2	7.1	8.5	16	15	47	3.8	9.2	24	9.7
Mercury	10	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
Nickel	3.0	11	8.3	11	14	39	5.4	9.6	22	8.0
Oil & Grease	780	410	290	206	1070	140	240	550	200	150
Lead	6.4	8.9	8.4	85	2.9	660	7.4	0.99	150	18
Phenol	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2
Total Organic Carbon (%)	0.12	0.10	0.08	0.15	0.10	0.13	0.10	0.12	0.08	0.05
Total Organic Halogen	0.20	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10	<.10
Zinc	5.3	9.4	7.4	57	14	1400	6.6	7.8	75	17
Acid/Neutral Extractable Organic Priority Pollutants (modified EPA Method 625)	-	-	-	-	-	None Detected	-	-	-	-

- = Not Analyzed.

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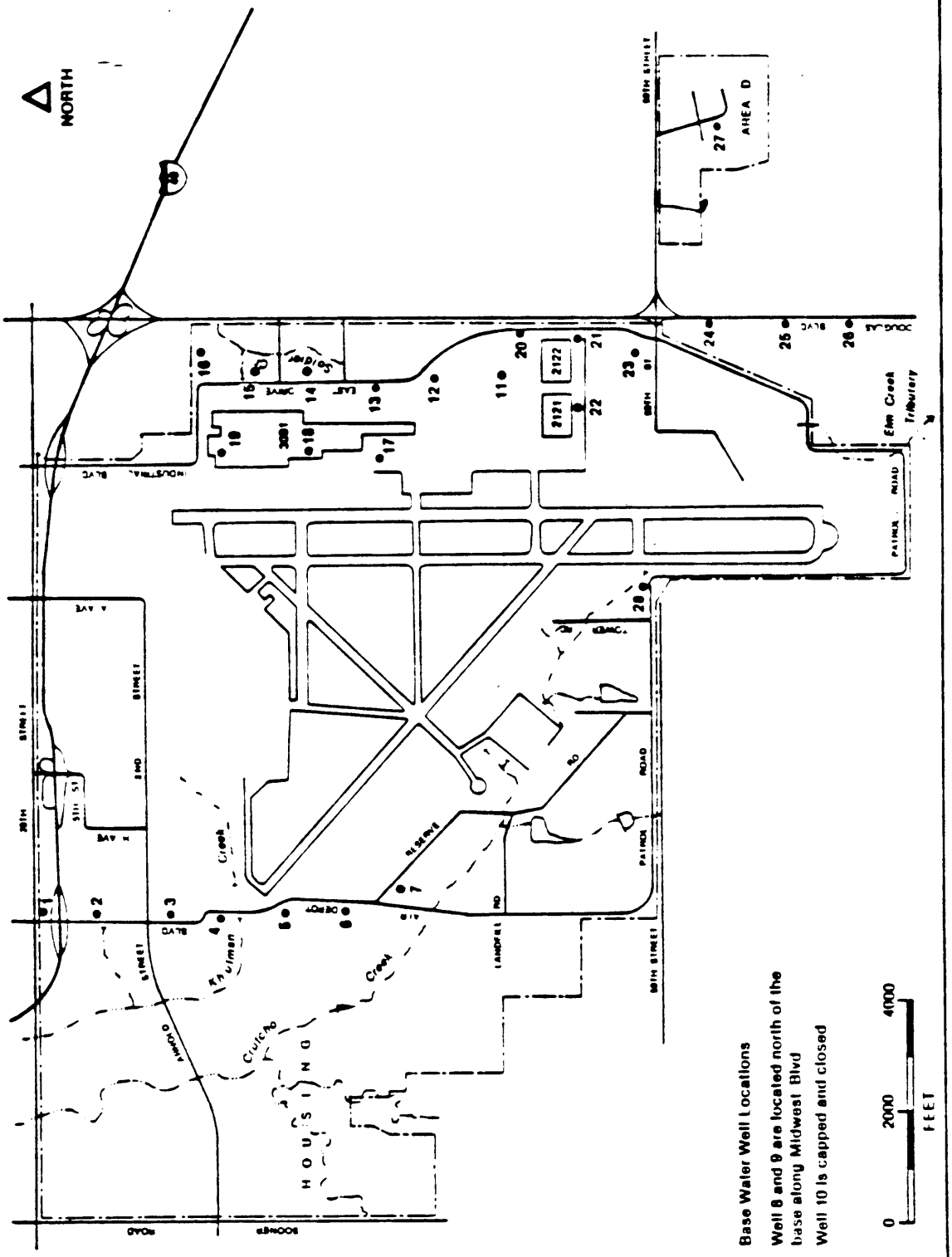

Figure 4-12. Location of Sampling Points, Zone 5 (Base Water Supply Wells).

TABLE 4-13. EPA METHOD 601 COMPOUNDE DETECTED IN BASE WATER SUPPLY WELLS (ZONE 5)

Compound (µg/L)	5	9	14	16	18	18 (resample)	19	19 (resample)
Methylene Chloride					1.1		0.6	
1,1-Dichloroethene					0.2			
1,1-Dichloroethane					1.4			
trans-1,2-Dichloroethene	1.7			1.2	31.7	32.8		
Chloroform		2.1						
1.2-Dichloroethane					25.8			
1,1,1-Trichloroethane					1.8			
Bromodichloromethane		0.4						
Trichloroethylene			0.7	2.2	1750	1530		
Tetrachloroethylene			0.3	0.7	30.1		7.8	2.8
Chlorobenzene					7.9			

TABLE 4-14. TRICHLOROETHYLENE CONCENTRATION DURING WELL 18 PUMP TEST

Sample Number T6-	Elapsed Time (hr:min)	Concentration (mg/L)
1	0:10	3.5
2	0:20	3.3
3	0:30	3.4
4	0:45	3.5
5	1:00	3.0
6	1:15	4.0
7	1:35	4.6
8	2:00	4.2
9	2:30	2.7
10	3:00	2.6
11	3:35	2.2
12	4:15	2.2
13	5:00	2.0
14	6:00	2.1
15	7:00	1.9
16	8:10	2.1
17	9:35	1.7
18	11:00	1.8
19	13:00	1.8
20	16:00	1.8

separate from that along the creek. The elevation of the water table in these three wells is about 1200 feet, compared to about 1215 to 1220 in wells 3, 4 and 5 along Crutcho Creek. Recharge from the shallow ground water to lower systems would be limited to permeable zones in the dominantly shale strata. The area of Zone 1 is a recharge zone, since piezometric heads decline with depth, as supported by the observation of the water level in core 1D, drilled to a depth of 150 feet (approximately elevation 1082). Three hours after drilling advanced to total depth, the water level was observed at 55 feet below the land surface, at approximately elevation 1183, some 20 feet below the level in wells 1A - 1C.

The measurement of water table elevation in Wells 1A - 1C allow determination of the direction of ground-water flow in the shallowest zones of the sandstone aquifer. Figure 4-14 shows the water table elevations in these three wells and the resultant inferred ground-water flow direction. Flow is to the southwest, in general agreement with the regional system (Figure 2-8). Note that this direction was derived from analytical geometry (three points define a plane in space), rather than from interpreted ground-water contours.

The analytical chemical data for Zone 1 show only limited impact of the landfills on ground-water quality. Of the three deep monitor wells, only the sample from Well 1A shows evidence of contaminant migration to deeper strata. While no human health standards or criteria are exceeded for the analyses performed, levels of total organic carbon (TOC, 5 mg/L), total organic halogen (TOX, 0.08 mg/L), iron (0.025 mg/L) and manganese (0.23 mg/L) are elevated relative to the other two deep wells. The concentration of manganese is also elevated in Well 1A relative to the secondary drinking water standard of 0.05 mg/L.

The State of Oklahoma analytical data (Appendix H) suggests the presence of volatile chlorinated organic compounds in Wells 1A (dichlorobenzene - 5 ppb) and 1C (trichloroethylene - 210 ppb and 1, 1, 2-trichloroethane - 6 ppb). The Phase II (Stage 1) study did not address these compounds. No volatile halocarbon analyses were performed. However, the

Phase II (Stage 1) analytical schedule does contain total organic halogen (TOX). This test is used as a screening parameter to test for the likely presence of chlorinated organic species. It is only a screening test, and should not be used for any final determination of the presence or absence of chlorinated compounds. It is subject to low bias due to loss of volatiles during transport and analysis and subject to high bias due to interference by inorganic chlorides. The nominal detection limit is 0.01 mg/L (10 ppb) of chlorine. TOX values reported for monitor wells 1A through 1C range from 0.06 to 0.08 mg/L (60-80 ppb), as chlorine. This is in rough correspondence with the State of Oklahoma GC-MS data, which show some volatile chlorinated organics in all three wells. In general, there is rough correspondence between TOX levels and the GC-MS data throughout the Base. In some cases, the TOX data suggest more chlorinated species were present than were found by the State of Oklahoma; in some cases, less. Additional sampling and analysis would be required to further address this issue.

Of the eight pre-existing monitor wells, only Wells 2 and 4 display contamination. Well 2 yields water with a TOC of 37 mg/L.; Well 4, water with TOC of 33 mg/L. and TOX of 0.2 mg/L. The concentration of manganese is also elevated in all shallow wells relative to the secondary drinking water standard of 0.05 mg/L. However, these data are at significant variance from the data obtained at the time the wells were drilled (Finn, 1981), when nearly all displayed large quantities of metals and TOC. Without knowledge of the conditions under which those samples were collected or the physical appearance of the samples, it is difficult to assess the cause of the difference between the two sample sets. The earlier data were collected in the fall, when leachate outflow from the landfills, rather than surface water recharge would have dominated the system. Perhaps the earlier samples merely came from a leachate-dominated system which does not persist year round. Periodic sampling over at least one full year would be required to assess the variability of the system. The State of Oklahoma data show volatile chlorinated organics in three of the six wells sampled. TOX is present in four of the eight wells.

permeable zones in the shale. A single data point is insufficient to determine a ground-water flow direction. Regional data (Figure 2-8) suggest a southerly flow at this point.

The analytical data do not provide evidence of significant contamination. No human health standards or criteria were exceeded. Monitor wells 6 through 8 display elevated manganese concentrations (relative to the secondary drinking water standard) and moderate (2 to 14 mg/L) levels of TOC. The deeper well (2B) displays TOC of 5 mg/L. The modified EPA Method 625 data also display a very low (3.2 ug/L) level of butyl benzyl phthalate, for which no human health or environmental criterion exists. Since the phthalate esters are nearly ubiquitous and are often an artifact of the analysis, detection of one at the low ppb level is probably not significant. The State of Okalahoma data (Appendix H) show appreciable levels of dichloroethene (385 ppb) and trichloroethylene (62 ppb) in existing well 6 and lesser quantities in well 7. No purgeable organic compounds were detected in Well 2B.

Landfill 6

Activities at Landfill 6 were limited to the installation and sampling of a single deep monitoring well (2A) south of the landfill. Pre-existing monitor wells 9 and 10, which were dry at the time of their installation (Finn, 1981), were not sampled. Ground water was encountered at a depth of approximately 36 feet below land surface, at approximately elevation 1259. Based on regional considerations, ground-water flow is to the south. The single data point of Well 2A is insufficient to establish local conditions.

The Phase II (Stage 1) analytical data do not provide evidence of ground-water contamination. No human health standards or criteria were exceeded. However, the State of Oklahoma data (Appendix H) report the presence of volatile chlorinated hydrocarbons (dichloroethane - 25 ppb; trichloroethylene - 30 ppb; tetrachloroethene - 12 ppb; and 1,1,1-trichloroethane - 4 ppb). These compounds were not addressed by the Phase II (Stage 1) study.

shows no evidence of contamination, whereas the well completed in the fill material (3G) shows material similar to that found in the soil cores at the site. Concentrations of Cd, Cr, Ni, Pb, Zn and phenol in Well 3G exceed human health standards or criteria. The wet chemistry phenol value of 80 mg/L is probably biased low, due to interferences with the colorometric procedure and the large dilutions required to bring the sample to within instrument range. The 220 mg/L GC-MS value is probably more accurate. The State of Oklahoma data (Appendix H) show large quantities of volatile organic contaminants in Well 3G, only. The TOX data show a similar pattern. The shallowest groundwater (that in the fill or the weathered zone near the surface) is either evaporating on a seasonal basis, or is moving downslope near the surface. The geophysical anomaly in the nearby gully (Figure 4-6) may be due to an overflow feature from the period of pit operation or to continued horizontal movement of leachate from the closed pit. The fact that a zone of near-background conductivity exists between the pit and the "overflow feature" suggests the former.

The results of the Phase II (Stage 1) investigation show a body of highly contaminated material occupying the site of the former waste pit. The geophysical results indicate that the constituents of this waste are not currently migrating away from the site. Provided that the surface is not disturbed or the effective surface drainage disrupted, it is unlikely that significant contaminant migration will occur.

4.3.4 Zone 4 (Industrial Waste Pit No. 1

The investigations at Zone 3 were designed to define the chemistry and geometry of the remains of Industrial Waste Pit No. 1. However, in contrast to conditions at Zone 3 (Industrial Waste Pit No. 2), the remains of the pit are very diffuse and not well defined. The various geophysical surveys show only one significant anomaly, with the balance of the area occupied with materials near or only slightly above background conductivity. The coring results show the waste materials to be shallow and more thoroughly mixed with soil. On the basis of available data, no reliable estimate can be made of the total volume of materials present.

4.3.5 Zone 5 (Base Water Supply Wells)

Pump samples were collected from the 20 operational Base water supply wells (out of a total of 27 existing wells). Of the 20 wells sampled, only six displayed any trace of chlorinated organic contaminants. Observations concerning the contamination in each well are provided below.

Well 9, located north of the base along Midwest Boulevard, had not been in service for over six months when sampled. It could be pumped for only five minutes, so the sample represents an inadequately purged, stagnant system. At the present time, very little can be said concerning the occurrence of the chlorinated hydrocarbons in this well. The concentration of chloroform (2.1 ug/L) does exceed the EPA toxicity criterion of 1.9 ug/L (Table 4-2). Until the well can be adequately purged, no further diagnostic testng can occur. The maintenance records should be flagged for resampling when the well is brought back on line.

Well 5, located in the western portion of the Base, is not associated with any obvious contaminant source; it is approximately 2,000 feet north of Landfill 1, the closest waste disposal area. The reported occurrence of a single chlorinated organic compound at (trans-1,2-dichloroethene) at a low level (1.7 ppb) is probably not significant. Further, there has been no toxicity guideline established for trans-1,2-dichloroethene (Table 4-1). This well should be resampled during a future activity.

Wells 14, 16, 18 and 19 are all in the vicinity of the Oklahoma City Air Logistic Center (Building 3001). Results of analyses are discussed in the context of Zone 6 (Building 3001 wells) in Section 4.3.6, below. Wells 18 and 19 are the specific object of study at Zone 6; Wells 14 and 16 are located east and northeast of the facility. It is noteworthy that none of the other wells in this area display any contamination.

With the exception of wells in the vicinity of Building 3001, all Base water supply wells appear to be substantially unaffected by contaminant migration from Base waste disposal sites.

5.0 ALTERNATIVE MEASURES

This section discusses the alternative measures available for actions at each of the zones investigated. As was discussed in the introductory material in Section 4.0, the occurrence of contaminants is significant primarily within the context of threats to a receptor. Alternative measures are considered as they relate to evaluating issues of exposure to candidate receptors. The prime receptors to be considered are the regional Garber-Wellington aquifer, a major water supply source, and the installation boundary, a de-facto receptor. All zones (Figure 5-1) have the potential to impact the Garber-Wellington. Zones 2 (Landfill 6) and 6 (Building 3001) have the potential to impact the installation boundary. The categories of measures to be considered include:

- Continued monitoring of existing wells;
- Installation of additional monitoring wells;
- Initiation of other sampling; and
- No further activities.

5.1 Volatile Hydrocarbon Sampling and Analysis

The Oklahoma State Deparment of Health split samples with the Radian team for much of the monitor well sampling effort. The state samples were analyzed for volatile organic by GC-MS, an analytical procedure not addressed in the Phase II (Stage 1) Statement of Work, other than for selected Base water supply wells. Significant quantities of chlorinated hydrocarbons (dominantly solvents) were discovered in several portions of the Base. Since the occurrence of chlorinated organic compounds in the ground water at the Base is an important discovery, and since all of these analyses were done by GS-MS, a semi-quantitative method, it is appropriate to verify the observations by resampling and analysis by gas chromatography, a more accurate method of quantitation. The available alternative measures are:

- Accept the State sampling data without comment or followup.

- Repeat the State sampling and analysis, utilizing the same procedures (GC-MS). This would provide an independent verification of the State data.

- Repeat the State sampling, but with analysis by GC (EPA Methods 601 and 602). This would combine an independent verification with more accurate quantitation.

Radian recommends resampling all wells for volatile organic compounds, with analysis by gas chromatography (EPA Methods 601 and 602 with provision for double columns). The following discussions of data needs at each zone presuppose the recommended resampling.

5.2 Zone 1 (Landfills 1 through 4)

Knowledge of ground-water flow conditions at Zone 1 is adequate to define the environmental impacts of the landfills. However, the chemical quality of ground water sampled by the existing monitor wells along Crutcho Creek is not sufficiently well described. The differences between observations at the time of drilling (Fall of 1981) and at the time of the Phase II (Stage 1) effort are large and need explanation. The most plausible explanation is that of seasonal variation in ground-water quality. The available alternative measures are:

- Consider that the original samples represented a period of the year when leachate dominated the shallow ground-water system and that the Phase II (Stage 1) samples represented a period when bank storage (recharge from the stream) dominated the system. Assume that the two samples describe the extremes of the system and interpret ground-water impacts accordingly.

5.4 Zone 3 (Industrial Waste Pit No. 2)

The existing hydrogeologic and chemical data are sufficient to describe current conditions and to evaluate the probable environmental effects of the pit. Therefore, no additional work need be planned for this Zone. Provided the existing land use and cover are maintained, no changes in impacts are anticipated.

5.5 Zone 4 (Industrial Waste Pit No. 1)

The existing hydrogeologic and chemical data are sufficient to describe current conditions and to evaluate the probable environmental effects of the pit. Therefore, no additional work need be planned for this Zone. With the exception of one small area, there appear to be very few traces remaining of this facility.

5.6 Zone 5 (Base Water Supply Wells)

With the exception of wells in the vicinity of Building 3001, discussed below, all the Base water supply wells appear to be substantially unaffected by USAF waste disposal activities. With this finding, no further IRP-related activities are contemplated. However, the occurrence of volatile chlorinated hydrocarbons has been documented at the Base. Therefore, some consideration should be given to establishing an ongoing Air Force sampling program with analysis by EPA Method 601, as part of the normal drinking water surveillance activities. For most wells, annual sampling and analysis is appropriate. For wells adjacent to "problem areas" such as Building 3001, semi-annual sampling is appropriate.

5.7 Zone 6 (Building 3001 Wells)

Hydrogeologic conditions and chemical contaminant occurrence in the vicinity of Building 3001 are not well known at the present time. Substantial quantities of TCE are known to exist in Well 18, along with lesser quantities

6.0 RECOMMENDATIONS

This section contains the Phase II IRP recommendations for further actions on Tinker AFB. The recommendations are listed below in order of priority with the most important activity first. The selection and prioritization criteria are:

- Resolution of issues concerning possible receptors; and
- Resolution of issues concerning contaminants of interest.

Specific recommendations are as follows:

1. Investigate hydrogeologic conditions and contaminant occurrence in the vicinity of Building 3001, as provided in Stage 2.

2. Investigate hydrogeologic conditions and contaminant occurrence in the vicinity of Landfill 6, as provided in Stage 2.

3. Investigate the occurrence of volatile halocarbons and aromatics in all monitor wells by resampling and analysis by EPA Methods 601 and 602.

4. Investigate the seasonal variations in water quality in the existing monitor wells along Crutcho Creek by conducting a quarterly sampling program for a period of one year. Analysis should be for total organic carbon, total organic halogen, and the metals on the parameter list in the current Statement of Work: Fe, Mn, Cd, Cr, Ni, Cu, Zn, Pb and Hg.

Reference #5
"Building 3001: Buried Pit and Tank Survey." Radian Corp.
31 Aug. 1984

RADIAN
CORPORATION

212-027-21

7 September 1984

CPT Robert W. Bauer
USAF OEHL/TS
Brooks AFB, Texas 78235

REF: USAF/RC Contract F33615-83-D-4001, Delivery Order 0021,
Tinker AFB IRP Phase II Stage 2

Dear CPT Bauer:

Enclosed is an informal report of the Buried Pit and Tank Survey (Task 1) for reference Delivery Order. This material will all be included in the final report of activities.

Please call me if you have any questions.

Sincerely,

William M. Little

William M. Little
Project Director

WML:sg
cc: (w/Encl.)
COL Russell, HQ, AFLC
CPT Cornell, Tinker AFB

8501 Mo-Pac Blvd. / P.O. Box 9948 / Austin, Texas 78766 / (512)454-4797

RADIAN
CORPORATION

212-027-21-11

31 August 1984

M E M O R A N D U M

TO: Distribution

FROM: Robert Wallace

SUBJECT: USAF Contract F33615-83-D-4001, Delivery Order 0021, Building 3001: Buried Pit and Tank Survey, Tinker AFB

1.0 INTRODUCTION

Field activities for this survey were conducted 18-22 June 1984 at Tinker Air Force Base. The objective of this task is to inventory past and present industrial operations in the Building 3001 area to locate any buried pits or tanks. The primary focus is to identify possible causes or potential contributors to the trichloroethylene contamination of the Bldg. 3001 water supply wells. These water supply wells are located within the building on the western wall (well #18) and near the northern wall (well #19) of Bldg. 3001. This contamination is the subject of ongoing geohydrologic investigations under the Phase II of the USAF Installation Restoration Program (IRP). The data available to date suggest that the contamination is localized and that its source is nearby. This survey included the following activities:

- A review of available Tinker AFB records;
- Interviews with appropriate Tinker AFB personnel; and
- A detailed surface inspection tour.

No tanks or pits were entered or sampled during this effort. The survey was conducted by Robert Wallace of Radian Corporation. Section 2.0 provides some general background information on the present and historical industrial operations within the Bldg. 3001 area. Section 3.0 describes the activities performed under this task and Section 4.0 summarizes the results and the significance of the findings. Section 5.0 discusses alternative measures available to complete this effort and Section 6.0 provides recommendations.

2.0 ENVIRONMENTAL SETTING

Bldg. 3001 houses numerous maintenance and repair activities and shops which support the mission of the Oklahoma City Air Logistic Center. This command operates an overhaul and modification complex engaged in repairing and upgrading aircraft including a vast quantity of engines and many thousands of accessory items. Industrial operations within the Bldg. 3001 area encompass a variety of repair and maintenance facilities which include:

- Disassembly, cleaning, and inspection of aircraft systems and components;
- Plating, painting, heat treating, testing of metal parts and components;
- Accessory shops including electrical, valve and governor, gear box, tubing and cable, fuel controls, nozzles, pumps, bearings, and other specialized repair shops; and
- Assembly and testing and packaging of aircraft and aircraft components.

In addition, other functions housed within this or other nearby buildings include utility (water, power and steam production), administrative and engineering offices, parts and material storage, and others.

Construction of the Oklahoma Aircraft Assembly Plants (as the Bldg. 3001 complex was known originally) began in 1942. Since then it has been operated as an aircraft overhaul and repair facility, as it is today. Although the specific aircraft and associated engines have changed, in most cases the nature of the industrial repair functions pertinent to this investigation have remained basically the same.

Halogenated hydrocarbon solvents have been and continue to be used primarily for cleaning and degreasing of metal engine parts undergoing overhaul or repair. Trichloroethylene was the solvent of choice for most degreasing operations from the early 1940's until the early 1970's, when tetrachloroethylene began to be substituted because of its lower vapor pressure. As originally designed, degreasing operations took place in metal tanks set below the floor level in concrete pits. These pits ranged in depth from three to eight feet and in size from approximately 8x10 up to 30x90 feet. Coincident with the shift from trichloroethylene to tetrachloroethylene, these below-floor pits were closed (typically filled with sand and topped with a concrete cap) and replaced with specially designed degreasing machines (a complete system including all piping, tanks and pumps) which is above ground or floor level.

Changes in the layout and purpose of the repair shops in this complex have coincided with shift from reciprocating to jet engine repair and overhaul. These changes affected the nature and number of underground storage tanks in their Bldg. 3001 area. Most of the storage tanks were and are for use during testing of aircraft engines or components, or for fuel storage for the utility boilers and electrical generators. Also there are solvent (not halogenated) storage tanks for a variety of uses but mostly connected with aircraft surface painting and cleaning. As the function or location of various shops changed, tanks were added and old tanks were either relocated or abandoned. Storage tanks for aviation (high octane) gasoline were converted over to either kerosene type fuels used in jet engines or to solvent storage. Records and interviews at Tinker indicate a practice of "abandoning in place" old tanks which were either no longer needed or not functioning (leaking). This was accomplished by removing surface connections and filling with sand where possible.

3.0 FIELD PROGRAM

The efforts on this task included interviews with present and past Tinker AFB personnel. Those interviewed included the present base bioenvironmental engineer, the present base civil engineer, the present environmental engineer for the maintenance command within the Bldg. 3001 area, the present and former base fuel storage official, a former base bioenvironmental engineer (1950-1956, 1968-1971), and a former aircraft production branch chief who had served in the Bldg. 3001 (1942-1980).

Records that were reviewed for this task include the Tinker AFB OPLAN 19-2 (Oil, Hazardous Substance, and Hazardous Waste Spill Prevention, Control and Countermeasures), the Real Property Inventory Detail reports, Tinker AFB civil engineering drawings, and fuel oil storage records. OPLAN 19-2 provided a list of underground storage tanks in the Bldg. 3001 area which had been prepared from input from each activity which owned or used the underground storage tanks. The real property inventory detail report was useful because it also identified underground storage tanks both currently active and historically used and provided a means of tracking the disposition of older tanks. The civil engineering drawings provided specific locations and details on each underground storage tank which were currently installed and historically present. Also the original construction drawings of the Assembly Building (3001) indicated the location of degreasing pits beneath the floor. Fuel oil storage records going back to 1964 were available which indicated the type liquid hydrocarbons which were stored on base in bulk quantities.

A detailed surface inspection of the Bldg. 3001 area was made in conjunction with the environmental engineer from the repair or maintenance activity within the building. All currently active underground storage tanks were visually inspected. In addition evidence of inactive underground storage facilities or buried pits were noted during the inspection tour at locations indicated on the civil engineering drawings.

4.0 RESULTS AND FINDINGS

4.1 Buried Pits

Table 4-1 summarizes the locations of buried pits beneath Bldg. 3001 together with the visual observations and characteristics noted during the surface inspection tour and reference civil engineering drawing numbers for the precise location of the buried pits. The locations described in this task refer to the frame numbering and lettering system used within Bldg. 3001. As previously noted, these pits have all been covered or closed and no longer in use. Most were covered with a concrete cap. One pit was covered with an old wooden cover and was believed by the nearby shop personnel to be filled with water. Interviews with former base employees indicate that up to fourteen drums of trichloroethylene were used on average every day in these pits during the 1940's, 1950's and 1960's. A majority of this liquid was reportedly lost to evaporation during the degreasing process.

Disposal practices were not recorded in detail although in some cases engineering drawings are available which show that interconnections were provided to the below floor storm sewer system from these pits. Presumably, these inteconnections were designed for cooling water return or ease of cleaning of the degreasing pits following the removal of solvent sludges. However, the possibility that waste or spent solvents or sludges were periodically washed to the storm sewer system exists. Also it is hypothetically conceivable that condensation of trichloroethylene vapor on walls, floors, pipes, equipment and subsequent cleaning of these surfaces could have, over time, also washed trichloroethylene laden waters into the storm sewers (an industrial waste sewer system was extended to all the shops in the Bldg. 3001 during the early 1970's). Another possibility was that these degreasing tanks were leaking trichloroethylene through holes in the metal tanks or valves left open in the storm sewers. Pure or relatively concentrated trichloroethylene (and tetrachloroethylene) has been shown to leach or travel through very impermeable clay soils due to dehydration or chemical dessication of the clay lattices.

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TABLE 4-1. BURIED PITS BENEATH BUILDING 3001, TINKER AFB

Pit	Location	Purpose	Visible Evidence	Reference DWGS
1	81-91, P-W	Old plating shop below ground pit	None	DWG-3001-F-125, 124
2	106,K	Vapor degreaser	Concrete cap	DWG-3001-G-58, 59
3	107-103,G	Chemical cleaning pit, jet engine overhaul	Possible cement cover	Proj. No. OC-168-59 As-Built DWG, DTD 2/10/54
4	109-104, F-H	Vapor degreasing pit	Possible concrete cover, metal latch	DWG-3001-G-48
5	99,K	Pit with trenches	Trenches visible with poured-in concrete	—
6	91,L	Pit "B"	Pit cap visible	OCBA-F-63114-2
7	87,I	Pit "A"	Possible 2 pit caps	OCBA-F-63114-2
8	99,A	Pit "C"	Possible 2 pit caps	OCBA-F-63114-2
9	88-89, E-F	Pit "D"	8'x16' caps grouted with rubber trenches covered with metal plates	OCBA-F-63114-2
10	87,A	Pit "E"	Currently a foundation for a large lathe	OCBA-F-63114-2
11	77-78, F-E	Buried tank pit	No visible indications, new floor has been poured	DWG 3108-F-16-71
12	36,N	2 degreaser pits	Concrete caps visible	DWG 3001-C-44
13	56,M	Pit	Concrete cover visible	DWG 3001-D-12
14	43-42, N-O	2 degreaser pits	Pit covers visible	DWG 3001-C-44
15	51,Q	Degreaser pit	Wooden cover visible	Ref. DWG BC-U-D-22-4 (Sheet No. G-302)
16	37, S-T	Degreaser pit	Metal lined cap	"
17	North wall, Col. J	Slaked lime pit	None	BC-U-D-22-4 (Sheet No. G-303)
18	10,C	Pit covered with concrete	BCE bldg. foundations	"
19	97, F&H	King lathe foundation pits	Concrete cap	OCBA-F-63114-2

Table 4-2 provides the location of vapor degreasing machines currently in use in the Bldg. 3001 area. Spent solvents are currently drummed and sent to DPDO for disposal.

4.2 Buried Tanks

Table 4-3 is an inventory of abandoned or inactive buried or underground storage tanks in the Bldg. 3001 area which includes the location, capacity, purpose, reference drawing number, and any visible observations. This inventory was arrived at in the process of correlating information from the records reviewed for this task. As a by-product of that review, Tables 4-4, 4-5, 4-6 were prepared which are inventories of currently active underground storage facilities in the Bldg. 3001 area according to three different Air Force records: Tinker AFB OPLAN 19-2, Civil Engineering Drawing OCBA-K-1017-A (Building and Street Layout), and the USAF Real Property Inventory Detail Report. The fact that there are inconsistencies among these records is not surprising since they were prepared at different times by different people and for different purposes, none of which was specifically to inventory underground tanks. In addition, the presence of these tanks was noted in the surface inspection tour. The physical evidence of inactive tanks or tanks not listed on these records was typically the presence of a vent pipe or line which emerged from the ground and was completed with a characteristic u-type fitting at the top. The location of these inactive tanks could then be compared to the appropriate drawings to see if historically there had ever been a tank at that location. If there had and in almost all of the instances this was the case, then the real property records could be researched to see if and when the particular tank had been abandoned. Also, the real property records provided an indication of the purpose or use of the tank from which it was possible to deduce whether or not the tank may have been used to store trichloroethylene.

In no case was there a record or any evidence that an underground storage tank in the Bldg. 3001 area was designed or used for bulk storage of

TABLE 4-2. CURRENT VAPOR DEGREASER LOCATIONS, BLDG. 3001, TINKER AFB

Building	Location	Estimated Annual Quantity (gallons)	Solvent
3001	K106	3960	P
	M82	3960	P
	M82	3960	P
	L95	1650	P
	Q61	11,880	P
	Q61	3575	P
	M63	1045	P
	X65	1045	P
	X65	1045	P
	A76	3960	P
	Ka51.1	660	P
	059	1320	T
	N37	660	P
	U45	660	P
	X69	2860	P
	S54	225	P
3105		3960	P

T - Trichloroethane

P - Perchloroethylene

TABLE 4-3. ABANDONED OR UNUSED UNDERGROUND STORAGE TANKS IN THE BLDG. 3001 AREA

Tanks	Location	Capacity	Purpose	Former USAF Facility No. or DWG No.	Visible Inspection
1	NW Corner of Bldg. 3117	500 (est) waste oil tank	Tank was designed to store chemical spills inside Bldg. 3117. Chemicals are no longer stored in Bldg. 3117.	--	Free standing 4" PVC vent/fill pipe on west side of 3117.
2	SW Corner of Bldg. 3215	500 (est) gal. Reportedly now filled with water.	Tank was designed to store chemical spills inside the 3215. This building no longer used for chemical storage.	--	8" PVC vent pipe and access pit visible on south side of 3215.
3	SE Corner of Center Section of Bldg. 3108	500 gal. waste oil tank	Waste oil tank for the fuel testing system in the 3108 Hazardous Test Area.	USAF DWG No. 3108-F-16-53 Rev. B 1/18/56	2" steel vent pipe visible extending to roof.
4	South 6' and 2' east of the SW corner of Bldg. 3108	1000 gal.	JP-1 supply tank for engine accessories overhaul.	3108-F-16-81 relocation of engine accessories overhaul & testing Bldg. 2108. (Possibly Facility No. 3151, 3152, 3153, 3154).	Outline of concrete pump pit & cover. Vertical lines visible on SW corner of 3108.
5		1000 gal.	JP 1 return tank for engine accessories overhaul.		
6		1000 gal.	Naphtha supply tank for engine accessories overhaul.		
7		1000 gal.	Naphtha return tank.		

(Continued)

TABLE 4-3. (Continued)

Tanks	Location	Capacity	Purpose	Former USAF Facility No. or DWG No.	Visible Inspection
8	8' N of the SE corner of the North Addition of Bldg. 3108	500 gal.	Waste fill tank for shop A/C engine depot addition (relocated).	USAF DWG NO. 3108-13-25-176 Rev. 27 Jan 72. (Shop A/C Engine Depot Addn./Alt., Mechanical, plan of piping outside Bldg. addn.	2" vent line visible.
9	90' N of the SE corner of the North Addition of Bldg. 3108	1000 gal.	Waste oil tank for shop A/C Engine Depot addition.		2" vent line visible.
10	50' W of 215' N of SW corner of Bldg. 3108	3000 gal.	Motor pump and subsurface fuel tank adjacent to railroad tracks west of Bldg. 3108.	USAF DWG.No.OCBA-F-6152-1 dated 24 Jan 1961.	Motor pump and piping visible at surface.
11-17	60' W and 80' to 160' S of SW corner of Bldg. 3108.	2-9000 gal. 5-20,000 gal.	Originally Air Corps gasoline storage tanks, listed on real estate records as solvent tanks in late 1960's.	Formerly 3140, 3141, 3142, 3144, tank 5, 3146*, 3147* Abandoned in place in 1972.	None.
18	6' W and 180' S of SW corner of Bldg. 3108.	20,000 gal.	Originally a lubricating oil storage tank which was listed on real property records as being converted to solvent storage in the late 1960's.	Austin Co. DWG No. C-341, C-342. A.C. gasoline & lubricating oil system, layout & retail (12/30/42). Formerly 3145*. Abandoned in place in 1972.	None.
19-20	15' E and 15' S of the NE corner of the Paint Bldg. (Bldg. 3105).	2-1800 gal.	1-Naphtha tank 1-Stoddard solest tank Tank for Paint Bldg. (3105). Abandoned in place.	Formerly 3132, 3133. Austin Co. DWG. No. PB 302 Oct. 7, 1942.	Vent line visible.

* Shown on current USAF DWG OCBA-K-1017-A (Tinker AFB Building and Street layout).

TABLE 4-4. LIST OF ACTIVE UNDERGROUND STORAGE TANKS CARRIED ON USAF REAL PROPERTY INVENTORY DETAIL REPORT IN BLDG. 3001 AREA

Facility	Capacity	Type	Location	OPLAN 19-2	Building & Street Lay-out DWG
3001	20,000 gal.	Fuel Oil	S of Boiler House	Yes	Yes
3002	1,000 gal.	Diesel	"	No	Yes
3003	1,000 gal.	Diesel	S of Bldg. 3406 (3001G)	No	Yes
3010	28,000 gal.	AVGAS	W of Bldg. 3001 (Col 101)	Yes	Yes
3011	28,000 gal.	AVGAS	"	Yes	Yes
3012	25,000 gal.	AVGAS	"	Yes	Yes
3100	15,000 gal.	Misc. Stur	W of Bldg. 3108 (Bldg. 3001 Col. 56)	Yes	Yes
3104	15,000 gal.	"	"	Yes	Yes
3106	30,000 gal.	"	"	Yes	Yes
3130	12,000 gal.	Solvent	S of Bldg. 3108	Yes	Yes
3131	12,000 gal.	"	"	Yes	Yes
3401	20,000 gal.	Diesel	N of Bldg. 3001 (Row F)	Yes	Yes
3404	235,000 gal.	HTG Fule Oil	"	Yes	Yes
3405	13,500	MOGAS	"	Yes	Yes

TABLE 4-5. LIST OF ACTIVE UNDERGROUND STORAGE TANKS IN THE BLDG. 3001 AREA CONTAINED IN ATTACHMENT 1 TO APPENDIX 1 TO ANNEX A (INSPECTION REPORT) OF TAFB OPLAN 19-2, "OIL, HAZARDOUS SUBSTANCE, AND HAZARDOUS WASTE SPILL PREVENTION, CONTROL AND COUNTER MEASURES"

Facility or Bldg. No.	Capacity	Type of Storage	Location	OBG Symbol	OPLAN 19-2 Reference Page No.	Bldg. Street DWG	Real Property
3001	20,000 gal.	#2 Diesel Fuel	Boiler Plant	DEMMH	A-1-67	No	Yes
3001	2,500 gal.	Solvent Waste Dump	West of Bldg. 3001, G-50	MA	A-1-69	No	No
3001G	20,000 gal.	#2 Diesel Fuel	3001 G ASC Power Plant	1985 CS	A-1-71	No	No
3010	15,000 gal.	Jet Fuel	SW of NW Corner of Bldg. 3001	DSDP	A-1-72	Yes	Yes
3011	15,000 gal.	Jet Fuel	SW of NW Corner of Bldg. 3001	DSDP	A-1-72	Yes	Yes
3012	30,000 gal.	Jet Fuel	SW of NW Corner of Bldg. 3001	DSDP	A-1-72	Yes	Yes
3100	15,000 gal.	Type 2 Calibrating Fluid	W of Bldg. 3108	MA	A-1-73	Yes	Yes
3104	15,000 gal.	"	"	MA	A-1-74	Yes	Yes
3106	30,000 gal.	"	"	MA	A-1-75	Yes	Yes
3108	500 gal.	"	E of Bldg. 3108 (center)	MA	A-1-76	No	No
3108	1000 gal.	"	E of Bldg. 3108 (north)	MA	A-1-77	No	No
3130	12,000 gal.	PD680 Solvent	S of Bldg. 3108	DSDP	A-1-80	Yes	Yes
3131	12,000 gal.	"	"	DSDP	A-1-81	Yes	Yes
3401	20,000 gal.	Diesel Fuel	N of Bldg. 3001	DEMMH	A-1-85	Yes	Yes
3404	235,000 gal.	#2 Fuel Oil	N of Bldg. 3001	DEMMH	A-1-86	Yes	Yes
3405	13,500 gal.	87 Octane Automobile Gasoline	N of Bldg. 3001	DSDP	A-1-88	Yes	Yes

TABLE 4-6. LIST OF ACTIVE UNDERGROUND STORAGE TANKS IN THE BLDG. 3001 AREA SHOWN ON THE TINKER AIR FORCE BASE BUILDING AND STREET LAYOUT (DRAWING NUMBER OCBA-K-1017-A, GENERAL UPDATE 30 SEP 81)

Facility Number	Real Property	OPLAN 19-2
3003	Yes	No
3010	Yes	Yes
3011	Yes	Yes
3012	Yes	Yes
3017	Yes	No
3100	Yes	Yes
3104	Yes	Yes
3106	Yes	Yes
3130	Yes	Yes
3131	Yes	Yes
3145	Yes[1]	No
3146	Yes[1]	No
3147	Yes[1]	No
3401	Yes	Yes
3404	Yes	Yes
3405	Yes	Yes

[1]Real property records indicate that these tanks were abandoned in place.

trichloroethylene or other halogenated solvent. There was evidence that storage tanks were found to be leaking and that this was the primary reason that old storage tanks were abandoned. The tanks listed in Tables 4-4, 4-5, and 4-6 are known (by current TAFB personnel) to contain and have contained materials other than the solvents of interest. The abandoned tanks listed in Table 4-3 are unlikely but possible candidates for unauthorized storage or disposal of spent solvents or sludges.

4.3 Significance of the Findings

Figure 4-1 summarizes the locations of the buried pits and tanks relative to the location of wells 18 and 19 beneath the floor of Bldg 3001. Although each of the pits and tanks would be considered candidates for possible sources of contamination, the survey results suggest that the trichloroethylene contamination is most likely the result of past industrial operations which occurred in degreasing pits throughout Bldg 3001 and over a period of up to 30 years.

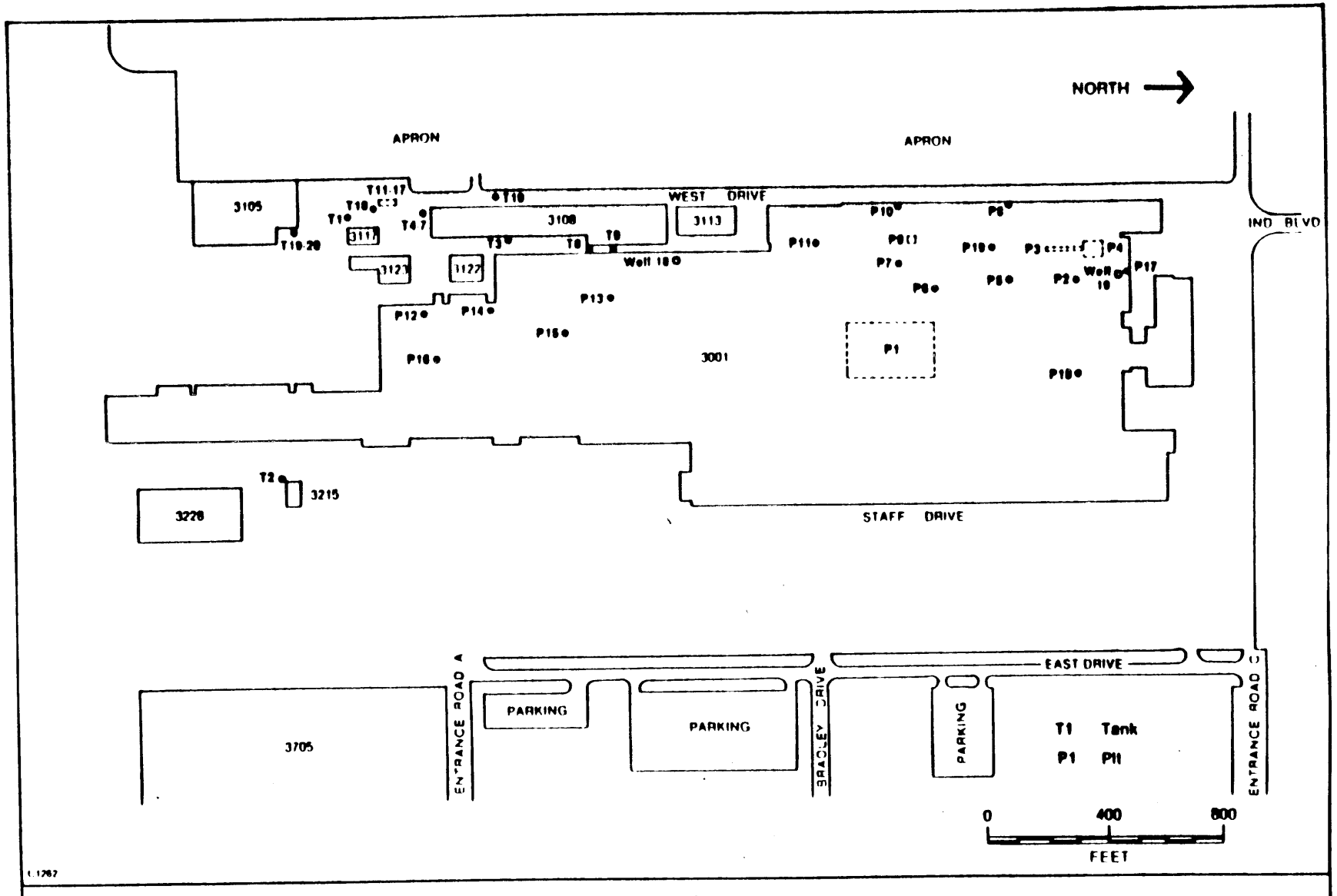


Figure 4-1. Locations of Buried Pits and Tanks Relative to Wells 18 and 19 in the Bldg. 3001 Area.

5.0 ALTERNATIVE MEASURES

This section discusses alternative measures available for actions relating to the buried pits and tanks in the Bldg. 3001 area.

The available measures relating to the buried pits beneath Bldg. 3001 are:

- Enter, inspect, and obtain samples for analysis of any liquid or fill material contained within each of the identified pits;
- Select one or two pits that can be easily entered for inspection/sampling; and
- No further activities.

Access to these buried pits will require either removal of the concrete cap (and temporary removal of any utilities or shop equipment which have subsequently been emplaced) or drilling one or more inspection ports through six inches of the concrete caps and possible coring through fill materials or depth-integrated sampling through any liquids to obtain a representative sample. Given the age of these pits and the length of time since their closure, it appears unlikely that much useful information can be gained from entering and sampling all of the pits identified. However, since these pits are known to have contained the solvents it would be of interest to verify the method of closure and the condition of the concrete subsurface flooring/storm sewer connections in at least one or two of these pits. Also, analysis of soil samples from below the pit floor would provide an indication of historical contamination if it exists.

The available alternative measures relating to the buried tanks in the Bldg. 3001 area are similar although in the case of the tanks there may be less difficulty in terms of access. In a majority of the cases, the tanks

identified were noticed by the presence of a vent tube or pipe which could provide access for the detection and sampling of any liquids remaining in the tanks. Access to those old tanks for which surface connections had been removed could be accomplished by coring either into the tank (filled with sand) or in the vicinity to obtain soil samples for analysis which would indicate the presence or extent of contamination from leaking tanks.

6.0 RECOMMENDATIONS

This section contains recommendations for further actions relating to the buried pits and tanks in the Bldg. 3001 area. The recommendations are listed below in order of priority with the most important activity first. The recommended actions are as follows:

1. Enter, inspect, and obtain samples from the contents and subsurface soils from selected pits buried beneath Bldg. 3001. Analyze samples for the presence of chlorinated solvents by EPA Method 601.

2. Obtain samples of any liquids from abandoned tanks buried in the vicinity of Bldg. 3001 where access is possible through vent pipes or surface connections. Analyze these samples for the presence of chlorinated solvents and hydrocarbon content.

Further, it is recommended that a general update or reconciliation of records concerning the size, location, use, and monitoring responsibilities for underground storage tanks containing hydrocarbons or other chemicals be conducted for all areas of Tinker AFB.

Reference #6
"Public Water Supply Report" for Midwest City and for Tinker AFB. 1982

Oklahoma State Department of Health
Environmental Health Services
State Environmental Laboratory
1000 N.E. Tenth
Oklahoma City, OK 73152

PUBLIC WATER SUPPLY REPORT

MAJOR
THROUGH
OTTAWA

1982

PUBLIC WATER SUPPLY REPORT

FACILITY: MIDWEST CITY

OPERATOR: MIDWEST CITY

ADDRESS: BOX 10570
MIDWEST CITY OK 73110

PHONE: 405 7322281

MSIS-NUMBER: 1020806

COUNTY: OKLAHOMA

POPULATION SERVED: 55400

SOURCE OF WATER:

	WELLS	LEGAL DESCRIPTION
THUNDERBIRD LK	00	SE1/4 SE1/4 NW1/4 S25 T09N R01W IM
GARBER-WELLING	32	S10 T11N R02W IM

Note: OSDH informed us that the computer cutoff point is 32 wells: wells beyond #32 will thus not be recorded by this report page.

STORAGE CAPACITY: 5900000 GALLONS

AVERAGE PRODUCTION: 4900000 GALLONS/DAY

PRODUCTION CAPACITY: 6000000 GALLONS/DAY

TREATMENT:

PERCHLORINATION	- YES
COAGULATION	- ALUM
SEDIMENTATION	- UPFLOW CLARIFIER
FILTRATION	- ANTHRACITE
CORROSION CONTROL	- LIME
TASTE/ODOR	- CARBON
DISINFECTION	- CHLORINE GAS

FACILITY: MIDWEST CITY

MSIS-NUMBER: 1020806

PARAMETERS	UNITS	1982	1981	----

FACIL TINKER AFB

OPERATOR. TINKER AFB

ADDRESS : 2854 ABGP/DE
TINKER AFB OK 73145

PHONE : 405 7327321

MSIS-NUMBER : 2005508

COUNTY : OKLAHOMA

POPULATION SERVED: 3320

SOURCE OF WATER:	WELLS	LEGAL DESCRIPTION		DEPTH
GARBER-WELLINGT	27	S23	R02W IM	0661-1256
OKLAHOMA CITY				

STORAGE CAPACITY : 17500000 GALLONS
AVERAGE PRODUCTION: 49000000 GALLONS/DAY

PRODUCTION CAPACITY: 95300000 GALLONS/DAY

Reference #7
"Inspection Report - Tinker Air Force Base." Oklahoma Water Resources, Water Quality Division. Dated June 19, 1984

JAMES R. BARNETT, Executive Director
MICHAEL R. MELTON, Assistant Director

OKLAHOMA WATER RESOURCES BOARD

P.O. BOX 53585 • 1000 N.E. 10TH STREET • OKLAHOMA CITY, OKLAHOMA 73152 • (405)271-2555

September 27, 1984

Mr. Roger Hartung (6W-E)
U.S. Environmental Protection Agency
Region VI
1201 Elm Street
Dallas, Texas 75270

Dear Mr. Hartung:

Enclosed is a copy of the Tinker Air Force Base state inspection report. We apologize for any inconvenience that we may have caused due to the lengthy report preparation. However, we feel that the quality of this report will speak for itself and is worth the delay.

If you have any questions regarding this report, please contact me or J. Fred Heitman at (405) 271-2541.

Sincerely,

Ron Jarman, Chief
Water Quality Division

RLJ:JFH:ft

Enclosure

GERALD E. BORELLI, Chairman
EARL WALKER, Vice-Chairman
L. L. MALES, Secretary

ERNEST R. "Jack" TUCKER, Member
BILL SECREST, Member
ROBERT S. KERR, JR., Member

R. G. JOHNSON, Member
RALPH G. McPHERSON, Member
GARY W. SMITH, Member

A-5

OKLAHOMA WATER RESOURCES
Water Quality Division

INSPECTION REPORT

REPORT DATE: June 19, 1984

PERMIT NO.: WD-79-031
Effective Date:
Expiration Date:

ENFORCEMENT:
( )New
(X)Scheduled (CEI; X CSI)
( )Complaint (No.)
( )Follow-up
( )Letter Follow-up
( )Other

FURTHER ACTION REQUIRED:
( )Enforcement; to:
(X)Permitting; to: NC Initial

PERMITTING:
( ) New ( ) Follow up
( ) Revision ( ) Other

INSPECTION DATE: April 17 thru 20, 1984
May 9 thru 11, 1984
June 11 thru 12, 1984

INSPECTORS: T. H. Maiello with J. J. Black and D. C. Schreiber

TITLE: Senior Environmental Specialist

INDUSTRY: Tinker Air Force Base TYPE: Federal, Aircraft repair & support AWACS

MAILING ADDRESS: Oklahoma City Air Logistics Center CITY: Oklahoma City

STATE: Oklahoma ZIP: 73145

PLANT LOCATION: N½ Section 21 and Sections 14, 15, 16, 22 and 23, Township 11N, Range 2WIM, Oklahoma County

GENERAL LOCATION: East of Sooner Road, South of SE 29th Street, North of SE 74th Street and West of Douglas Boulevard

COMPANY RESPONSIBLE OFFICIAL: Col. Ray D. Reaves TELEPHONE: (405) 734-2101

TITLE: Base Commander

FACILITY REPRESENTATIVE: Col. Danny Rivera TELEPHONE: (405) 734-3451

TITLE: Base Civil Engineer

OTHER REPRESENTATIVE: Bob Coleman TELEPHONE: (405) 734-3201

TITLE: Environmental Engineer

SUMMARY:

An extensive State inspection was performed of Tinker Air Force Base (TAFB) during April, May, and June, 1984. This followed an initial inspection which was an EPA NPDES Compliance Sampling Inspection. The state inspection was performed in response to a spill/complaint report and investigation (OWRB #WR-84-117) in February 1984.

TAFB consists primarily of three industrial/maintenance areas, each drained by separate watersheds. Area 1 contains Buildings 2280 and 2121, the 507th Squadron with various support facilities, the fire training pit, "South 40" storage, the 3rd Mobil Communication Group and support facilities, and on-base housing. The area is drained by Crutcho Creek and one of its tributaries. There are no industrial waste sewer lines in Area 1 leading to the industrial treatment plant. Area 2 contains base operations offices, various warehouses and distribution centers, the central AWACs command with maintenance and support facilities, flight control operations, and base personnel services. The area is drained by the headwaters of Kuhlman Creek, a tributary to Crutcho Creek. Area 3 contains the heavily industrialized facilities of Building 3001 and numerous support operations, the industrial and sewage waste treatment plants, the fuel unloading/distribution facility and various storage facilities. The area is drained by the headwaters of two unnamed tributaries to Soldier Creek: one drains the west side of Building 3001 and the other (commonly called East Soldier Creek) drains the east side of Building 3001 and other support and maintenance facility areas. Both tributaries flow to Soldier Creek which is a tributary of Crutcho Creek. All watersheds on TAFB ultimately flow to the North Canadian River north of Midwest City.

Legal descriptions of the watershed areas are listed below. All sections are in Township 11N and Range 2WIM (Figure 1).

Area 1 - Crutcho Creek watershed including: Sections 21 and 22; west 3/4 of Section 16; southwest ¼, northwest ¼ and west ½ of the southeast ¼ Section 23; and a majority of SW¼ of Section 14.

Area 2 - Kuhlman Creek watershed including: east ¼ of Section 16; and west ½ of northwest ¼ of Section 14.

Area 3 - East Soldier Creek watershed including: most of Section 14 except the NE¼ and the remainder of Section 23. The East Soldier Creek watershed includes all of Building 3001, the water treatment area and all permitted discharges Outfalls 001 through 005. East ½ of northwest ¼, southeast ¼ and a portion of the southwest ¼, Section 14; and northeast ¼ and the east ½ of southeast ¼ Section 23.

During this inspection a problem was encountered involving the organization of base personnel in responding to spills, improper waste discharge connections and other pollution problems. No single group or person has direct authority to correct or eliminate pollution problems. When more than one base group must be utilized for earth-work, blueprint verification, waste material disposal, or other corrective action, a long delay results due to administrative paper work channeling authority up and down a multitude of chains-of-command. Response time to pollution episodes often stretches into months or years resulting in continued contamination to state waters and frustration for both base personnel and environmental regulatory agencies.

The facility's blueprints were out of date and erroneous. Waste lines identified as "industrial waste" became storm sewers and/or storm sewers were connected to industrial waste process areas. Buildings constructed after the last blueprint update were connected to lines identified as "industrial waste" which were actually storm sewers. This constitutes a violation of OWRB Rules and Regulations 1045.11(c) in that the blueprints do not represent actual field conditions. The magnitude of this problem is enormous and can only be rectified by an intensive, thorough and inter-disciplinary survey of 1) all industrial sanitary and storm sewers; 2) all lift station hook-ups to verify proper industrial or storm sewer connections; and 3) all floor drain and in-building connections to discharge sewers to verify if the waste liquids are going to the industrial treatment plant or to the storm sewers.

Field investigation across a majority of the base revealed major problems including unpermitted discharges, toxic material discharges, current and past spill events, improper storage of hazardous or toxic materials, and base procedures resulting in potential or immediate contamination to waters of the state.

TAFB rests atop the Garber Wellington aquifer which is a primary water supply aquifer for central Oklahoma including all of Oklahoma and Cleveland Counties and portions of Logan, Lincoln and Pottawatomie Counties. Freshwater stored in this aquifer results from the continuous downward percolation of surface waters that have entered at its recharge area. TAFB lies directly over the known recharge area for the Garber Wellington aquifer. The facility is underlain by fine-grain sandstone irregularly interbedded with shale and siltstone which are outcrops of the aquifer itself. These outcrops provide a hydraulic connection between the aquifer and uncontained surface contamination sources as are described in the body of this report.[1]

The inspection began with a review of available blueprints of the industrial waste, sanitary waste and storm sewer lines utilized by TAFB personnel for waste disposal and determination of waste stream flow to the treatment facilities. The remainder of the inspection consisted of examining a majority of the facility's 5.6 square mile area. Key areas of concern were unpermitted discharges, waste disposal, chemical and hydrocarbon storage, and permit and application verification.

FINDINGS:

The following violations and/or problems were discovered:

A. Building 1030 - 507th Squadron (Inset 1):

1. An oil and grease trap discharges to the spill pond (photo 1). This discharge also violates Oklahoma Water Quality Standards (OWQS) 4.3(d) for the oil sheen present in the discharge.

2. Truck wash on the west side discharges to unknown location, possibly to the oil and grease trap in Building 1030. This may be a violation of OWRB Rule 1020.2(a).

[1] Johnson, K. S. 1983. Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahom. Groundwater Resources in Oklahoma, Oklahoma State Department of Health.

B. Building 1071 - Oil and grease trap discharges through manually operated valve on the north to a tributary of Crutcho Creek and then to the spill pond (photos 2 and 3)(Inset 1). This violates OWRB Rule 1020.2(a).

C. Spill Pond - (photo 4). The pond is actually a portion of Crutcho Creek which has been impounded to contain spills. Contained water is discharged either to Crutcho Creek through a valve or to the Del City sewage treatment plant through a manhole in the pond. The banks and substrate of the pond were black, supporting sparse vegetation and the pond surface had a visible oil sheen with standing white foam (The foam is described in item E.2. of Area 1). This pond receives discharge and runoff from Building 1071 oil and grease trap, fire training area, Tower Road 72" storm drains, Building 1030 oil and grease trap, "South 40" storage area, watershed area runoff, and possibly Building 1030 truck wash water. This is a violation of Board Rule 1020.2(a). The pond and its discharge also violate OWQS 4.3(d) for visible oil (Inset 1).

D. South Forty Storage:

1. Building 1123 (Inset 1) consists of a Quonset hut with a dirt floor equipped with concrete curbing and corner valves for stormwater release. The hut is used for temporary storage of barrels and small containers of various chemicals. Spillage was evident near stored trichloroethylene (TCE) barrels and in other locations inside the building. At the time of the inspection, a water main break was being repaired immediately adjacent to Building 1123. The leak had unknowingly existed for quite some time but was masked by the lack of surfacing water. This demonstrates the highly porous nature of the local soils and the danger of groundwater contamination as a result of spills in the hut and on adjacent surfaces. Additionally, the stormwater corner drain valves were open, defeating the purpose of the curbing. Generally, this area is not functional as a chemical control/storage area unless the surface soils are covered or sealed with an impermeable substance for groundwater protection. Storage of materials in this area violates OWRB Rule 1050.1 because the storage area is capable of causing pollution if accidentaly discharged. The pressence of spilled material in the storage area violates OWRB Rule 1050.3 for failing to immediately initiate and complete appropriate steps to contain and clean up the spilled material. The OWRB was neither immediately notified of the spills nor was written notification to the OWRB received within one week concerning these spills. This also violates OWRB Rule 1050.3.

2. The outside storage areas for chemicals in the vicinity of Building 1123 are not provided with curbing or impermeable surface to prevent runoff or groundwater contamination. This improper storage of materials violates OWRB Rule 1050.1.

3. An outside storage area consisting of a concrete, curbed containment structure, 30 yards northeast of Building 1123, is used for the storage of a variety of chemicals. This structure has an old, deteriorated asphalt floor and no valves in the concrete walls to allow controlled discharge of stormwater. Stormwater soaks into the ground or evaporates. Minor spillage in this area was evident during

the inspection. The storage of materials in this area violate OWRB Regulation 1050.1 because the deterioriated floor may allow any spillage to cause pollution. OWRB Rule 1050.3 was violated because proper spill clean up had not been initiated and the OWRB had not been notified of the spills.

E. 72" storm drain (discharge point) at north end of Tower Road (Inset 1).

1. Building 2280 is used for aircraft maintenance and has discharges similar to the other maintenace areas on the base (Figure 1). The discharges are evidently connected to storm sewers which flow beneath the runway to this discharge point. During this inspection a "sweet airplane glue" odor (aromatic hydrocarbons) was apparent and was emanating from the 72" storm drain. This umpermitted discharge violates OWRB Rule 1020.2(a).

2. In and around Buildings 2280 and 3102 (Figure 1), fire safety procedures involve the use of AFFF fire suppressant foam. During an emergency, a six foot wall of foam is sprayed across the hanger floor and adjacent taxiways. Such an emergency occurred on April 20, 1984 when an elecrical fire broke out in Building 3102. After use of the foam, the foam was apparently washed off the surfaces and into the storm drain. This foam is very persistent, as was evident during the inspection with foam still present in the 72" storm drain two weeks later (photo 5). Foam was also visible from this storm drain in and along Crutcho Creek to the outside of the spill pond containment dam (photo 4). This unpermitted discharge violates OWRB Rule 1020.2(a) and also violates OWQS 4.10(d) for foam on the waters of the state.

F. Two 72" storm sewers north of SE 59th Street and Midwest Boulevard (Figure 1).

Although no discharge was noted, storm drains from Buildings 2121, 2122 and 2101 discharge at this location. Any discharge from these buildings to these storm sewers would constitute a violation of OWRB Rule 1020.2(a). Blueprints showing industrial waste, sanitary sewage, and storm drains lines should be verified to confirm that only uncontaminated stormwater enters the storm drains. Vehicle maintenance and fuel storage in and around the buildings should be contained so that no spillage or unpermitted discharges occur.

G. Fire training area (Inset 1):

1. The fire training area was renovated after a July 19, 1981 state/NPDES inspection. Existing soil in the area, which was saturated with aviation fuel (JP-4), was removed to allow construction of a concrete collection system to stop discharges into Crutcho Creek. The soil was placed in two large piles that were still present during the current inspection (photos 6 and 7). JP-4 in the soil piles is possibly contaminating groundwater and surface stormwater which enters Crutcho Creek. This condition constitutes violations of OWQS 4.3(d) for oil and grease (petroleum related) discharge, OWRB Rule 1050.1 for an inadequate storage system, and 1020.2(a) unpermitted discharge.

2. The renovated fire training area consists of a gravel bed surrounded by a concrete trench which channels unburned JP-4 and contaminated fire water through a drain to an underground recovery tank. A slightly elevated berm surrounds the trench and bed to prevent fuel and fire water from running into Crutcho Creek. The recovery tank is approximately 25 yards east of the drainage basin on the perimeter of the fire training area. On April 20, 1984, a discharge of JP-4 from the recovery tank occurred through a vent pipe on the top of the tank. The tank contents were vacuumed at the request of state inspector Jerry Black. The discharged JP-4 was not removed or cleaned up (photos 8 and 9). Additionally, on April 20, 1984 the fire pit area discharged over the berm to Crutcho Creek. These incidents were neither reported nor were contaminants cleaned up which constitutes a violation of OWRB Rule 1045.11. The discharges violate OWRB Rule 1020.2(a), umpermitted discharge, and OWQS 4.3(d), petroleum related oil in waters of the state.

Area 2

A. Multiple storm drain basin at the headwaters of Kuhlman Creek located at the center of Section 5, Township 11N, Range 2WIM (Inset 2).

Continuous unpermitted discharges are flowing to this basin from 60" and 72" storm drains and into Kuhlman Creek. Origination of the 72" drain discharge could not be determined, but the 60" pipe discharge was identified as originating in Building 230. The discharge from this building was located in the storm drain north of Building 230 which discarges to Kuhlman Creek through the 60" pipe. Evidence of contamination in this discharge is present in the form of oil and solvents on the water surface and in the common basin for the three storm drains. This unpermitted discharge violates OWRB Regulation 1020.2(a).

An additional discharge into the 60" storm drain was discovered as a result of a complaint received on January 30, 1984 (OWRB #WR-84-117) which alledged that oil was being discharged to Kuhlman Creek from TAFB. Investigation on February 10, 1984 revealed lift station #3 on TAFB was discharging contaminated process water (OWRB #8621, Figure 1) to Kuhlman Creek through the above mentioned 60" storm sewer in this basin. The discharge violated Oklahoma Water Quality Standards 4.3(h) for chromium, copper, and oil and grease [4.3(d)]. This investigation led to the discovery of potential problems with lift stations on the base being designed to bypass wastes into the storm sewer in the event of breakdown of the lift stations or wastewater back-up in the individual sewer lines. Evidence of continued dischage of solvent and oil and grease was still present during a July 27, 1984 follow-up inspection by the OWRB. This discharge constitutes a violation of OWRB Regulation 1020.2(a) if intentional, 1045.9 if it constitutes a bypass, or 1045.1(d) if the discharge is accidental. In any event, appropriate agencies were not notified when base personnel became aware of the discharge which violates OWRB Regulation 1050.3.

B. Kuhlman Creek oil and grease trap (Inset 2) - An oil and grease trap is located adjacent to Kuhlman Creek (north side) south of the intersection of "L" Avenue and South Street. This trap receives water from Kuhlman

Creek below the industrial and storage areas in Area II. The trap contained copious amounts of oil and solvent at the time of the inspection. The discharge is not permitted and constitutes a violation of OWRB Regulation 1020.2(a0 and OWQS 4.3(d) for oil and grease.

C. Fuel storage tank discharges - Tanks 273, 274, 483, 484 (Inset 2) and tank 349 (Figure 1) feed fuel by gravity to underground tanks. Condensate and other water inside the tanks are discharged through an oil and grease separator to either the storm sewer or directly to Kuhlman Creek. The traps are not listed on the permit application, and the discharges are not permitted or sampled. This is a violation of OWRB Regulation 1020.2(a) for unpermitted discharge.

D. Cooling towers near Building 210 (Figure 1) are reported to be discharging to the sanitary sewer but this could not be verified by base personnel. These discharges may constitute a violation of OWRB Regulation 1020.2(a) for unpermitted discharge.

E. Storm lines connected to off-base drains or discharging off base (Figure 1). Based on the "Master Plan Storm Sewage System" blueprint, two stormwater lines have connections to off-base storage drains. One line extends north along Air Depot Boulevard and the other extends north of "F" Avenue from a wide spread area between 4th Street to I-40. These lines could be conduits for unpermitted discharges which would violate OWRB Regulation 1020.2(a).

Area 3

A. Building 3001 (Insets 3 and 4). An internal inspection of 3001 by Tinker personnel revealed 116 discharge connections to storm drains leading to waters of the state. None are permitted. These storm drain discharges violate OWRB Regulation 1020.2(a).

1. Westside - Discharge ditch parallel to Building 3001 receives cooling water at south end from permitted Outfall 004. Three pipes on the east side of ditch, originating within Building 3001, discharge into the ditch without a permit (photos 10, 11, 12 and 13). Sample analyses from the common discharge point at the north end of the ditch (photo 14) revealed high concentrations of tetrachloroethylene, chromium, and other volatile hydrocarbons (OWRB #8719 and #8727). This ditch discharges directly off base to an unnamed tributary of Soldier Creek. One line discharging to the ditch contained waste plastic bags originating from within Building 3001. The entire ditch contained an oil sheen as evidenced by stained banks (photos 15 and 16) and stains on a dual oil skimmer across the ditch (photo 17). These unpermitted discharges violate OWRB Regulation 1020.2(a) as well as OWQS 4.3(h) for toxic substances and chromium, and 4.3(d) for oil and grease.

2. Eastside -

a. North storm drain (30") has a constant clear water discharge. The appearace of fish, algae and lush vegetation and the sample analysis (OWRB #8712) indicate this discharge source could be a

drinking water line leak. Chromium at 56 ug/L was detected in this discharge. This unpermitted discharge violates OWRB Regulation 1020.2(a).

b. Middle storm drain (60") has a constant discharge which is reported by TAFB to be entirely composed of cooling water discharge monitored at Outfall 002. However, analysis (OWRB #8715), indicate additional sources discharge here. On May 3, 1984 inspectors discovered an estimated 15 gallons-per-minute discharge of purple water from this 60" storm drain (photos 18 and 19). This discharge had a pH of 12.5 S.U. and sample analysis revealed the presence of tetrachloroethylene at a concentration of 72.9 micrograms per liter (OWRB #8728). The source was determined to be a lift station which was erroneously connected to the storm sewer instead of the industrial waste sewer. Base personnel were unaware of the discharge but responded to the incident upon the inspectors request. The incident was not reported to appropriate state and federal agencies and a letter of explanation was not received by the OWRB which constitutes a violation of OWRB Regulation 1045.11(d). Sediments in the runoff path from this storm sewer discharge were black with oil and grease, violating OWRB Regulation 1025.13 for accumulation of deleterious substances in uncontained areas. The stream banks contained thick oil deposits up to 6" deep. When the drainage ditch substrate was stirred, a thick oil sheen appeared on the water's surface. Therefore, this discharge also violates OWQS 4.3(d) for oil and grease and 4.3(h) for toxic substances (tetrachloroethylene).

c. South storm drains (2x60") receive contaminated runoff and uncontrolled dumping of liquid wastes (paints, solvents, etc.) from inside and outside of the south end of Building 3001 and from the area south of the storm drain discharge point. Several outside storm drain grates were stained with paints, solvents, and oil and grease indicating improper disposal of waste materials from south of the 60" storm drains. A cooling tower, located on the south side of Building 3773, discharges to this storm sewer and is not described in the facility's permit application. The fuel receiving area, located east of Building 3211, had spillage around the piping system, and the sediments in the storm water ditch smelled of JP-4. Contaminated runoff from this ditch flows to the south storm drains. The areas were not cleaned up which constitutes a violation of OWRB Regulation 1025.13(a). Contaminated water from inside and outside of tanks 3716 and 3718 is discharged to the storm sewer. Storm drains on the south side of Building 3001 are located so as to receive wash water, condensate, and other wastes originating from maintenance and processes inside and outside of this end of Building 3001. These unpermitted discharges violate OWRB Regulations 1020.2(a) and 1025.13.

d. Underground tank 3405 (Inset 3) located on the north end of Building 3001 had a leak of motor vehicle gasoline of unknown quantity. The tank was emptied but not removed or filled with

inert material. The spilled gasoline was never quantified or cleaned up and the spill was never reported to appropriate agencies. This constitutes a violation of OWRB Rules, Regulations and Modes of Procedure 1045.11(d) for no clean up or reporting and OWQS 4.1(e) for petroleum related oil and grease in a location to contaminate a water supply.

B. Underground industrial waste line along outside of east side property line fence.

1. Concrete box access port to the industrial waste line north of 59th Street lift station contained wastewater with a metallic blue sheen (Photo 20). The liquid indicates the underground line is leaking. Dead vegetation on the surface along the industrial line also indicates line leakage (Photo 21).

2. Another concrete box access port to the industrial waste line near Gate 24 contained a valve with a discharge hose (Photo 22). Soil immediately adjacent to the concrete box was saturated with JP-4 fuel and a runoff track was evident leading to the barrow ditch and then to Soldier Creek (Photos 23 and 24). The runoff track was also saturated with JP-4 fuel. This situation constituted a spill event which was not reported or cleaned up and violates OWRB Regulation 1045.11(d).

II. SPCC and/or Storage Systems for Materials:

A. The following storage buildings, areas, or tanks are not listed on the facility's SPCC plan:

1. Buildings 1130, 1131, and 1132 in the "South 40" storage area.

2. Underground spill containment tank at northwest corner of Building 16.

3. Underground and above ground storage tanks around Building 1030; including "mo-gas" underground tank and outside barrel storage.

4. The spill pond north-northwest of Building 1030.

5. Underground retention tank at fire training pit for containment of JP-4 and contaminated water.

6. All outside storage in the "South 40" storage area.

7. Building 53 storage shed.

8. New above ground storage tanks at the AWACS alert facility.

9. Underground JP-4 transfer lines connecting fuel receiving area to above ground tanks located around the base, including lines to south side of base. Leaks are known to have occurred from the transfer lines with no cleanup and no listing of such spills in the plan. The lines were installed in the early 1960's.

B. The following storage buildings, areas, or tanks need to be modified or contained to protect surface and/or groundwaters of the state. The fate of spillage through floor drains, storm drains into the ground or to treatment systems must be certified. Descrepancies in proper and effective spill prevention and/or containment violated OWRB Regulation 1050.1 for inadequate storage systems for materials.

1. Verification of floor drains in Building 16 going to the outside underground storage tank.

2. Verification on the fate of floor drain in Building 212 surfuric acid tank containment structure.

3. Building 1123 (Quonset hut) is not constructed to prevent groundwater contamination and drain valves in curbing were open during inspection. Surface water contamination can result from precipitation events from spills which were evident inside the hut. Surface and groundwater contamination can occur because the curbing was constructed away from the hut roof, allowing rain water to enter inside the curbing. Storm water will inundate the hut floor and carry spilled material into groundwater and/or be discharged to surface waters when the valves are opened or left open.

4. North of Building 210, a storage building sits on concrete blocks with no curbing to contain or prevent a spill from reaching an adjacent storm drain.

5. Fenced storage north of Building 209 needs curbing to prevent spillage from reaching nearby storm drain.

6. Building 53 needs safeguards to prevent spillage from reaching storm drains.

7. Fire training pit retention tank needs safeguards to prevent overfill/spillage from occurring and to prevent such spillage from reaching Crutcho Creek.

8. Buildings 1130, 1131, and 1132 need safeguards to prevent internal spills from exiting the structures and contaminating nearby grounds and Crutcho Creek.

9. Sampling of spill pond sediments for toxics or hazardous wastes to determine if groundwater contamination is occurring. The pond may need to be dredged and lined.

10. Integrity test run on JP-4 transfer lines on a periodic and frequent basis.

11. All abandoned or leaking underground storage tanks which are leaking should be removed or emptied and filled with an inert substance.

C. Evaluation of SPCC Plan/storage systems for materials:

1. The OWRB is not listed on the SPCC plan for notification in the event of a spill and is not notified of spills which constitutes a violation of OWRB Rule 1045.11(d).

2. The plan appears to be excellent. However, the plan is not always followed. This was exemplified in the May 5, 1984 lift station discharge of "purple water" to East Soldier Creek. The discharge met all five TAFB Oplan 19-2 criteria for reportable spills and yet was not reported to appropriate state or federal agencies.

3. Need to update regional response telephone number which is (214) 767-2720.

4. Review of Site Inspection Reports contained in the SPCC plan (TAFB Oplan 19-2) revealed the following deficiencies which constitutes a violation of OWRB Rule 1050.1 and/or 1025.6 for the permitee's application:

   a. Buildings A01F & A01M & N - Need listing of types of pollutants stored, as none were listed, no volume listed and no attachment of list as cited by report.

   b. Building A16 - Identify the route that pollutants would flow in the event of a spill.

   c. Building 1123 (South 40 storage) - Need to seal bottom of outside dike area and install storm valve to discharge stormwater after sampling.

   d. Buildings 201, 209, 212, 2210, 2122 & 3117; portable tank on south end of Building 3108; Building 3703 "Syn-lub" oil and perchloroethylene tanks; 5728, 3750, open storage east of Building 3772 - Inspection report states, "There is no way to contain a spill." The recommended safeguards should be performed. See specific inspection sheet in TAFB Oplan 19-2.

   e. Buildings 214 & 2110 - Verify fate of a spill to floor drain as going to industrial sewer rather than storm sewer.

   f. Buildings 228 & 289, inspection report states, "There is no way to contain a spill of material stored outside." Proper containment should be provided to abate a spill. Also, determine fate of discharge from oil and grease separator to assure connection to industrial sewer instead of the storm sewer. Large tanks need dikes or berms capable of holding the contents of the single largest container within each containment structure.

   g. Storage tanks 273, 274, 349, 482, 483, 484 and 2108; Building 2121 tank; Building 3306 sulfuric acid tank; storage tanks 3732, 3735, 3716, 3718, 3730 & 3731 - Spills inside the dikes should

be cleaned up and contaminated soils removed and replaced. Contaminated stormwater must be sampled prior to discharge and the discharge must be permitted. Water from the inside of the tanks must be permitted and sampled prior to discharge. Periodic integrity tests must be performed on the tanks and piping to assure protection of groundwater.

h. All underground storage tanks and waste dump tanks, specifically tank 3405 - All underground tanks must be emptied in the event of a leak and the leaked or spilled materal cleaned up including soil removal and replacement. Periodic hydrostatic integrity tests must be performed to assure groundwater protection.

i. Building 1010 - Tank needs dike or berm capable of containing contents of tank. Contaminated gravel and soil should be removed in the event of a spill. Washrack drain should be verified to be connected to sanitary sewer since no industrial line runs to this portion of TAFB.

j. Building 1123 - Spilled material must be cleaned up including removal of contaminated soil. The curbing and quonset hut floor are inadequate for surface and groundwater protection and valves in the curbing were open during the inspection. The spilled material cannot be contained in dike area.

k. Building 2101 - Verify that floor drains go to industrial sewer or construct recommended structure rather than allowing waste to flow to storm sewer for spill containment.

l. Building 2112 - Spill containment structure should be constructed to abate spill from above-ground storage and during fuel unloading. Safeguards recommended in Oplan 19-2 inspection report should be followed.

m. Building 62516 Waste phenol, chromic acid, sulfuric acid and cyanide tanks - Verify integrity of plaster-lined tanks periodically to assure protection of groundwater.

5. Fuel jettison site - The TAFB OPlan 19-2 has a designated area for emergency fuel and/or fuel container jettison site to provide increased safety for emergency landings on base. The jettison site is located on the McClain-Cleveland County border, including the east half of Sections 1 and 12 in Township 19N and Range 4WIM in McClain County; and the west half of Sections 6 and 7 in Township 9N and Range 3WIM in Cleveland County. The Canadian River runs directly through the center of the designated site. Base personnel stated that at least two events have occurred involving fuel or container jettison since this area was designated. The events were not reported to state or federal environmental agencies and no attempt was made to determine the impact of the dumpings. Inquiries made to base personnel revealed that landowners in this area have not been informed that their property has been designated for emergency fuel

jettison. Inspection reports by state inspectors (NPDES inspections on January 14, 1982 and July 14, 1981) noted that no environmental assessment has been made as to fuel jettison impact on the site and that landowners had not been notified of their designation. Response from base personnel indicated that they were not required to assess the area or notify landowners but that notification should be done out of courtesy. Landowners have not been notified as of yet and an environmental impact assessment has not been performed.

RECOMMENDATIONS:

I. Organizational problems must be rectified to allow for efficient and timely handling of environmental incidents. It is recommended that one group of personnel be responsible for all environmental concerns. This groups should be endowed with the authority to activate the necessary personnel and equipment for proper environmental response. Any attempt to continue the current haphazard system, which does not allow personnel from different areas of command a direct line of authority or supervision, will undermine attempts to gain control of TAFB environmental problems. Significant reorganization of personnel and priorties is needed for TAFB to properly manage its environmental concerns.

II. Send Tinker Air Force Base a compliance letter requiring correction or verification of all the violations or potential problems found herein, not limited to the following:

A. Update facility industrial/sanitary/storm sewer blueprint by verifying that:

1. Lift stations are connected to industrial sewer and do not have bypass capability to storm sewer. If the lift stations have bypass capability for emergencies, alarms must be installed to notify appropriate personnel of the emergency discharge so sampling can be performed and discharge volumes calculated.

2. All floor drains are connected to industrial sewers, sanitary sewers or collection tanks. Those not so connected must be designated for outfall sampling or re-routed to appropriate industrial or sanitary sewer.

3. All discharges to industrial sewers are actually connected to industrial lines and not to storm sewers or sanitary sewers. Should connections lead to storm sewers, they should be re-routed to industrial or sanitary sewers or be identified for outfall designation and sampling. If the connections lead to the sanitary sewer instead of the industrial sewer, the discharge should be re-routed or identified as a contribution to the sanitary discharge on the permittee's application.

B. Update state application to include additional chemicals and compounds to be routed to the industrial and sewage treatment plants. Include expected volumes, concentrations and treatability of each compound or chemical and the expected discharge concentrations and loadings from each treatment

facility. Also, include industrial discharges which flow into the sewage treatment plant, i.e. cooling towers and truck washing. The updated application must meet the requirements of OWRB Rules, Regulations and Modes of Procedure 1025, especially 1025.6 for each operation on base. OWRB Rule 1025.6(b) must be addressed base wide and should include buildings used specifically for the storage of chemical compounds and raw materials.

C. Designate which unpermitted discharges which will not be re-routed so that outfall numbers and parameter discharge limits can be issued for each additional discharge. List pollutants, water treatment methods, and discharge loadings for each additional outfall.

D. Provide the OWRB with the total volume of additional loading(s) to industrial and/or sewage treatment plant as a result of re-routing unpermitted discharges.

E. Additional pollutants to be received by the treatment plants and the ability of the treatment plant to handle the additional waste compounds.

F. Collect representative sample sediments and/or water in the following locations for priority pollutants and heavy metals and submit to an OWRB certified laboratory for analysis. The analyses are to be submitted to the OWRB for environmental evaluation and possible corrective actions.

1. Area 1:

   a. spill pond;
   b. Crutcho Creek as it leaves the base;
   c. below 72" storm drain north end of Tower Road;
   d. floor of Building 1123 - composite of various spill material;
   e. substrate of concrete retainment area northeast of Building 1123; and

2. Area 2:

   a. Kuhlman Creek as it leaves base;
   b. below oil and grease trap discharge into Kuhlman Creek;
   c. above low water dam adjacent to oil and grease trap;
   d. common basin for 36", 72" and 60" storm drain north of tank 274 below discharges; and
   e. storm drain discharge from storm drain exiting base north of "F" Avenue. Sediments should be sampled at the discharge point off base.

3. Area 3:

   a. common discharge point on north end of storm ditch on west side of Building 3001;
   b. below Outfall 001;
   c. immediately above Outfall 005 from the bottom of the impounded water;
   d. in the oil skimmer basin above Outfall 002;
   e. above low water dam below 60" storm drain which discharges from Outfall 003; and
   f. above low water dam below 3 storm drains on south end (upper most) of East Soldier Creek.

G. Evaluate contamination of water and sediments in Crutcho Creek and unnamed tributary with head waters in Area 1, Kuhlman Creek, Soldier Creek, and related tributaries. Evaluation should include sample analyses for heavy metals and priority pollutants, both on base and downstream off base, representative of any contamination which has historically or is presently discharged from TAFB operations. Analytical results are to be submitted to the OWRB for environmental evaluation and possible corrective actions.

H. Provide the OWRB with all sample results from past and recent on-base sampling of waters and sediments. The information should specifically include results from Bio-monitoring personnel sampling including heavy metals and priority pollutants.

I. If base lab is to continue analytical capabilities for the purpose of the state permit, then Tinker is required to secure OWRB laboratory certification. If certification is not acquired, then TAFB must use a certified commercial lab.

J. Report all current and future spills which occur on base to the OWRB for logging and clean-up evaluation. Follow all steps in SPCC plan including clean-up and reporting procedures. All spills must be logged into SPCC plan.

K. Locate and remove, or fill all abandoned underground storage tanks with an inert material and remove soils contaminated by tank leakage.

L. Develop groundwater monitoring program to assess contamination arising from leakage in underground tank, chemical spillage, and creek bed contamination from unpermitted discharges. The program should specifically include the north and west sides of Building 3001, the fire training pit area, the spill pond, the low water dam in Kuhlman Creek and all underground storage tank areas. Any program should be approved by the OWRB prior to monitor well installation. This program should include the following information:

1. Report on specific past incidents of leaks or spills from underground tanks or lines and remedial action performed, to include tank 3405 and JP-4 across base transfer lines tanks.

2. Verify integrity of the following:

   a. JP-4 lines across base and clean-up areas of known leakage, past and present.

   b. All fuel transfer lines.

   c. All industrial sewage lines or provide records showing intergity tests, test methods used and frequency of tests.

This facility has approximately 2.4 million gallons of underground storage. Interviews with base personnel indicate that a majority of the underground storage tanks were installed in the 1940's. In order to assure protection for the groundwater of the state and to prevent loss of the product stored, reliable and accurate integrity tests should be performed periodically and with sufficient frequency to prevent groundwater and/or surface water contamination.

The inspector recommends that Tinker Air Force Base personnel provide the following information to allow assessment of potential and/or ongoing groundwater contamination:

1. Age and contents of each underground tank and the material of which the tank is constructed.

2. Age of all underground transfer lines.

3. Backfill material around each underground tank.

4. Type of corrosion protection or integrity protection for each underground tank or line.

5. Specific method and frequency of integrity testing for tanks and transfer lines.

6. Number and location of abandoned underground tanks.

7. Standard operating procedure for handling abandoned underground tanks.

Table 1. Tinker Air Force Base sample analyses from State/NPDES inspection by Oklahoma Water Resources Board, Spring 1984.[1]

OWRB #	DATE	SITE	TYPE	TOTAL CHROMIUM	TOTAL NICKEL	TOTAL COPPER	TOTAL ZINC (mg/L)	TOTAL LEAD	H-C	T-P	TCE[2]	DCE[3]	TTCE[4]	pH (s.u.)	OBSERVATION COMMENT
8719	4-18-84	NW	Grab	90	13	12	24	<20	<0.1	46	--	--	--	--	O/G sheen
8727	5-3-84	NW	Grab	--	--	--	--	--	--	--	4.6	24.7	64.6	--	O/G sheen
8717, 8716	4-17-84	SE	Grab	11	--	7	24	76	140	44	--	--	--	8.1	solvent sludge
8729	5-3-84	SE	Grab	--	--	--	--	--	--	--	--	--	27.0	--	solvent sludge
8715	4-17-84	mid-E	Grab	16	<10	72	45	20	<0.1	200	--	--	--	--	black
8728	5-3-84	mid-E	Grab	--	--	--	--	--	--	--	--	--	72.9	12.5	black
8712	4-17-84	NE	Grab	56	42	27	18	<20	--	10	--	--	--	--	--
8718	4-18-84	001	24-hr. comp.	286	329	13	8	<20	--	--	--	--	--	7.4	--
8710	4-17-84	001	Grab	515	476	20	158	--	--	1480	--	--	--	7.3	4000 ug/L Manganese purple
8621	2-13-84	Lift Stn #3	Grab	8620	--	320	133	<200	6.7	3140	--	--	--	7.3	O/G sheen solvent odor
8711	4-17-84	01s	Grab	--	--	--	--	--	--	8970	--	--	--	--	

[1] All units in micrograms per liter except where noted.
[2] Trichlorethglene.
[3] Tran ,2 Dichloroethylene.
[4] Tetrachloroethylene.

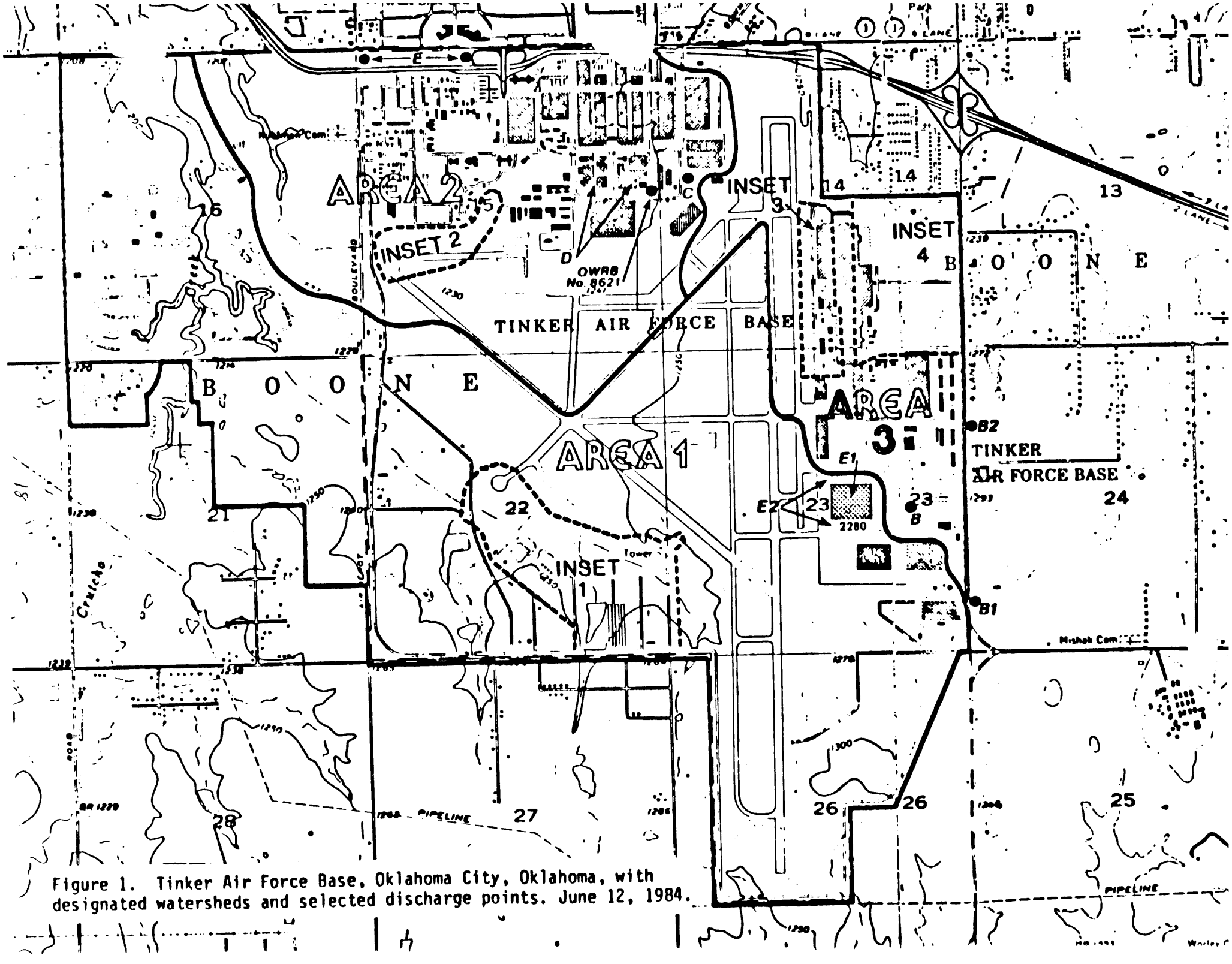
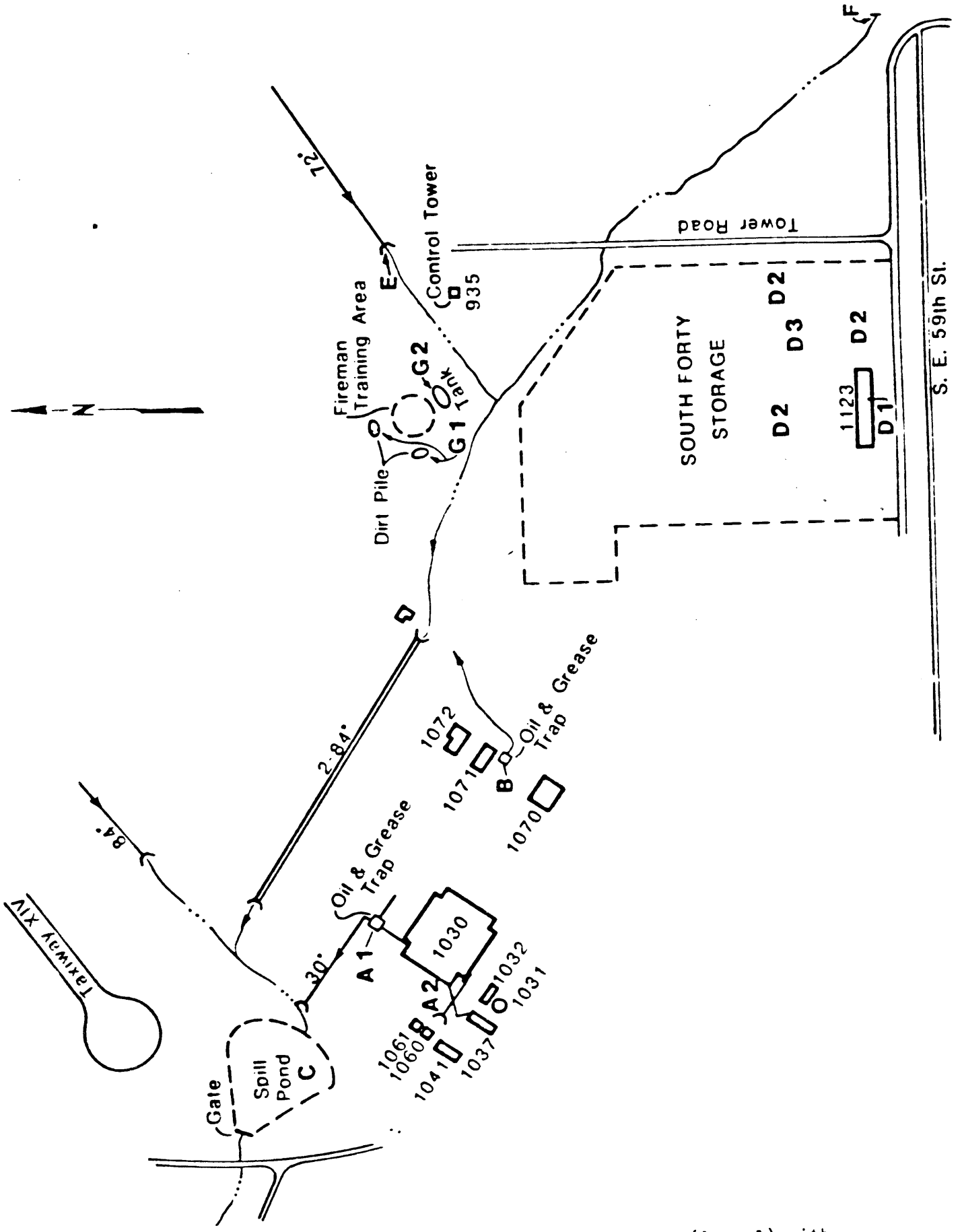
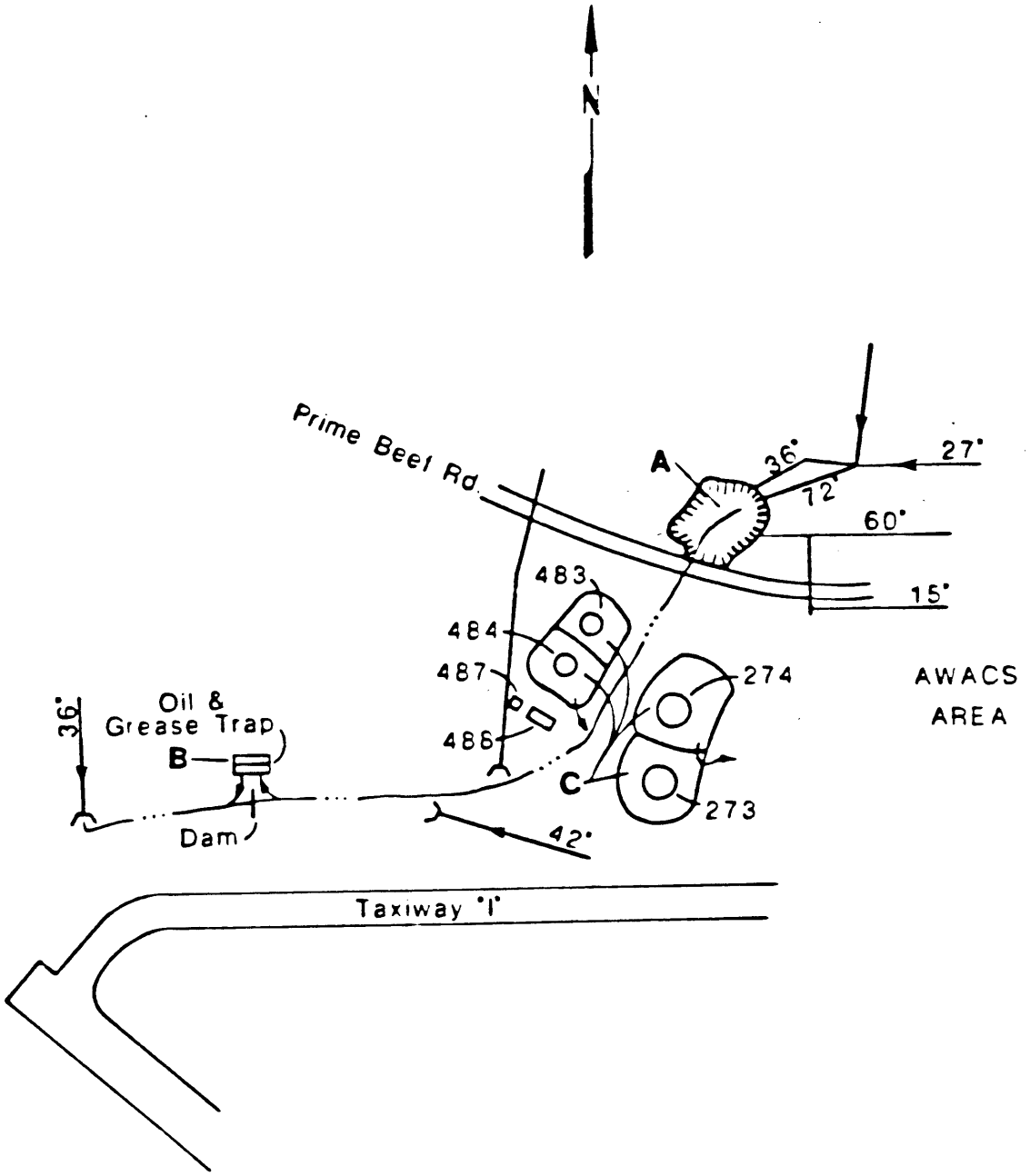


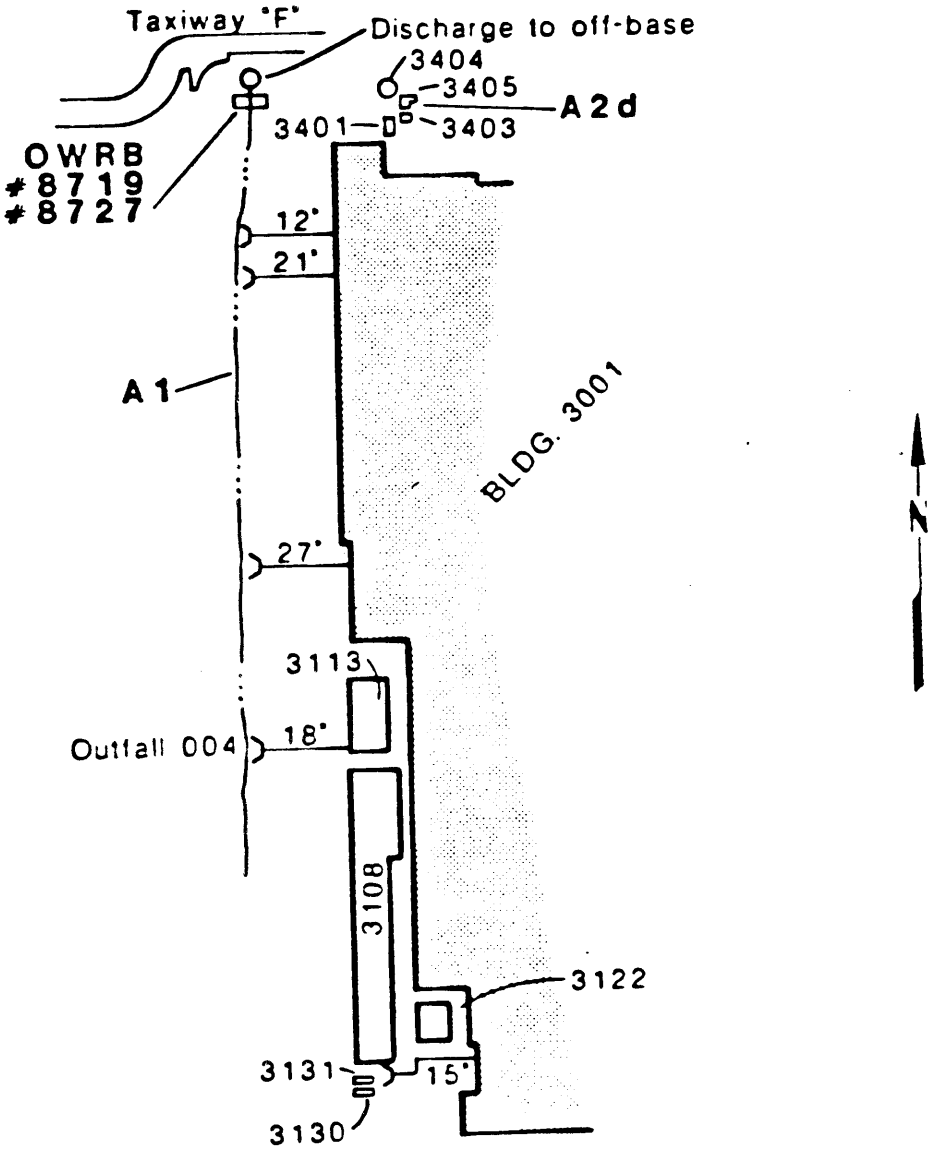
Figure 1. Tinker Air Force Base, Oklahoma City, Oklahoma, with designated watersheds and selected discharge points. June 12, 1984.



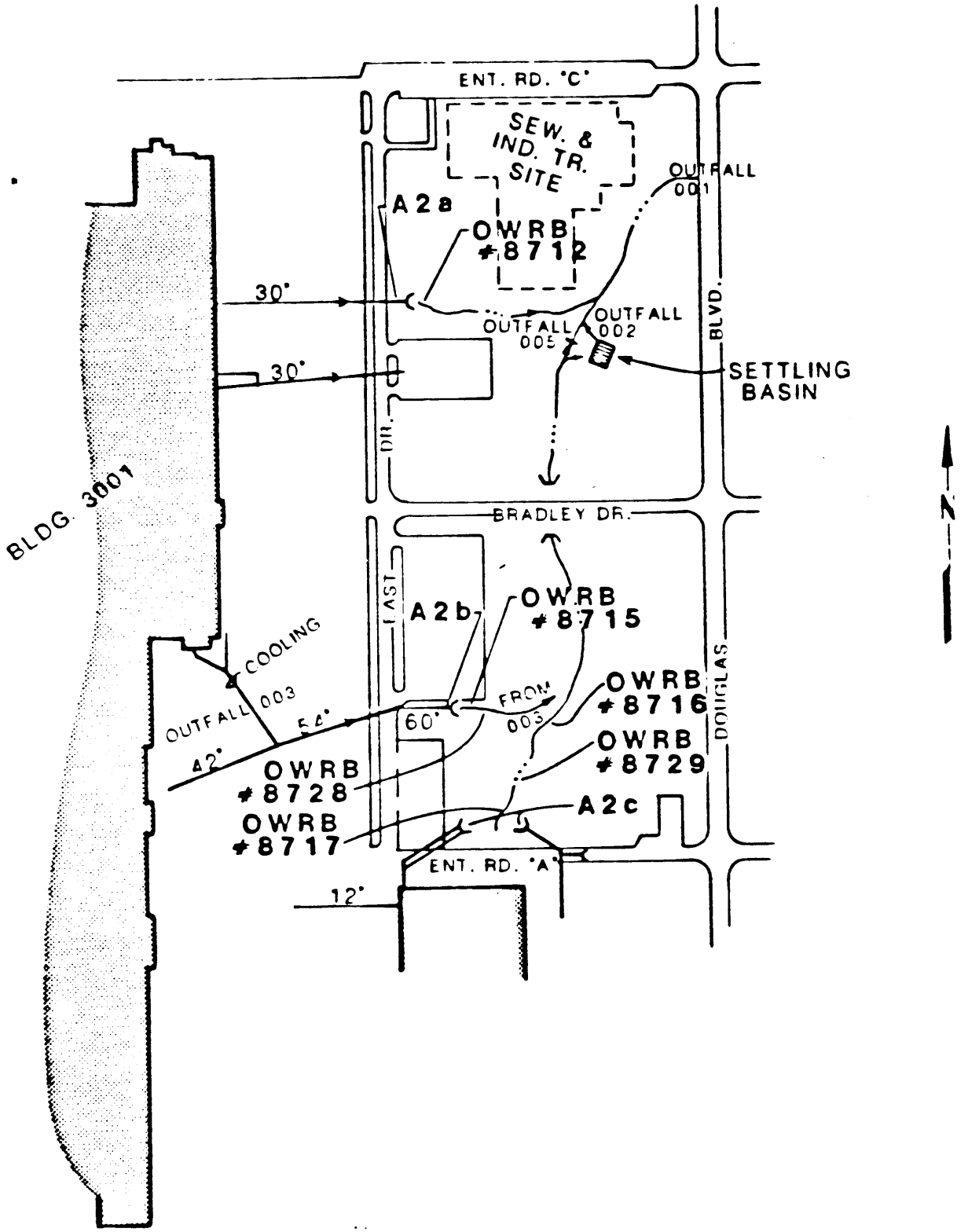
Inset 1 - Tinker Air Force Base Crutcho Creek drainage (Area 1) with maintenance and storage areas and discharge points. June 12, 1984.



Inset 2 - Tinker Air Force Base Kuhlman Creek drainage (Area 2) with discharge sources and locations. June 12, 1984.



Inset 3 - Tinker Air Force Base Soldier Creek drainage (Area 3) with discharge points. June 12, 1984.



Inset 4 - Tinker Air Force Base East Soldier Creek drainage (Area 3) discharge points and treatment plants. June 12, 1984.

Photo 1 - 5/11/84 - Discharge point for oil and grease trap at Bldg. 1030; view is to southeast. Trap lies 25 yds. southeast of pictured outlet. Discharge channel had visible oil and sheen and oil was released when sediments were stirred. Flow goes to spill pond.

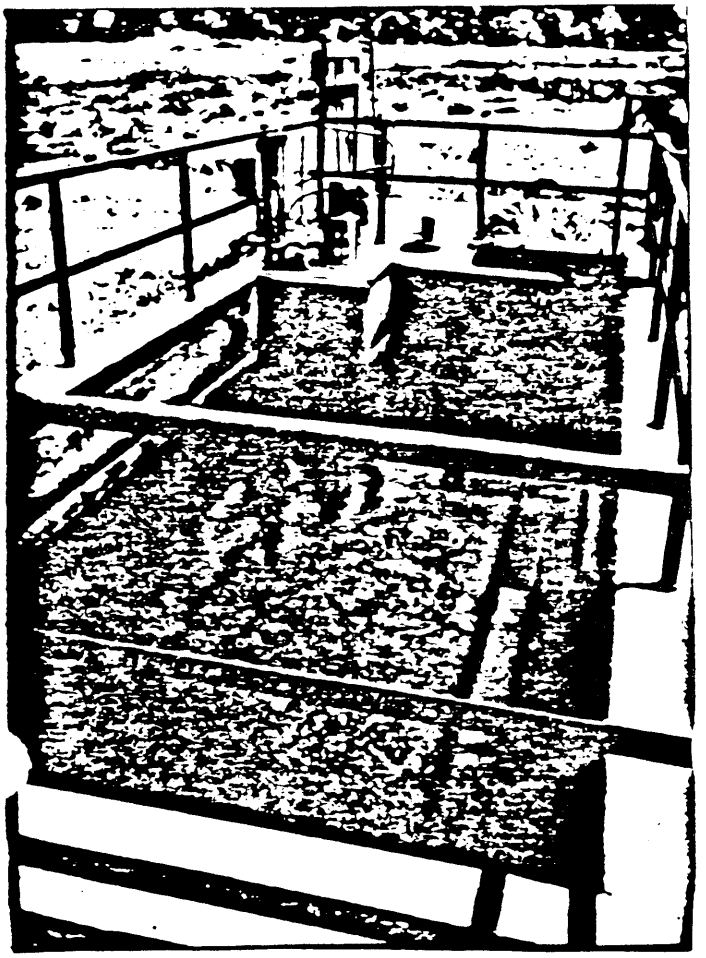


Photo 2 - 5/11/84 - Oil and grease trap at Bldg. 1071. Water is discharged from trap with oil and grease retained until sufficient quantity accumulates for hauling and disposal. Discharge flows to Crutcho Creek tributary to spill pond.

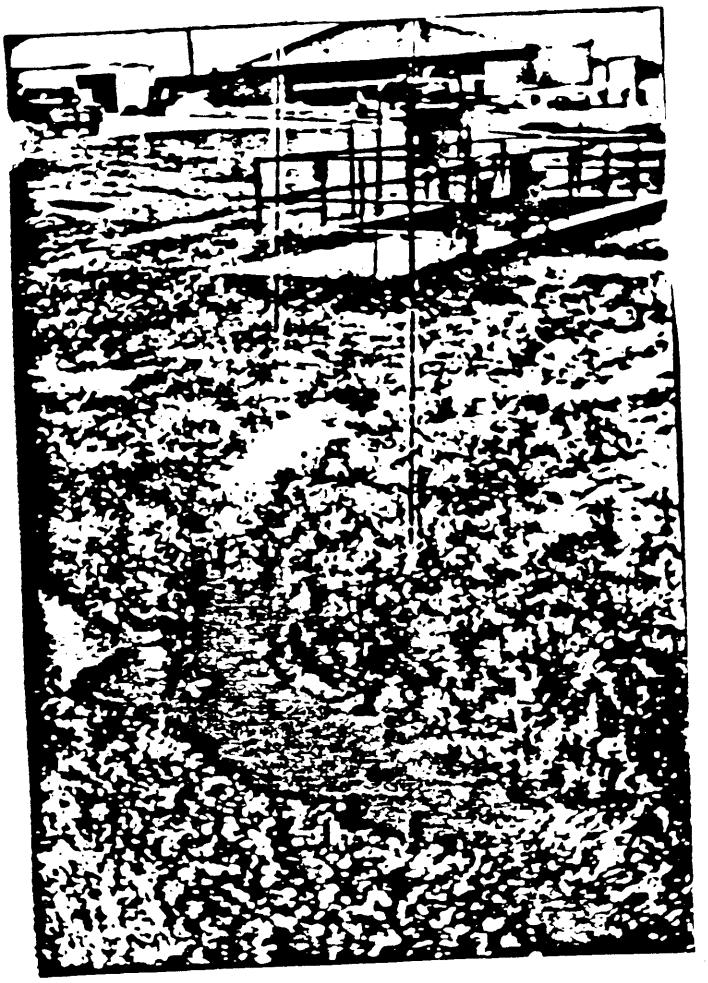


Photo 3 - 5/11/84 - Bldg. 1071 oil & grease trap with on-going surface discharge. Note dark color of water, oil sheen, and sparse vegetation where discharge contacts the soil surface.

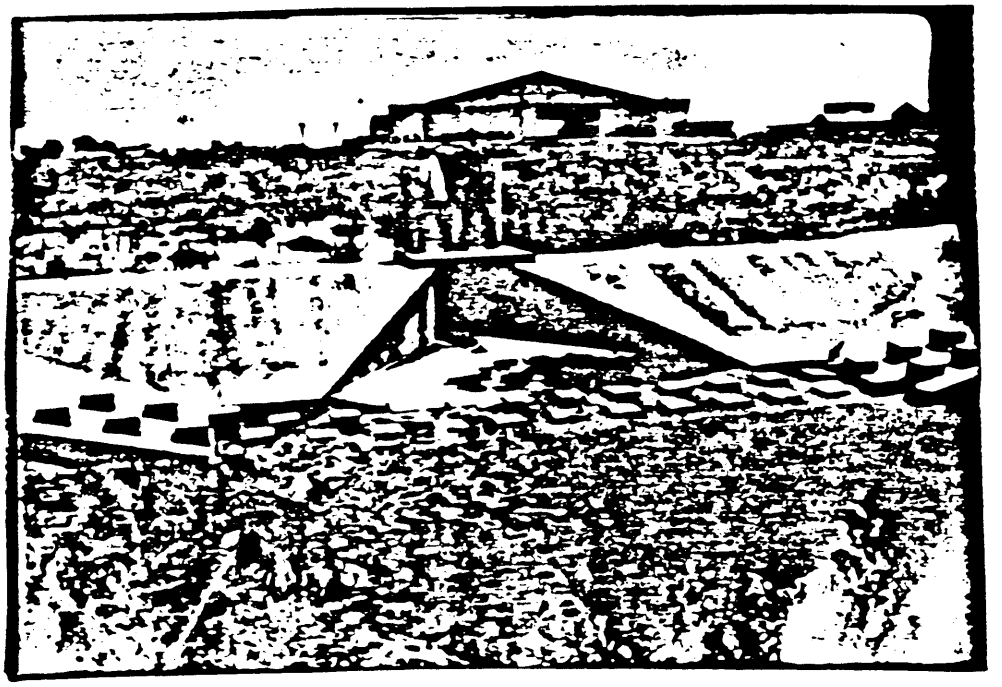


Photo 4 - 5/11/84 - Pond containment structure with manually operated gate for discharge. Note foam outside of structure and sparse vegetation in and around the spill pond.

Photo 5 - 5/10/84 - View to east-northeast of 84" storm drain. Note visible foam. Air in and around drain pipe smelled of aromatic hydrocarbons.

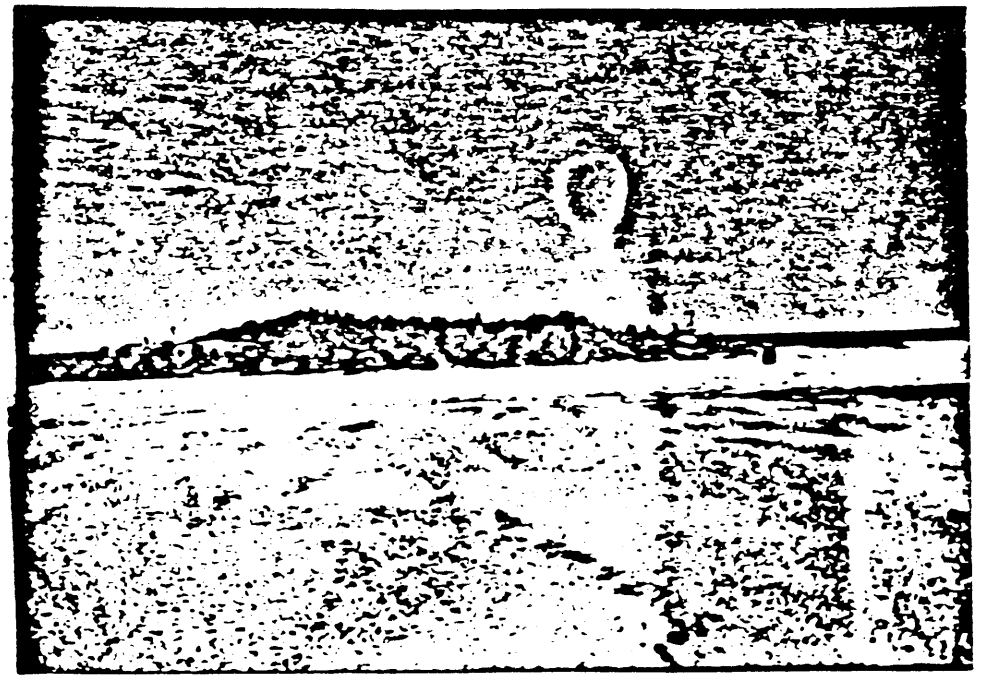


Photo 6 - 5/10/84 - Dirt pile on northeast corner of fire training pit area. This soil is contaminated with JP-4 and is improperly disposed. Runoff flows into Crutcho Creek.

Photo 7 - 5/10/84 - Additional JP-4 contaminated dirt pile from fire pit renovation. See photo 6.

Photo 8 - 5/10/84 - Vent pipe and access port for underground waste fluid retention tank at fire training pit area. One month prior to this photo, an overflow fill occurred resulting in the contaminated flow path at left leading to Crutcho Creek.

Photo 9 - 5/10/84 - Contaminated flow path of JP-4 and contaminated water from April overfill event. Note that no clean up has occurred.

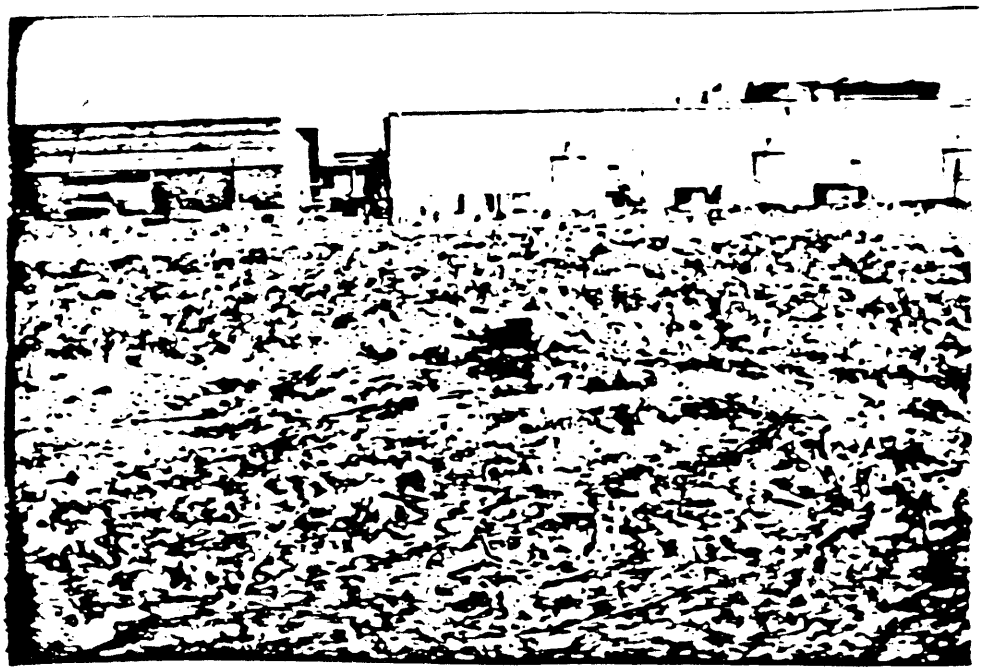


Photo 10 - 5/10/84 - 18" discharge pipe from Outfall 004 and other process areas. Pipe is located on west side of Bldg. 3001, approximately 1500 ft. above underground discharge pipe to Soldier Creek. Oil sheen was visible on the water surface when sediments were stirred. This discharge is a contributor to OWRB #8719 and #8727.

Photo 11 - 5/10/84 - 27" discharge pipe from Bldg. 3001. Pipe is located on the west side of Bldg. 3001, approximately 1250 ft. above underground discharge pipe to Soldier Creek. Flocculated material on substrate, with visible oil sheen and hydrocarbon odor released when sediments are stirred. This discharge is a contributor to OWRB #8719 and #8727.

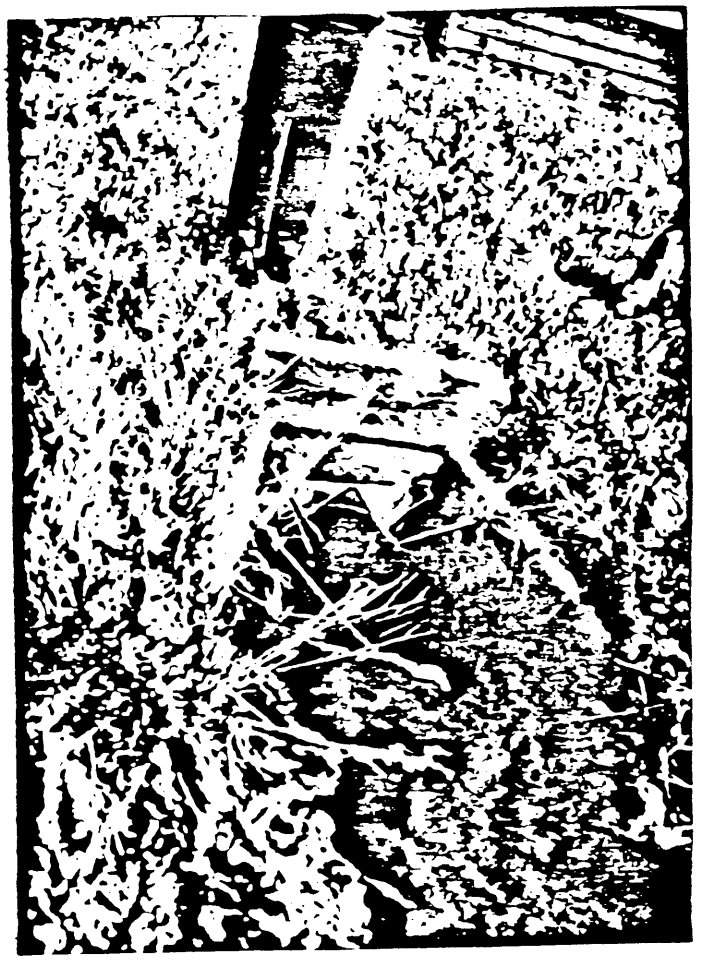


Photo 12 - 5/10/84 - 21" discharge pipe from Bldg. 3001. Pipe is located on west side of Bldg. 3001, approximately 500 ft. above underground discharge pipe to Soldier Creek. Note oil sheen. this discharge contributes to OWRB #8719 and #8727.

Photo 13 - 5/10/84 - 12" discharge pipe from Bldg. 3001. Pipe is located on west side of Bldg. 3001, approximately 450 ft. above underground discharge pipe to Soldier Creek.

Photo 14 - 5/10/84 - Underground discharge pipe to Soldier Creek and sample site for OWRB #8719 and 8727. This pipe receives wastewater from Outfall 004 and several other unpermitted sources. See photos 10-13 and photos 15-17.

Photo 15 - 5/10/84 - View to south-southeast of westside ditch of Bldg. 3001. Photos 10 and 11 were taken above (south) this point. Note staining on banks, hydrocarbon or oil sheen on the water surface and filamentrous algae on the substrate.

Photo 16 - 5/10/84 - Sample site for OWRB #8719 and #8727. View to south from atop underground discharge pipe to Soldier Creek. Note stained banks upstream and old flow control structure in foreground.

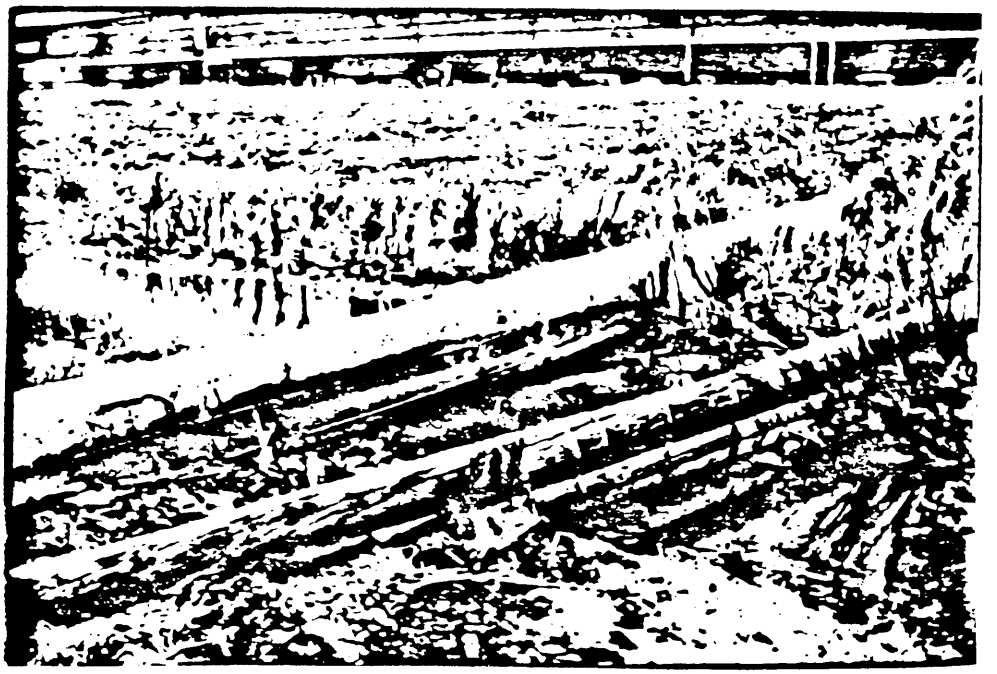


Photo 17 - 5/10/84 - Concrete and telephone pole oil skimming devices in storm drain on west side of Bldg. 3001. Skimmers are located approximately 1150 ft. above underground discharge pipe to Soldier Creek. Note oil sheen on water surface, staining on skimmers, black dried material on bank, and water level below skimmer.

Photo 18 - 5/3/84 - "Purple" water discharge (spill) from lift station near Outfall 003. Site location is approximately 20 yds. below 60" storm drain on east side of Bldg. 3001 (middle storm drain).

Photo 19 - 5/3/84 - "Spill" discharge from lift station near Outfall 003. Flow rate was approximately 15 gallons per minute.

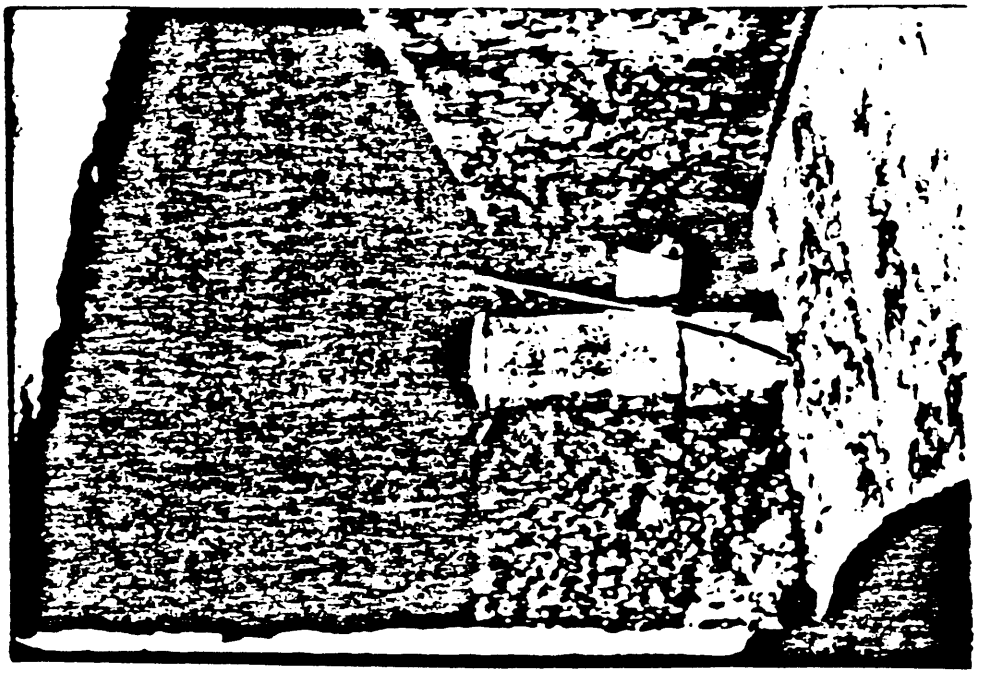


Photo 20 - 5/11/84 - Access port to industrial waste line along Douglas Boulevard. Line is underground outside of TAFB fence. Liquid in concrete box indicates possible leakage from line. Metallic blue sheen visible on liquid surface and area around box and over waste line does not support plant life.

Photo 21 - 5/11/84 - Dead vegetation over and along underground industrial waste sewer line north of 59th Street lift station near Bldg. 2100.

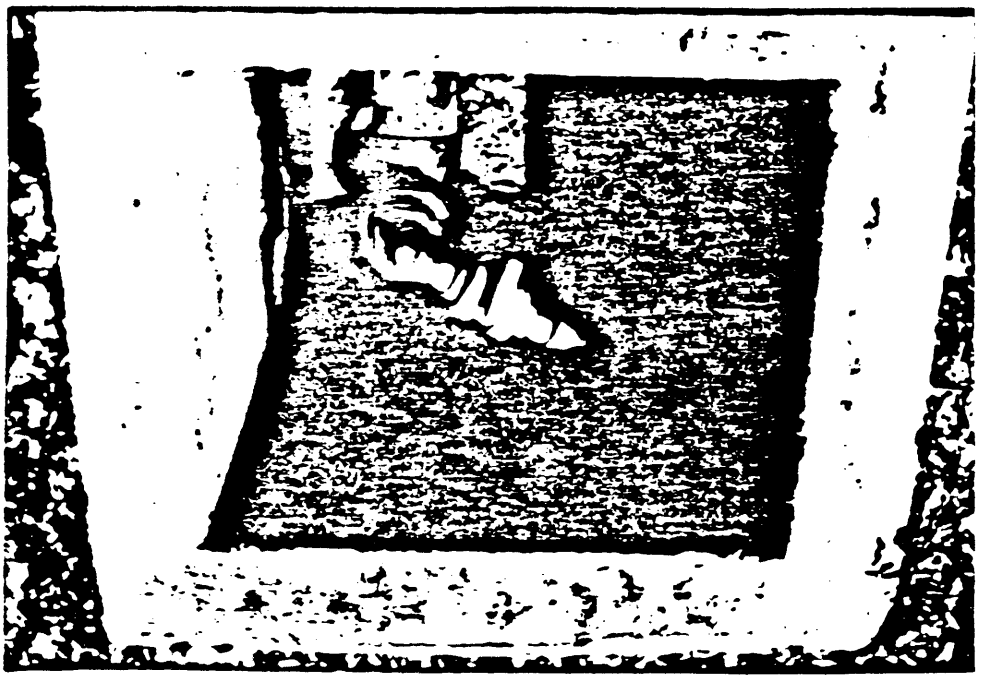


Photo 22 - 5/11/84 - Access port to underground industrial sewer line on outside of east fence near Gate 24. Line has valve with hose connected to it allowing discharge out of concrete box. JP-4 spillage on ground apparently originated from this hose.

Photo 23 - 5/11/84 - Flow path of JP-4 spill to storm drain then to Soldier Creek. Soil was saturated with JP-4. No clean up was performed. Flow went to concrete storm drain on left side of photo.

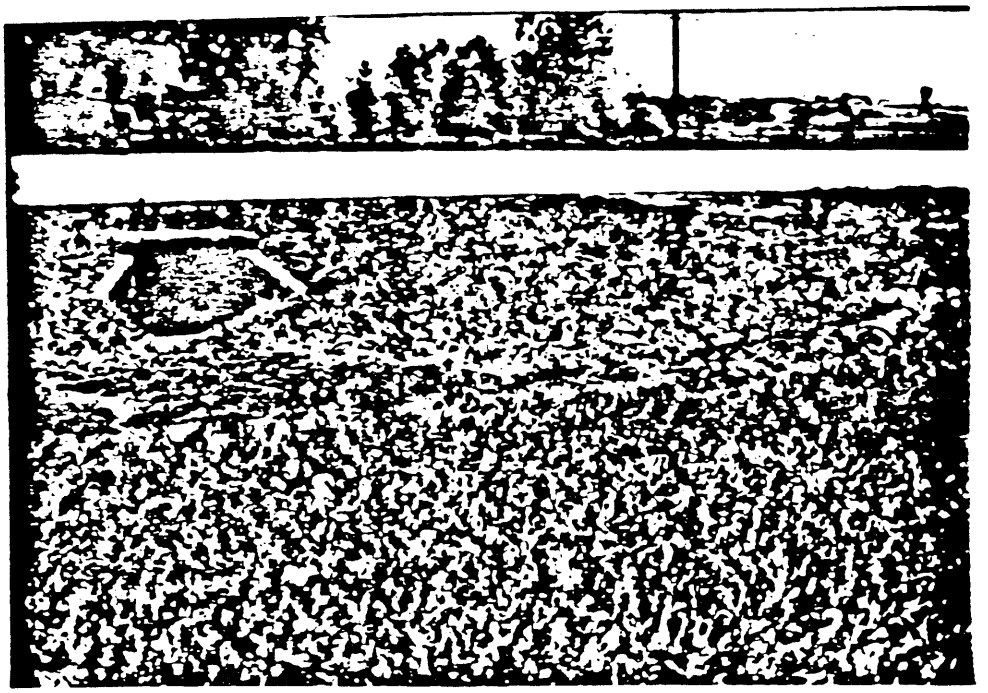


Photo 24 - 5/11/84 - JP-4 spill flow under Douglas to Soldier Creek drainage in top of photo.

Reference #8
Record of Communication. Drew Puffer, USEPA, to Lt. Bill Johnson, Tinker AFB. Location of wells 8 & 9, along with map showing location
11/28/84

RECORD OF COMMUNICATION

☑ PHONE CALL ☐ DISCUSSION ☐ FIELD TRIP ☐ CONFERENCE
☐ OTHER (SPECIFY)

(Record of item checked above)

TO: Lt. Bill Johnson
Civil Engineering
Tinker AFB

FROM: Drew Puffer

DATE: 11/28/84

TIME: 2:50 PM

SUBJECT: Location of wells #8 and #9 (base water supply wells)

SUMMARY OF COMMUNICATION

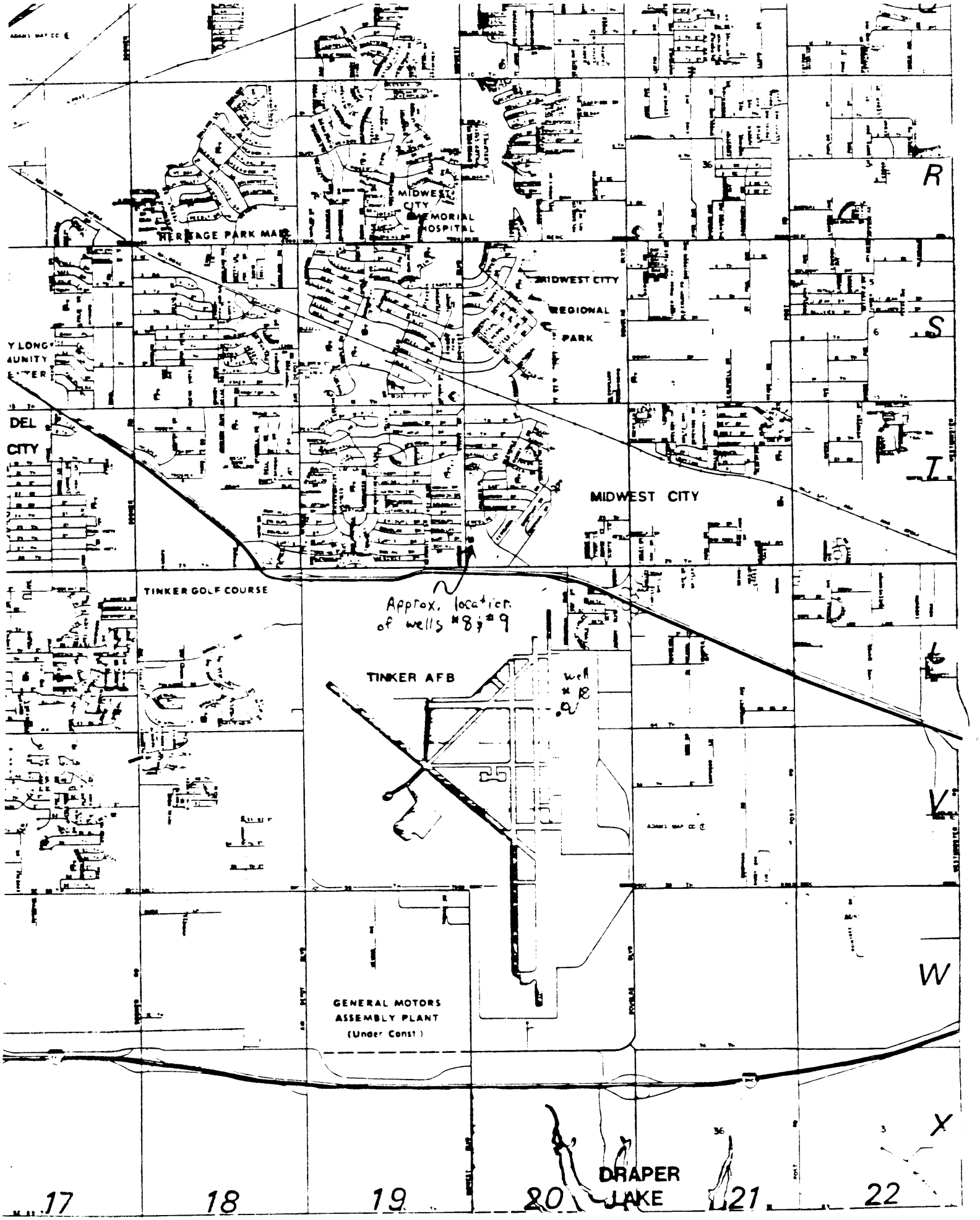
Lt. Johnson said that wells #8 and #9 were 1/4 mile North of the base along Midwest Blvd. The wells are within approximately 200 yds. of each other. I asked if these wells were close to 29th St. and Lt. Johnson said yes; they were within a couple hundred yards north of 29th St. next to a restaurant called "El Rancho", on Midwest Blvd.

CONCLUSIONS, ACTION TAKEN OR REQUIRED

INFORMATION COPIES

BY: File

EPA Form 1200-6 (7-73) REPLACES EPA FORM 1200-6 WHICH MAY BE USED UNTIL SUPPLY IS EXHAUSTED.


MIDWEST CITY MEMORIAL HOSPITAL
HERITAGE PARK MALL
MIDWEST CITY REGIONAL PARK
MIDWEST CITY
TINKER GOLF COURSE
Approx. location of wells #8, #9
TINKER AFB
well #8
GENERAL MOTORS ASSEMBLY PLANT (Under Const.)
DRAPER LAKE
R
S
T
V
W
X
17
18
19
20
21
22

Reference #9
CERCLA 103C Notification, Tinker AFB. 28 May 81

OKS 000001-084 003723

Washington DC 204

RECEIVED

JUN 09 1981

6AEP

This initial notification information is ~~required~~ by Section 103(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and must be mailed by June 9, 1981

Please type or print in ink. If you need additional space, use separate sheets of paper. Indicate the letter of the item which applies

Hazpit # 03646

A Person Required to Notify:

Enter the name and address of the person or organization required to notify

OKI 57 172 4391

Name: Tinker Air Force Base

Street: 2854 CES/DEEX

City: Oklahoma City State: OK Zip Code: 73145

B Site Location: ~~OKD 98 062-0959~~

Enter the common name (if known) and actual location of the site

HAZ-OK03646

Name of Site: Landfill Rd, Tinker Air Force Base

Street: Landfill Road, Tinker Air Force Base

City: Oklahoma City County: Okla. State: Ok Zip Code: 73145

C Person to Contact:

Enter the name, title (if applicable), and business telephone number of the person to contact regarding information submitted on this form.

Name (Last, First and Title): Burris, David--Environmental Engineer

Phone: 405-734-3201 (2854 CES/DEEX)

D Dates of Waste Handling:

Enter the years that you estimate waste treatment, storage, or disposal began and ended at the site

From (Year): 1941 To (Year): 1969

F Waste Type: Choose the option you prefer to complete

Option I: Select general waste types and source categories. If you do not know the general waste types or sources, you are encouraged to describe the site in Item I—Description of Site

General Type of Waste:
Place an X in the appropriate boxes. The categories listed overlap. Check each applicable category

1 ☒ Organics
2 ☒ Inorganics
3 ☒ Solvents
4 ☐ Pesticides
5 ☒ Heavy metals
6 ☒ Acids
7 ☒ Bases
8 ☐ PCBs
9 ☒ Mixed Municipal Waste
10 ☒ Unknown
11 ☐ Other (Specify)

Source of Waste:
Place an X in the appropriate boxes

1 ☐ Mining
2 ☐ Construction
3 ☐ Textiles
4 ☐ Fertilizer
5 ☐ Paper/Printing
6 ☐ Leather Tanning
7 ☐ Iron/Steel Foundry
8 ☒ Chemical, General
9 ☒ Plating/Polishing
10 ☒ Military/Ammunition
11 ☐ Electrical Conductors
12 ☐ Transformers
13 ☐ Utility Companies
14 ☒ Sanitary/Refuse
15 ☐ Photofinish
16 ☐ Lab/Hospital
17 ☒ Unknown
18 ☐ Other (Specify)

Option 2. This option is available to persons familiar with the Resource Conservation and Recovery Act (RCRA) Section 3001 regulations (40 CFR Part 261)

Specific Type of Waste:
EPA has assigned a four-digit number to each hazardous waste listed in the regulations under Section 3001 of RCRA. Enter the appropriate four-digit number in the boxes provided. A copy of the list of hazardous wastes and codes can be obtained by contacting the EPA Region serving the State in which the site is located.

K054	F006	U032
D000	F007	U054
D001	F008	U057
D002	F009	U080
D011	F010	U112
F001	F017	U159
F002	F018	U210
F003	P030	U220
F004	P097	U226
F005	U002	U238
		U239

Form Approved
OMB No. 2000-0138
EPA Form

Atch 1

facility types found at the site

al facility waste amount" space estimated combined quantity of hazardous wastes at the site bic feet or gallons

"total facility area" space give the ated area size which the facilities py using square feet or acres

2 [ ] Land Treatment
3 [X] Landfill
4 [ ] Tanks
5 [ ] Impoundment
6 [ ] Underground Injection
7 [ ] Drums Above Ground
8 [X] Drums Below Ground
9 [ ] Other (Specify) _____

gallons _____

Total Facility Area

square feet _____

acres Acres total 35-40

Known, Suspected or Likely Releases to the Environment:

Place an X in the appropriate boxes to indicate any known, suspected, or likely releases of wastes to the environment

[X] Known [X] Suspected [ ] Likely [ ] None

Note Items H and I are optional Completing these items will assist EPA and State and local governments in locating and assessing hazardous waste sites Although completing the items is not required, you are encouraged to do so

H Sketch Map of Site Location: (Optional)

Sketch a map showing streets, highways, routes or other prominent landmarks near the site Place an X on the map to indicate the site location Draw an arrow showing the direction north You may substitute a publishing map showing the site location

See attached U.S.G.S. map of the Tinker Air Force Base Area.

Description of Site: (Optional)

Describe the history and present conditions of the site Give directions to the site and describe any nearby wells, springs, lakes, or housing Include such information as how waste was disposed and where the waste came from Provide any other information or comments which may help describe the site conditions

This landfill site has been used by Tinker Air Force Base for as long as anyone can remember. There are no records of what exactly was placed into the landfill over the years, but one can assume that the same industrial wastes were dumped at this disposal site as are being generated today.

Tinker Air Force Base is an Air Force Logistics Command (AFLC) base. Its primary mission is aircraft maintenance and jet engine rebuilding. The Installation Restoration Program, established by Defense Environmental Quality Program Policy Memorandum 80-6, is a three-phase effort to identify, monitor, and restore all suspect DOD landfills. Tinker AFB is scheduled for a tour by HQ AFLC to identify our landfill sites.

Signature and Title:

The person or authorized representative (such as plant managers, superintendents, trustees or attorneys) of persons required to notify must sign the form and provide a mailing address (if different than address m A) For other persons providing ation, the signature is optional the boxes which best describe the ionship to the site of the person required to notify If you are not required to notify check "Other"

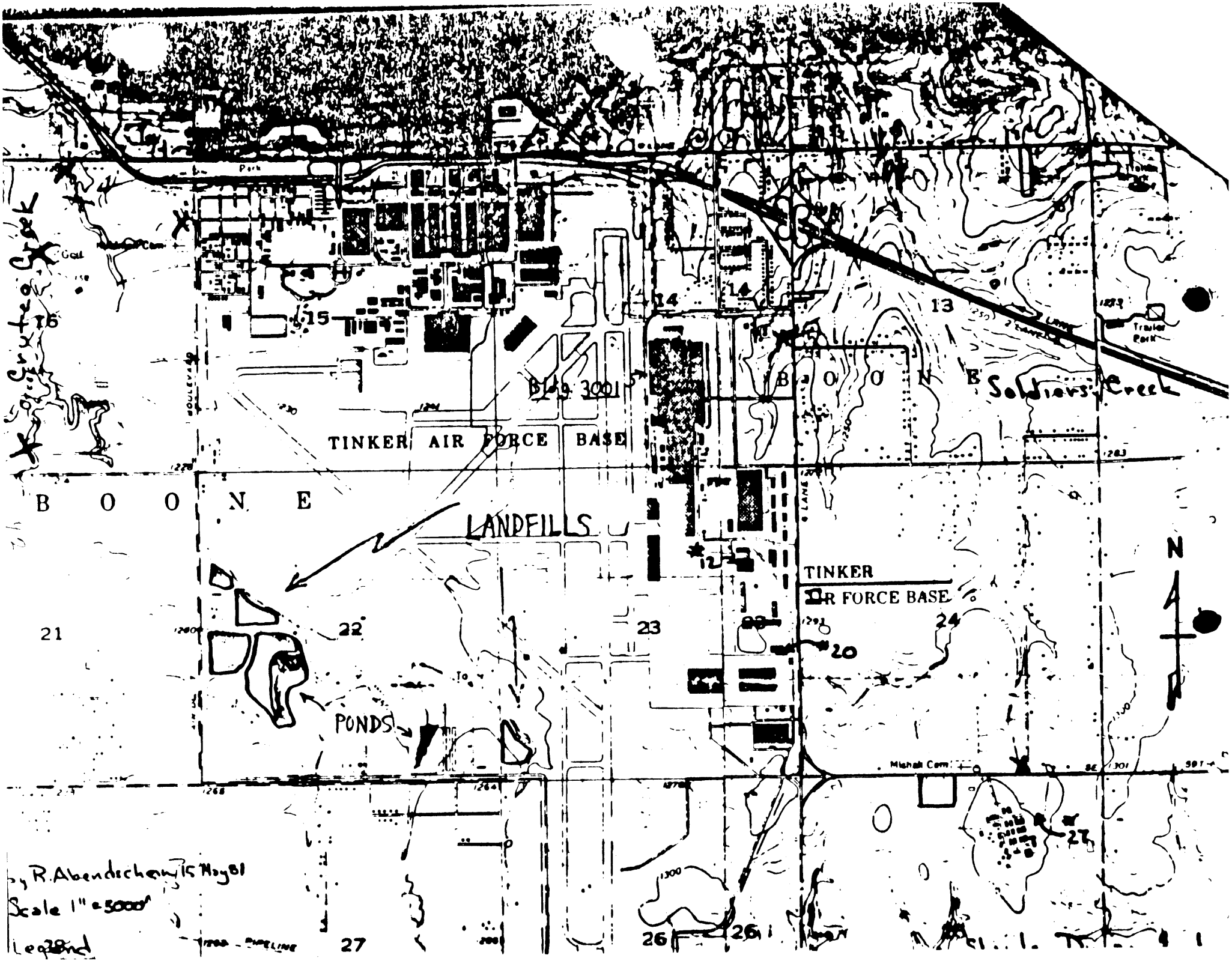
Name I.L. Piersall

Street 2854 CES/DEEX, Tinker AFB

City Oklahoma City State OK Zip Code 73145

Signature [signature] Date 28 May 1981

[ ] Owner, Present
[ ] Owner, Past
[ ] Transporter
[ ] Operator, Present
[ ] Operator, Past
[X] Other



Crutco Creek
Soldiers Creek
TINKER AIR FORCE BASE
B O O N E
LANDFILLS
PONDS
TINKER
AIR FORCE BASE
Bldg 3001
Trailer Park
Mishak Cem
N
13
14
15
16
20
21
22
23
24
26
27
by R. Abendschein 15 May 81
Scale 1" = 5000'
Legend

Reference #10
Maps Showing Principal Groundwater Resources and Recharge Areas in Oklahoma: Sheet 2 - Bedrocks Aquifers and Recharge Areas. Compiled by K.S. Johnson, Oklahoma Geological Survey, 1963

MAPS SHOWING PRINCIPAL GROUND-WATER RESOURCES AND RECHARGE AREAS IN OKLAHOMA:

SHEET 2 - BEDROCK AQUIFERS AND RECHARGE AREAS

(Reduction and composite of original)

Compiled by

Kenneth S. Johnson
Oklahoma Geological Survey

1983

EXPLANATION

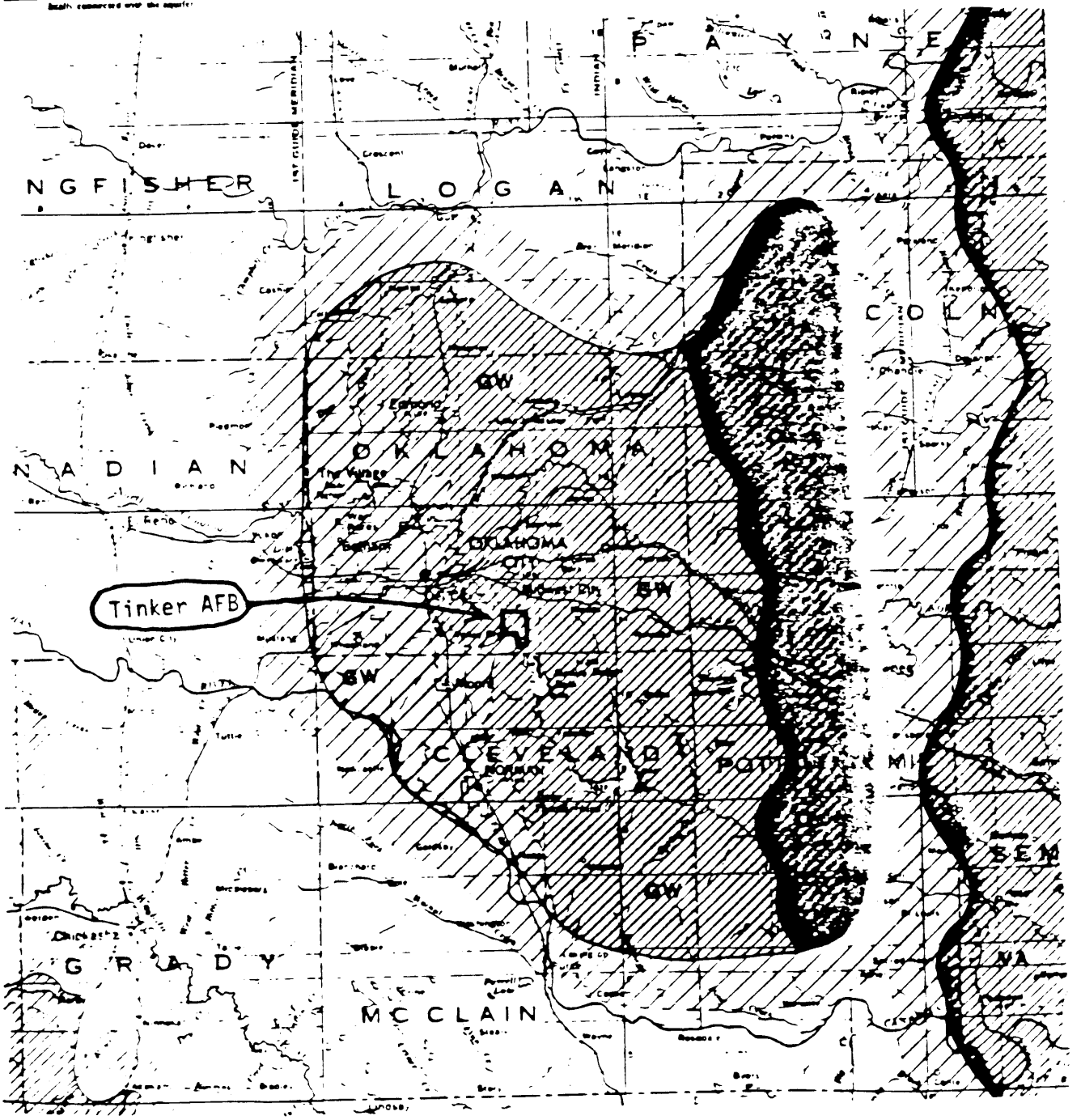
RECHARGE AREAS

Patterns of red lines on the map show known or potential recharge areas for the various bedrock aquifers.

Recharge Area. This pattern shows areas that are known to be part of the recharge area for a bedrock aquifer; includes outcrops of the aquifer and of overlying porous and permeable rocks hydraulically connected with the aquifer.

Potential Recharge Area. This pattern shows areas that may be part of the recharge area for a bedrock aquifer; includes areas where confining strata may contain pathways for downward movement of water to the aquifer, and safer zones (generally extending 4 miles beyond the known limits of the aquifer) that may overlie unknown extensions of the aquifer or rocks hydraulically connected with the aquifer.

GW — Garber Sandstone and Wellington Formation (Permian in age). Fine-grained sandstone irregularly interbedded with shale and siltstone in central Oklahoma; grades into shale to north and south. Thickness of aquifer ranges from about 300 ft in the south to about 800 ft in the north. Wells commonly yield 25 to 400 gpm of water that is of good quality (generally 200 to 1,000 mg/L dissolved solids). Recharge areas consist of outcrops of the aquifer and extend eastward to the approximate top of shales that make up much of the lower one third of the Wellington Formation. Potential recharge areas include areas in the west where aquifer underlies younger Permian strata; also areas that extend 4 miles south, west, and north of aquifer limits. References: HA-4; also Other Reports 4, 5, 29, 33, 61, 67, 68.



Reference #11
Testimony: Dr. C.J. Mankin, Director, Oklahoma Geological Survey, at Tinker Air Force Base Hearing, Subcommittee on Environment, Energy and Natural Resources, Dec. 12, 1984

Tinker Air Force Base Hearing

Subcommittee on Environment, Energy and Natural Resources

December 12, 1984

Testimony of Dr. Charles J. Mankin, Director

Oklahoma Geological Survey

Thank you, Mr. Chairman. I am Charles Mankin. I serve as Director of the Oklahoma Geological Survey and as Executive Director of the Energy Resources Institute at The University of Oklahoma. In connection with this testimony it should be noted that I also serve on the Board of the Environmental Institute for Waste Management Studies at the University of Alabama.

This presentation has been developed with assistance from the staff of the Oklahoma Geological Survey with special acknowledgment to Dr. Kenneth Johnson, Associate Director of the Survey, who assembled much of the technical information for this purpose. It should be noted also that much of this information has been derived through the cooperative program between the Oklahoma Geological Survey and the Water Resources Division of the U.S. Geological Survey.

Geohydrology of Tinker Air Force Base Area

Outcropping rock units in and around Tinker Air Force Base (TAFB) include sandstones and shales that make up a major ground-water aquifer for the greater Oklahoma City area (Figure 1). These sedimentary rocks were laid down as part of a complex of alluvial and deltaic sediments deposited by streams that flowed westward across central Oklahoma during the Permian Period of geologic time, about 250 million years ago. The rock units are the Hennessey Group, consisting mainly of shale that mantles TAFB, and the thick, underlying Garber Sandstone and Wellington Formation,

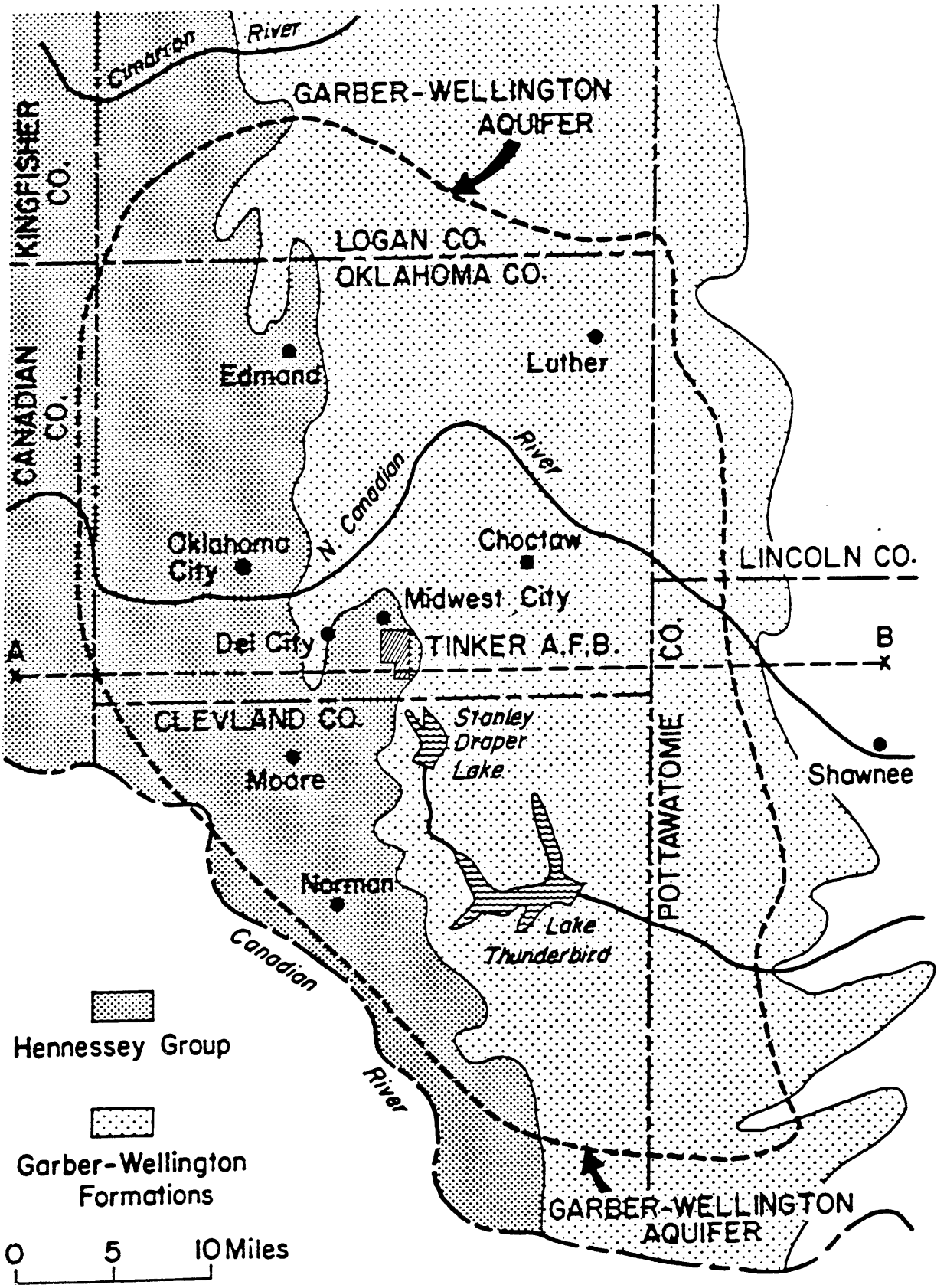


Figure 1. Generalized bedrock geologic map of central Oklahoma showing outcrops of Garber-Wellington formations and Hennessey Group. Also shown is outline (dashed line) of area where Garber-Wellington aquifer is a major ground-water resource. Cross section A-B shown on next figure. Modified from Miser and others (1954), Wood and Burton (1968), and Bingham and Moore (1975). 47

both of which consist mainly of sandstone and comprise the major aquifer for the region. All three of these sedimentary rocks units dip gently to the west (Figure 2) at an angle of about one-third of a degree (about 30 feet per mile).

The Hennessey Group consists mainly of reddish-brown shale with some layers of siltstone and fine-grained sandstone (Wood and Burton, 1968). The shales are clayey to silty, and the siltstones and sandstones commonly contain large amounts of clay. Inasmuch as the upper and middle portions of the Hennessey have been eroded from the TAFB area, only the basal 10 to 50 feet of the Hennessey strata are still present at TAFB. Shales of the Hennessey generally have a low permeability, and thus disposal of waste materials in trenches dug into the Hennessey probably was regarded as acceptable. However, closeness of the disposal sites to the underlying aquifer makes it possible that some of the waste material could eventually migrate downward into the aquifer through natural and/or man-made pathways that penetrate the base of the Hennessey into the top of the Garber.

As noted previously, immediately underlying the Hennessey are red-bed sandstones and shales of the Garber Sandstone and the Wellington Formation. The Garber and Wellington are similar in lithology and are not readily distinguishable in the area. The two formations also have similar water-bearing characteristics and therefore they commonly are mapped as a single unit (Figures 1 and 2) and treated as a single aquifer (the Garber-Wellington aquifer). The total thickness of the Garber-Wellington in the vicinity of TAFB is about 800 to 1,000 feet.

The contact between the Garber Sandstone and the overlying Hennessey is gradational in parts of central Oklahoma; locally, sandstone layers having a lithology similar to the Garber grade laterally into shales resembling the Hennessey (Wood and Burton, 1968). Therefore, at times there has been uncertainty in the detailed mapping of the TAFB area. Wood and Burton (1968) mapped most of the TAFB outcrops as Hennessey, whereas a later, reconnaissance mapping program by Bingham and Moore

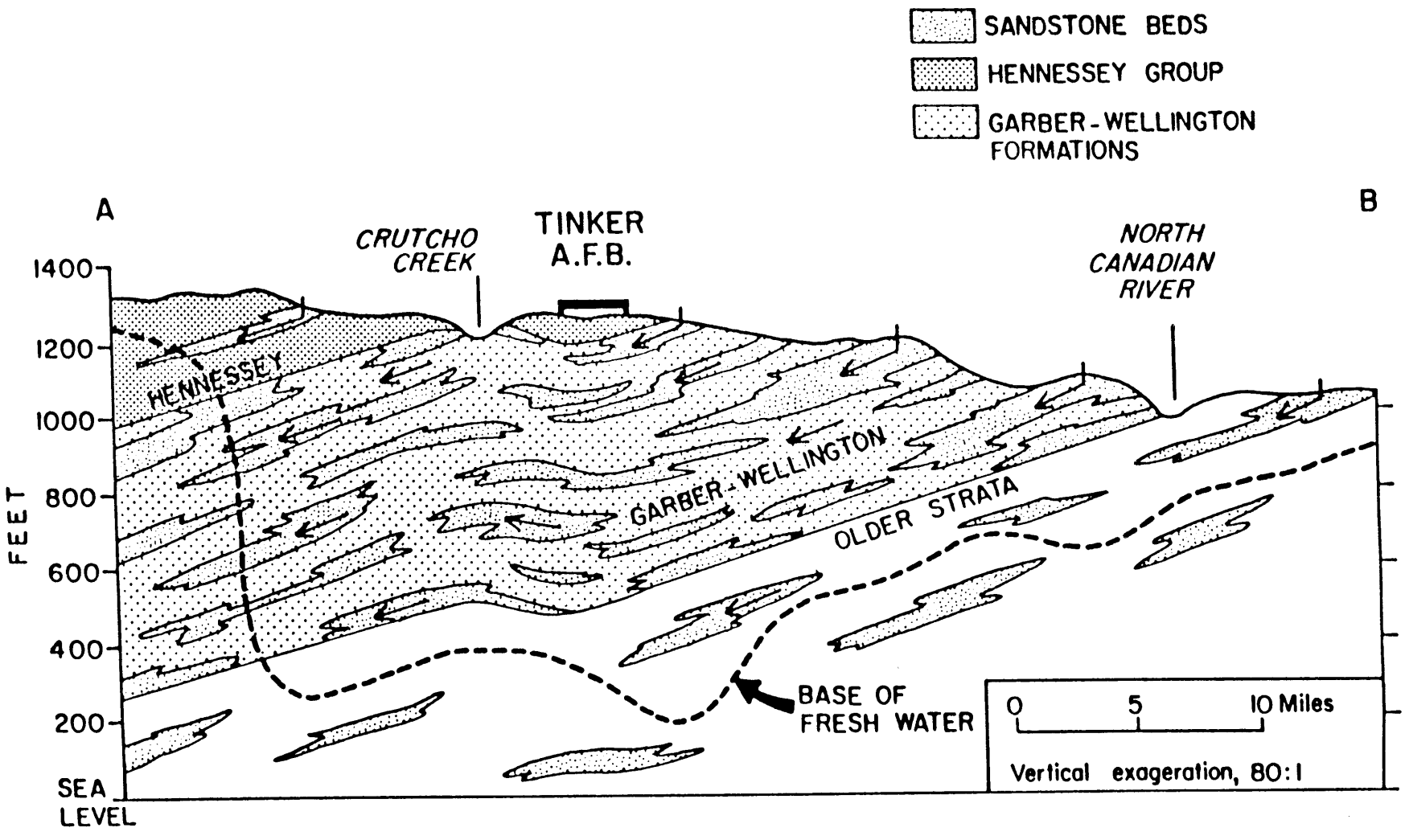


Figure 2. Schematic east-west cross section A-B through southern Oklahoma County, showing irregular distribution of sandstones (stipple) in the Garber-Wellington aquifer, recharge of sandstone aquifers (arrows), and the base of fresh water in the aquifer (dashed line). Modified from Wood and Burton (1968).

(1974) mapped most of the same outcrops as Garber: current data indicate that Wood and Burton's work was correct in assigning TAFB outcrops to the Hennessey Group.

The Garber and Wellington consist of lenticular beds of massive-appearing, cross-bedded sandstone irregularly interbedded with shale which is in part sandy to silty (Wood and Burton, 1968; Carr and Marcher, 1977). The sandstone layers are fine- to very-fine-grained, loosely cemented, and typically are highly porous and permeable. Variability in thickness and distribution is characteristic of the individual sandstone units. Individual sandstone layers range in thickness from a few inches to as much as 50 feet, and these thicknesses vary greatly in short distances. Although some of the sandstone beds are quite thick, beds 5 feet or less in thickness are more common. In general, the sandstone content of the Garber and Wellington is greatest in southeastern Oklahoma County, where about 75 percent of the exposed rock is sandstone and 25 percent is shale.

Ground water occurs in the porous and permeable sandstone layers of the Garber-Wellington aquifer beneath and in the vicinity of TAFB (Figure 2). The aquifer is recharged where surface waters (precipitation, surface runoff, streams, and lakes) percolate into the permeable sandstone layers and eventually migrate downward to the zone of saturation (water table). This is a dynamic system inasmuch as the Garber-Wellington aquifer is being recharged continuously, and ground water is migrating slowly downdip to the west within the sandstone layers and lenses.

The Garber-Wellington aquifer may also be recharged locally on TAFB by percolation of surface waters downward through the lower Hennessey strata until the water reaches the top of the Garber. Such recharge may occur where the Hennessey contains naturally-occurring high-permeability layers, joints, and fractures, or man-made boreholes, trenches, and other excavations. Any of the natural or artificial features that penetrate through the Hennessey strata into the underlying Garber-Wellilngton

aquifer represents a potential pathway for surface waters locally to enter the aquifer (Johnson, 1983).

Owing to the irregular thickness and distribution of sandstone layers and lenses in the Garber and Wellington formations, the aquifer is not a continuously uniform, saturated rock unit, but instead is a series water-bearing zones enveloped in shale. Each water-bearing zone has its own potential for storing water. Wells drilled into the aquifer commonly tap a number of individual sandstone beds, and thus may penetrate 200 to 300 feet of water-bearing sandstone while being drilled to a total depth of 400 to 500 feet. Other wells drilled to similar depths nearby may tap only a few relatively thin beds of sandstone, and thus penetrate only 50 to 100 feet of water-bearing strata. Thus it is clear that the ability of the Garber-Wellington aquifer to store and transmit water varies markedly from place to place, and without understanding the distribution and permeability of the principal sandstone units it is difficult or impossible to adequately evaluate or monitor ground-water flow in the Garber-Wellington aquifer.

The Garber-Wellington aquifer is the most important source of potable ground water in the greater Oklahoma City area. Cities in southern Oklahoma County, such as Midwest City, Del City, Jones, Spencer, and Choctaw, all have municipal wells drilled into the Garber-Wellington aquifer, and they use ground water as a principal water supply (Wickersham, 1979). A number of institutions and industries in southern Oklahoma County and northern Cleveland County also are heavy users of the Garber-Wellington aquifer. TAFB draws heavily upon the aquifer beneath the base itself to supply its water needs. Also, a great number of wells have been drilled in the Oklahoma-Cleveland County area as domestic and stock wells. All these uses and demands for water from the Garber-Wellington aquifer should increase in the future as the population of the area continues to rise.

Wells drilled into the Garber-Wellington aquifer commonly yield from 25 to 400 gallons per minute, and the water is typically of good quality, containing about 200

to 1,000 milligrams of dissolved solids per liter of water. Wells drilled to depths in excess of about 800 to 1,000 feet near TAFB may pass through the good-quality water and encounter brackish or salty water that underlies the fresh-water zone.

The potential for contamination of the Garber-Wellington aquifer is clear and immediate. Inasmuch as the recharge area is being developed more and more by urban expansion, industrial growth, and petroleum exploration, there is an ever-increasing likelihood that contaminants will accidentally be placed within or upon some parts of the recharge area. If contaminants are in liquid form, or if a leachate can be generated from the contaminant, then contaminated fluids may percolate into the permeable sandstone layers, migrate downward to the zone of saturation, and eventually disseminate through a portion of the aquifer. Fractures, boreholes, or other openings that penetrate the base of the Hennessey may enable rapid migration of contaminants downward into the Garber-Wellington aquifer. Such may be the case with the detection of contamination in TAFB wells 18 and 19, as mentioned in the report by Radian Corporation (1984).

Data presented by Wickersham (1979) indicate that in 1976 the ground water in the upper part of the Garber-Wellington would flow toward the west and northwest across TAFB (Figure 3). Water in the upper part of the aquifer that might emerge as springs after passing under TAFB would most likely be emitted along the banks or tributaries to Crutcho Creek to the northwest, or perhaps the North Canadian River, some 5 to 8 miles northwest of parts of TAFB. Therefore, most of the surface waters or ground waters that could be contaminated by leachate from the disposal sites existing on TAFB apparently would flow northwestward to Crutcho Creek, and eventally to the North Canadian River. Leachate from landfill 6 and perhaps from industrial-waste pit 2, in the extreme southeast part of TAFB, apparently would flow southward into the tributaries that enter Stanley Draper Lake, a major municipal water supply located about one mile south of landfills 2 and 6.

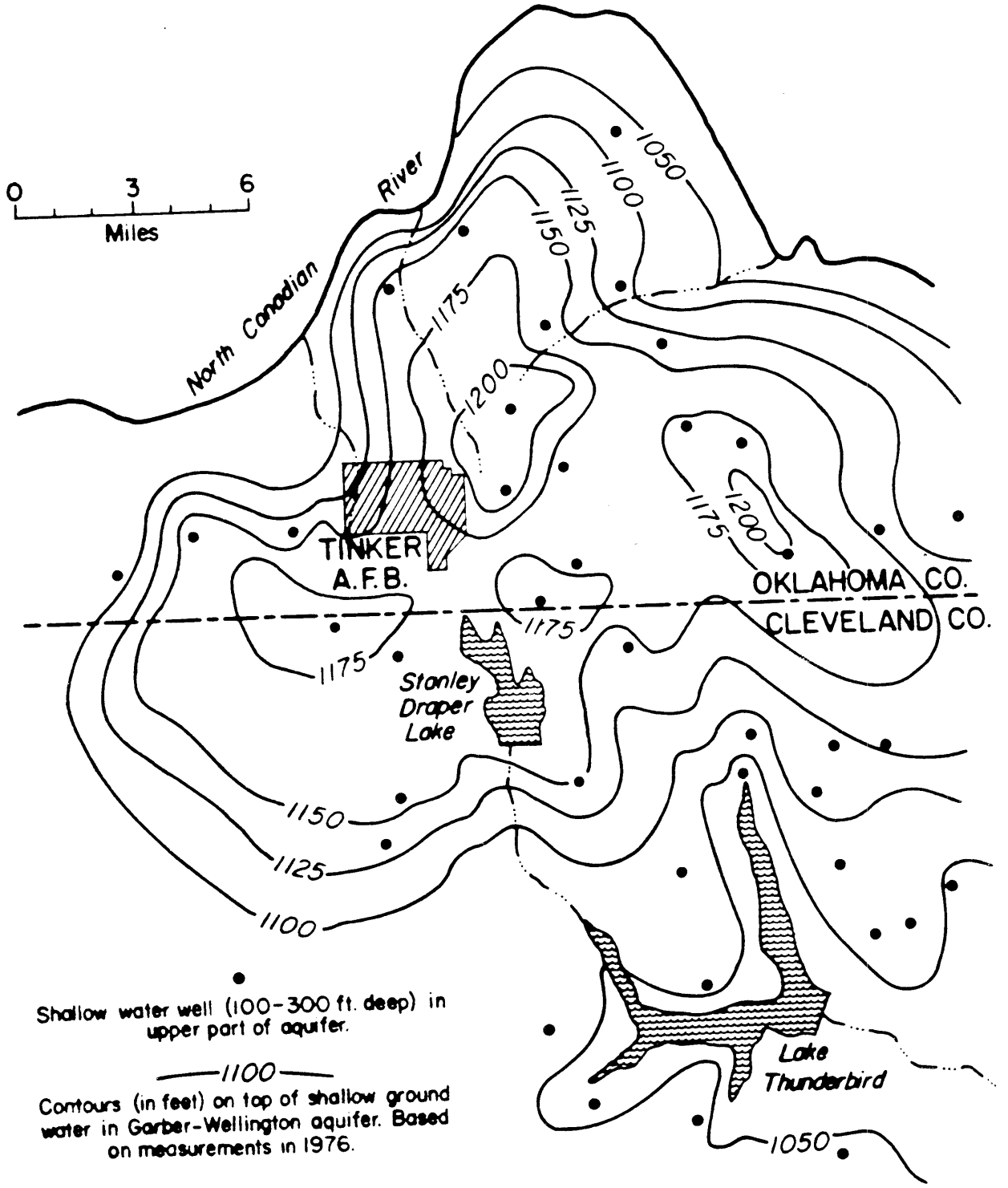


Figure 3. Elevation of ground-water surface in upper parts of Garber-Wellington aquifer in the vicinity of Tinker Air Force Base. Modified from Wickersham (1979).

Contamination from Waste-Disposal Sites

Shales and clays are generally the most desirable rock units for geologic containment of waste materials (Johnson and others, 1980). Most shales and clays, when wet, have more soil-like rather than rock-like properties, and they consist chiefly of clay minerals, such as illite, montmorillonite, chlorite, and kaolinite, that generally have the ability to absorb metals and other ions. Owing to their low permeabilities, shales and clays also have the property of retarding the lateral and/or vertical migration of leachates and other fluids.

As illustrated in Figure 4, leachate from an improperly sited or constructed waste-disposal site can filter laterally or downward to the water table, where it can then cause contamination of ground water, water wells, ponds, and streams. Although the bedrock at TAFB consists mainly of shales of the Hennessey Group, the fact that there is only some 10 to 50 feet of shale overlying a major ground-water aquifer requires extreme care in the siting, construction, maintenance, closure, and monitoring of waste-disposal facilities operated in such a setting.

Comments Concerning Studies Done to Date

The major concern regarding the study done at TAFB (Radian Corporation, 1984) is that there are inadequate data concerning the detailed hydrogeology of the area to enable characterizing ground-water flow and to monitor actual or potential contamination of the ground water from the waste-disposal sites. The work by Wickersham (1979) is regional in scope, and no additional water-well data within one mile of TAFB have been included in the current study in order to determine more accurately the ground-water flow directions. Such data are essential in order to plan the location of monitoring wells around the various waste-disposal sites at TAFB. For instance, the water table in wells drilled by Radian on the south side of TAFB is typically 1,200 to 1,260 feet above sea level (Radian Corporation, 1984, Figure 2-5), whereas the earlier data by

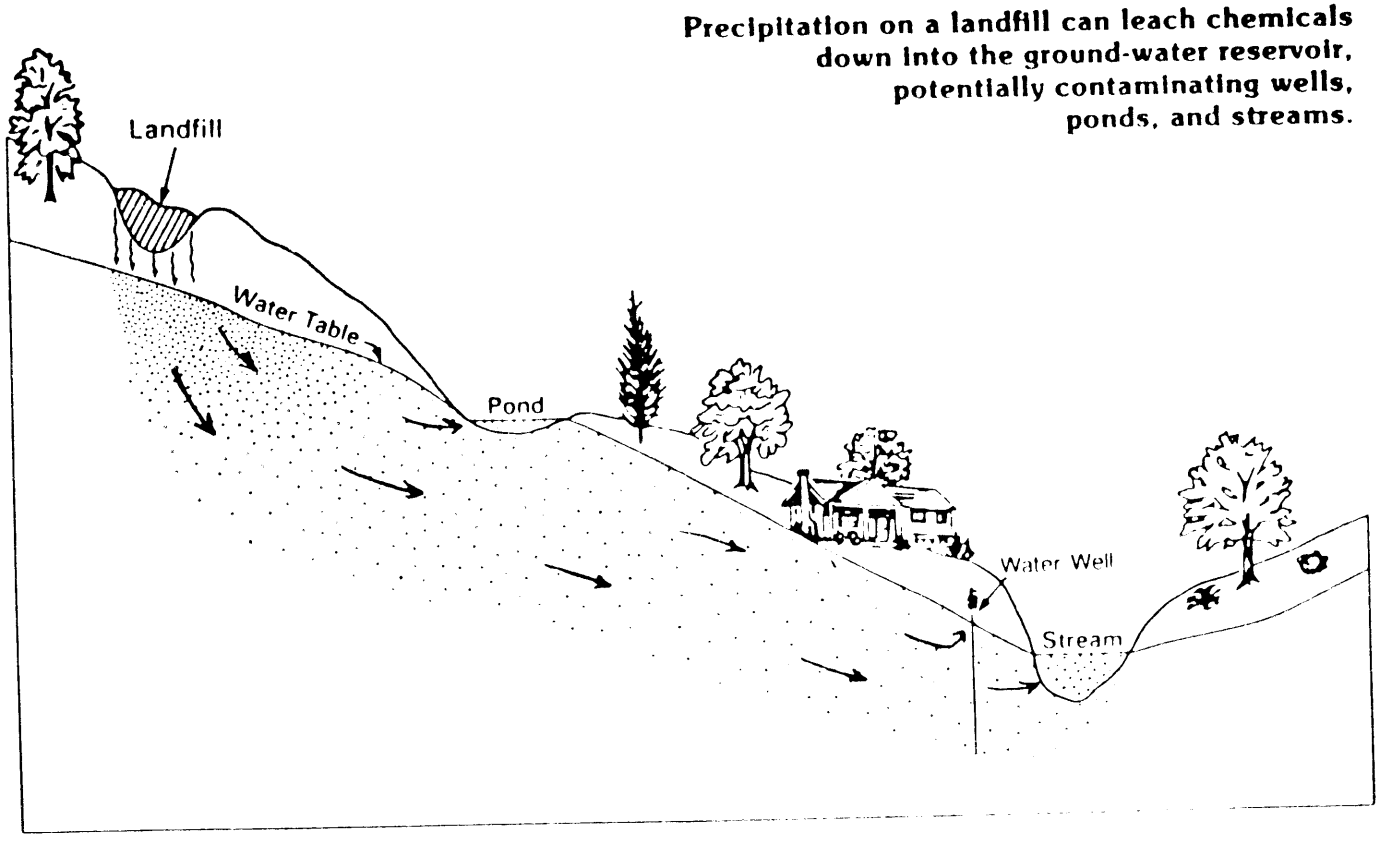


Figure 4. In various parts of the country, rain and snow on a landfill may carry dissolved substances downward, delivering pollutants to the ground water. The degree of hazard depends on the geology of the site, design of the landfill, and character of the wastes. Modified from American Institute of Professional Geologists (1984).

Wickersham (1979) indicate the water table in that area should be between 1,150 and 1,175 feet above sea level. These new data obtained by Radian need to be reconciled with the earlier data of Wickersham.

The sandstone beds in the Garber-Wellington aquifer at TAFB are irregular in terms of both their thickness and their distribution, and there are inadequate borehole data to enable characterizing the location and distribution of the principal water-bearing zones. Such data are needed in order to determine the likely pathways for rapid ground-water flow that might carry leachate from a waste-disposal site to other parts of the aquifer. An understanding of the distribution, thickness, permeability, and continuity of these principal water-bearing zones, and the pathways to them, is needed to set up an adequate monitoring-well program for the various waste-disposal sites.

The presence of trichloroethylene (TCE) in 2 wells (wells 18 and 19) in the vicinity of Building 3001 could be a very serious problem. There are insufficient data available on the hydrogeology of the area to enable determination of the source of TCE, the migration path of TCE to the two boreholes, the depth to the contaminated zone in the boreholes, the extent of contamination, and whether the aquifer in that area is permanently damaged and/or contaminated.

In summary, the lack of adequate detailed hydrogeologic data for the TAFB area, and the positioning of monitoring wells without such data, makes me uncertain as to what the long-term effect of the waste-disposal sites will be on the local environment, and particularly upon the Garber-Wellington aquifer.

References Cited

American Institute of Professional Geologists, 1984, Hazardous waste, issues and answers: Arvada, Colorado, American Institute of Professional Geologists, 25 p.

Bingham, R. H., and Moore, R. L., 1975, Reconnaissance of the water resources of the Oklahoma City Quadrangle, central Oklahoma: Oklahoma Geological Survey Hydrologic Atlas 4, 4 sheets, scale 1:250,000.

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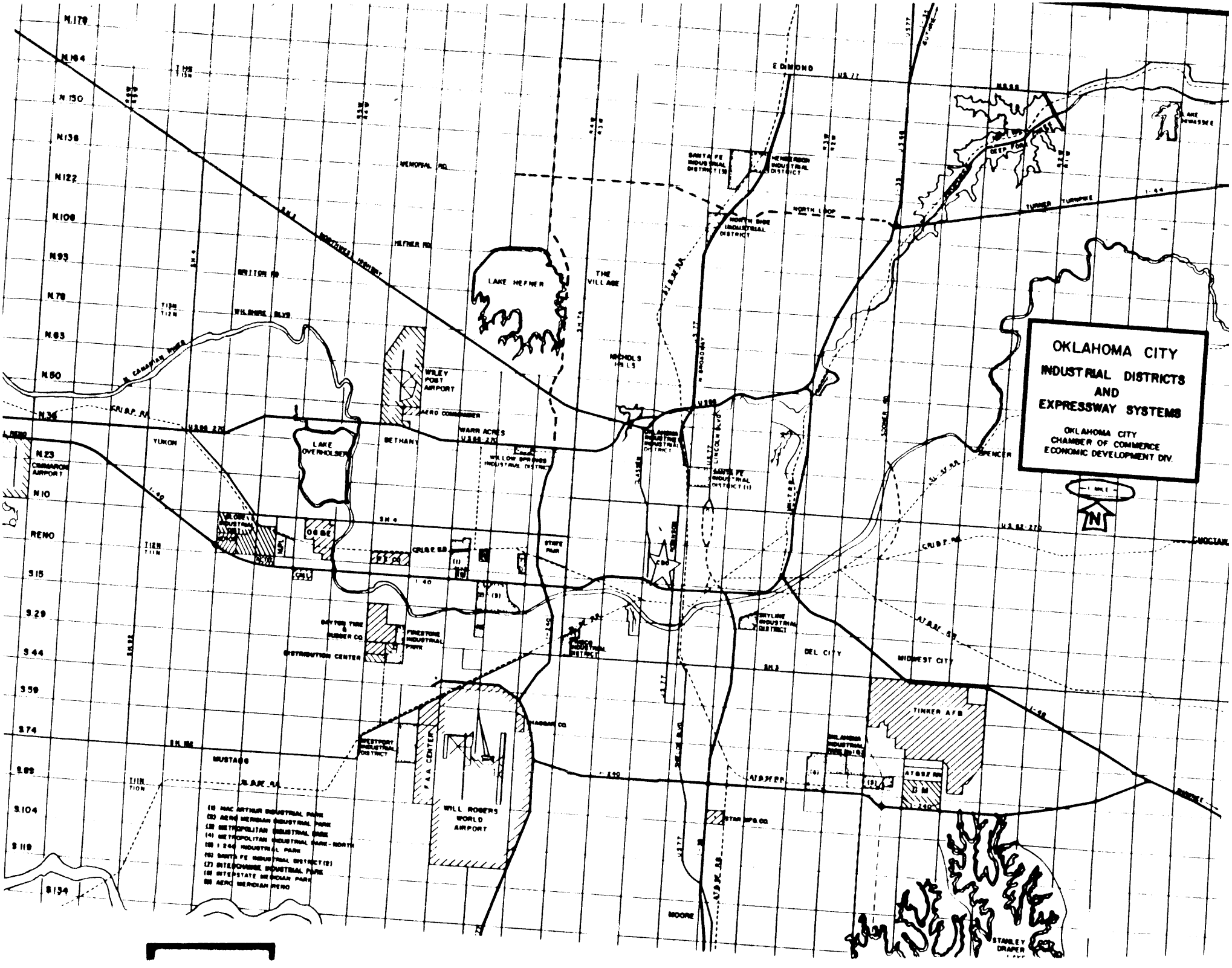
Reference #12

Map: Oklahoma City Industrial Districts and Expressway Systems.
Oklahoma City Chamber of Commerce, Economic Development Division


OKLAHOMA CITY
INDUSTRIAL DISTRICTS
AND
EXPRESSWAY SYSTEMS
OKLAHOMA CITY
CHAMBER OF COMMERCE
ECONOMIC DEVELOPMENT DIV.
EDMOND
LAKE HEFNER
THE VILLAGE
NICHOLS HILLS
WILEY POST AIRPORT
AERO COMMANDER
LAKE OVERHOLSER
BETHANY
WARR ACRES
YUKON
CIMMARON AIRPORT
RENO
MUSTANG
WILL ROGERS WORLD AIRPORT
F.A.A. CENTER
DEL CITY
MIDWEST CITY
TINKER AFB
MOORE
STANLEY DRAPER
SPENCER
LAKE HIWASSEE
NORTH LOOP
TURNER TURNPIKE
MEMORIAL RD.
HEFNER RD.
BRITTON RD.
WILSHIRE BLVD.
SANTA FE INDUSTRIAL DISTRICT (3)
HENDERSON INDUSTRIAL DISTRICT
NORTH SIDE INDUSTRIAL DISTRICT
SANTA FE INDUSTRIAL DISTRICT (1)
WILLOW SPRINGS INDUSTRIAL DISTRICT
SKYLINE INDUSTRIAL DISTRICT
FIRESTONE INDUSTRIAL PARK
DISTRIBUTION CENTER
WESTPORT INDUSTRIAL DISTRICT
STATE FAIR
(1) MAC ARTHUR INDUSTRIAL PARK
(2) AERO MERIDIAN INDUSTRIAL PARK
(3) METROPOLITAN INDUSTRIAL PARK
(4) METROPOLITAN INDUSTRIAL PARK - NORTH
(5) I 240 INDUSTRIAL PARK
(6) SANTA FE INDUSTRIAL DISTRICT (2)
(7) INTERCHANGE INDUSTRIAL PARK
(8) INTERSTATE MERIDIAN PARK
(9) AERO MERIDIAN RENO

Reference #13
Analytical Results, Wells 6A through 6G, 1984. Transmitted by
WM Little, Radian Corp, to Cpt. R.W. Bauer, Tinker AFB.
8/8/84 and 9/13/84

RADIAN
CORPORATION

212-027-21-01

13 September 1984

CPT Robart W. Bauer
USAF OEHL/TS
Brooks AFB, Texas 78235

REF: USAF/RC Contract F33615-83-D-4001, Delivery Order 0021,
Tinker AFB IRP Phase II Stage 2

Dear CPT Bauer:

Enclosed are the analytical results of the GC-MS analyses (EPA Methods 624 and 625) of ground-water samples from Tinker AFB. The EPA 601 (GC) results have been forwarded separately. A sketch map of well locations is also provided.

Please call me if you have any questions.

Sincerely,

William M. Little

William M. Little
Project Director

WML:sg

cc: (w/Encl)
COL Russell, HQ, AFLC
CPT Cornell, Tinker AFB

Enclosures (a/s)

8501 Mo-Pac Blvd. / P.O. Box 9948 / Austin, Texas 78766 / (512)454-4797

RADIAN
CORPORATION

212-027-21-01

13 September 1984

CPT Robart W. Bauer
USAF OEHL/TS
Brooks AFB, Texas 78235

REF: USAF/RC Contract F33615-83-D-4001, Delivery Order 0021,
Tinker AFB IRP Phase II Stage 2

Dear CPT Bauer:

Enclosed are the balance of the analytical results from the ground-water sampling at Tinker AFB. A sketch map of well locations is also provided. Note that a second-column confirmation step was performed for many samples. The GC-MS results for these samples have been forwarded separately.

Please call me if you have any questions.

Sincerely,

William M. Little

William M. Little
Project Director

WML:sg

cc: (w/Encl)
COL Russell, HQ, AFLC
CPT Cornell, Tinker AFB

Enclosures (a/s)

8501 Mo-Pac Blvd / P.O. Box 9948 / Austin, Texas 78766 / (512)454-4797

RADIAN
CORPORATION

212-027-21

9 August 1984

CPT Robart W. Bauer
USAF OEHL/TS
Brooks AFB, Texas 78235

REF: USAF/RC Contract F33615-83-D-4001, Delivery Order 0021,
Tinker AFB IRP Phase II Stage 2

Dear CPT Bauer:

Enclosed are partial analytical results from the first round of groundwater sampling at Tinker AFB. A sketch map of well locations is also provided. Note that a second-column confirmation step was performed for all samples. The GC-MS results for these samples will be forwarded as soon as they are available.

Please call me if you have any questions.

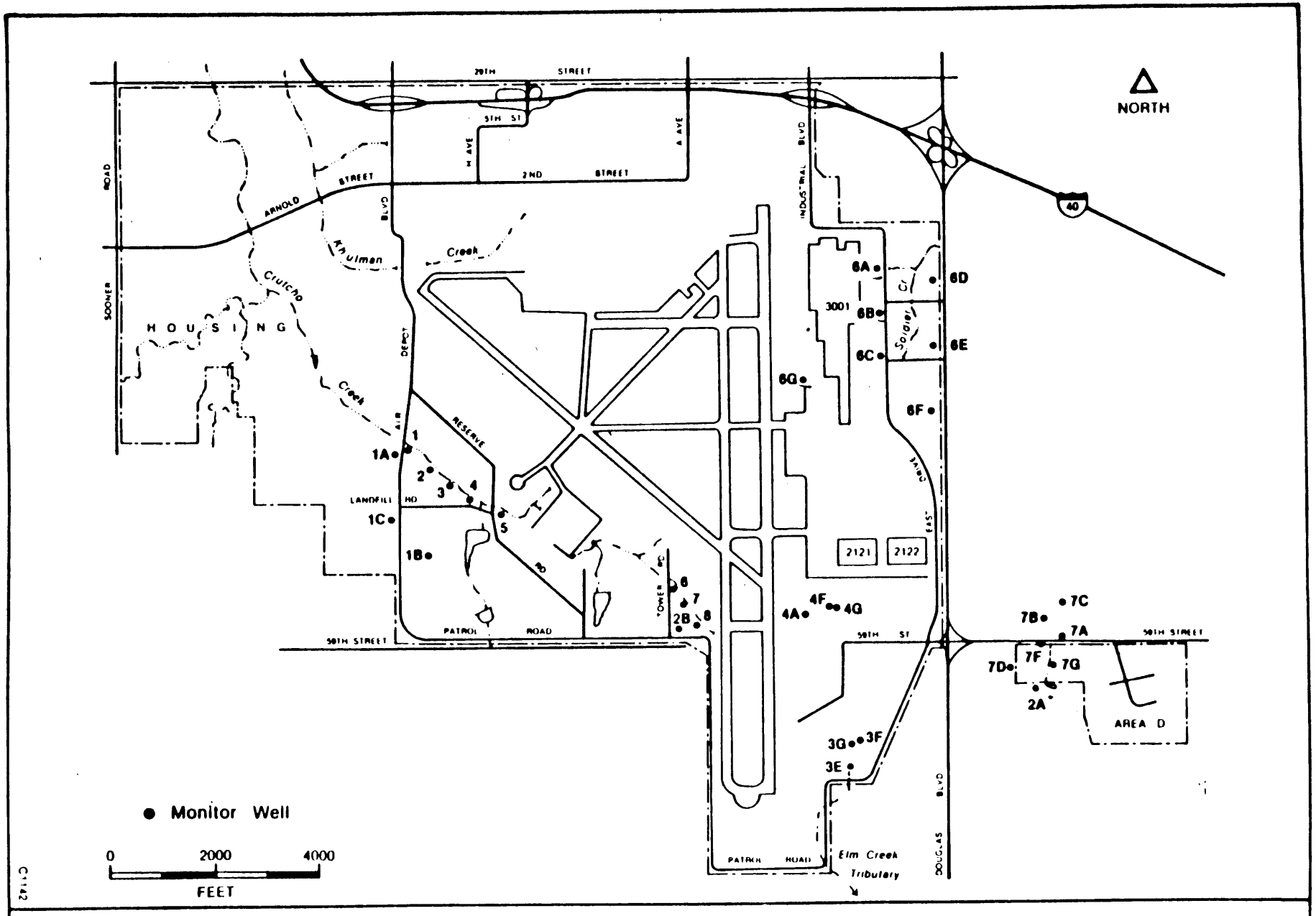
Sincerely,

William M. Little

William M. Little
Project Director

WML:sg
cc: (w/Encl): COL Russell, HQ, AFLC
CPT Cornell, Tinker AFB

8500 Shoal Creek Blvd. / P.O. Box 9948 / Austin, Texas 78766 / (512)454-4797



Monitor Well Locations - Tinker AFB.

CORPORATION

GE 1 — Analytical Serv — RK ORDER — LAB # 84-07-131

IENT: TINKER — CON: CONOVER — CAT: DO_21 — RCVD: 07/23/84 DUE: 08/06/84

PROJ: — GROUP #0 — 07/27/84 09:13:48 — STAT: TRANSMITTED 07/24/84

MPANY Tinker AFB
FACIL

REP William Little
PHONE Radian

RK ID USAF, Well Water
TAKEN 7/18/84, Nancy Stein
TRANS federal express
TYPE H2O

REPORT Radian
TO Bl 4
Austin

ATTEN William Little

NVOICE Accounting
TO Radian
Austin
Building 6
ATTEN David Browning
P.O. # 212-027-21-05

	TRANSMIT	REPORTED	INVOICED	TOTAL $
PREV	07/24/84			
FIRST				

RK ORDER COMMENTS

INVOICE BY	R		
% SURCHARGE			
% DISC: ALL			
TEST/JOB			
# REP/INV	3	3	
SAMPLES	6		
KEEP FOR	60		
KEEP TIL	10/05/84	07	16
DISP	D		
QUOTED $	3605.00		
SAMPLE $	4000.00	11	5
MISC $			
TOTAL $	3605.00		
INV #			
CREATED	07/24/84		
WRITTEN	07/27/84		
TRANSMIT	07/24/84		
COMPLETE			
REPORTED			
INVOICED			

DEPTS/ TESTS		DASH	SAMPLE IDENTIFICATION	JOB
		Q1A	6A	
		Q1B	6A	
		Q1C	6A	
		Q2A	6B	
		Q2B	6B	
		Q2C	6B	
		Q3A	6C	
		Q3B	6C	
		Q3C	6C	
		Q4A	7G	
		Q4B	7G	
		Q4C	7G	
		Q5A	14F	5/6 7F
		Q5B	14F	
		Q5C	14F	
		Q6A	Trip Blank	

624 | 625

59

CORPORATION

PAGE 5 Analytical Serv WORK ORDER LAB # 84-07-131

CLIENT: TINKER CON: CONOVER CAT: DO_21 RCVD: 07/23/84 DUE: 08/06/84

PROJ: GROUP #0 FRACTION DESCRIPTIONS STAT: TRANSMITTED 07/24/84

DASH #06A ID Trip Blank 07/24/84 STORED Sac-VOA JOB

CATEGORY WHEN COLLECTED 07-MS 624

SAMPLE AND WORK DESCRIPTION

RECEIVED: 07/23/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-131
Continued From Above

SAMPLE ID 6A

FRACTION 01B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 624, (Federal Register, 12/3/79).

RECEIVED: 07/23/84

Analytical Serv REPORT LAB # 84-07-131
Results by Sample

SAMPLE ID 6A

FRACTION 01B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

DATA FILE 4CU07131V01 DATE INJECTED 07/25/84 ANALYST BWB VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 1

NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND
2V		3V	acrylonitrile	ND
3V		4V	benzene	ND
6V		6V	carbon tetrachloride	ND
7V		7V	chlorobenzene	ND
15V		10V	1,2-dichloroethane	ND
27V		11V	1,1,1-trichloroethane	ND
14V		13V	1,1-dichloroethane	ND
28V		14V	1,1,2-trichloroethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND
9V		16V	chloroethane	ND
4V		17V	bis (chloromethyl) ether	ND
10V		19V	2-chloroethylvinyl ether	ND
11V		23V	chloroform	ND
16V		29V	1,1-dichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND
17V		32V	1,2-dichloropropane	ND
18V		33V	cis-1,3-dichloropropylene	ND
18V		33V	trans-1,3-dichloropropylene	ND
19V		38V	ethylbenzene	ND
22V		44V	methylene chloride	ND
21V		45V	methyl chloride	ND
20V		46V	methyl bromide	ND
5V		47V	bromoform	ND
12V		48V	dichlorobromomethane	ND
30V		49V	trichlorofluoromethane	ND
13V		50V	dichlorodifluoromethane	ND
8V		51V	chlorodibromomethane	ND
24V		85V	tetrachloroethylene	ND
25V		86V	toluene	ND
29V	313	87V	trichloroethylene	779
31V		88V	vinyl chloride	ND

Analytical Serv .EPORT
Results by Sample

LAB # 84-07-112
Continued From Above

:EIVED: 07/20/84

1PLE ID 6A

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

TES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

b3

GE 2
CEIVED: 07/20/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-112

MPLE ID 6A

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/25/84 ANALYST RGS MCL VERIFIED BY JSG
NC. FACTOR 1 INSTRUMENT b COMPOUNDS DETECTED 9

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	1.2
2	1,1-Dichloroethene	1.7
3	1,1-Dichloroethane	1.4
4	trans-1,2-Dichloroethene	18.1
	Chloroform	ND
5	1,2-Dichloroethane	2.6
6	1,1,1-Trichloroethane	4.2
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
7	1,2-Dichloropropane	0.3
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
8	Trichloroethene	642
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
9	Tetrachloroethylene *	4.7
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

RECEIVED: 08/02/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-020
Continued From Above

SAMPLE ID 6A

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

PAGE 2
RECEIVED: 08/02/84

Analytical Serv REPORT LAB # 84-08-020
Results by Sample

SAMPLE ID 6A FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE A DATE INJECTED 08/09/84 ANALYST RAM VERIFIED BY JSG
CONC FACTOR INSTRUMENT a COMPOUNDS DETECTED 9

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
1	Methylene Chloride	1.4
	Trichlorofluoromethane	ND
2	1,1-Dichloroethene	0.8
3	1,1-Dichloroethane	1.3
	trans-1,2-Dichloroethene	ND
4	Chloroform	9.9
5	1,2-Dichloroethane	2.0
6	1,1,1-Trichloroethane	2.5
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
7	1,2-Dichloropropane	0.2
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
8	Trichloroethene	444
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
9	1,1,2,2-Tetrachloroethane #	2.7
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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:ECEIVED: 07/20/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-112
Continued From Above

SAMPLE ID 6B

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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4

IVED: 07/20/84

Analytical Serv REPORT LAB # 84-07-112

Results by Sample

LE ID 6B

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

ATA FILE B DATE INJECTED 07/25/84 ANALYST RGS VERIFIED BY JSG

FACTOR INSTRUMENT b COMPOUNDS DETECTED 9

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
1	Methylene Chloride	0.9
2	Trichlorofluoromethane	2.7
	1,1-Dichloroethene	ND
3	1,1-Dichloroethane	1.4
4	trans-1,2-Dichloroethene	33.2
	Chloroform	ND
	1,2-Dichloroethane	ND
5	1,1,1-Trichloroethane	0.2
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
6	Trichloroethene	102
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
7	Tetrachloroethylene *	1.7
8	Chlorobenzene	1.3
	1,3-Dichlorobenzene	ND
9	1,2-Dichlorobenzene	1.1
	1,4-Dichlorobenzene	ND

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RECEIVED: 08/02/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-020
Continued From Above

SAMPLE ID 6B

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/02/84

Analytical Serv REPORT LAB # 84-08-020
Results by Sample

SAMPLE ID 6B

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST RAM VERIFIED BY JSG
CONC. FACTOR INSTRUMENT b COMPOUNDS DETECTED 2

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
1	Chloroform	19 B
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
2	Trichloroethene	52 B
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
	Tetrachloroethylene *	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

30

RECEIVED: 07/23/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-131
Continued From Above

SAMPLE ID 6B

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 624, (Federal Register, 12/3/79).

RECEIVED: 07/23/84

Analytical Serv REPORT LAB # 84-07-131

Results by Sample

SAMPLE ID 6B

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS

Date & Time Collected 07/18/84 Category

DATA FILE 4CU07131V02 DATE INJECTED 07/25/84 ANALYST BWS VERIFIED BY LAK

DILUTION FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 2

PDEB	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND
2V		3V	acrylonitrile	ND
3V		4V	benzene	ND
6V		6V	carbon tetrachloride	ND
7V		7V	chlorobenzene	ND
15V		10V	1,2-dichloroethane	ND
27V		11V	1,1,1-trichloroethane	ND
14V		13V	1,1-dichloroethane	ND
28V		14V	1,1,2-trichloroethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND
9V		16V	chloroethane	ND
4V		17V	bis (chloromethyl) ether	ND
10V		19V	2-chloroethylvinyl ether	ND
11V		23V	chloroform	ND
16V		29V	1,1-dichloroethylene	ND
26V	214	30V	1,2-trans-dichloroethylene	48

NPDEB	SCAN	EPA	COMPOUND	RESULT
17V		32V	1,2-dichloropropane	ND
18V		33V	cis-1,3-dichloropropylene	ND
18V		33V	trans-1,3-dichloropropylene	ND
19V		38V	ethylbenzene	ND
22V		44V	methylene chloride	ND
21V		45V	methyl chloride	ND
20V		46V	methyl bromide	ND
5V		47V	bromoform	ND
12V		48V	dichlorobromomethane	ND
30V		49V	trichlorofluoromethane	ND
13V		50V	dichlorodifluoromethane	ND
8V		51V	chlorodibromomethane	ND
24V		85V	tetrachloroethylene	ND
25V		86V	toluene	ND
29V	316	87V	trichloroethylene	134 ug/l
31V		88V	vinyl chloride	ND

56

ECEIVED: 07/20/84

Analytical Serv REPORT
Results by Sample

LAB # 84-07-112
Continued From Above

AMPLE ID 6C FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

OTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

74

ECEIVED: 07/20/84

Analytical Serv REPORT LAB # 84-07-112
Results by Sample

AMPLE ID 6C FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/26/84 ANALYST RGS VERIFIED BY JSG
ONC. FACTOR 1 INSTRUMENT b COMPOUNDS DETECTED 7

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	3.9
	1,1-Dichloroethene	ND
2	1,1-Dichloroethane	0.3
3	trans-1,2-Dichloroethene	2.9
4	Chloroform	0.7
	1,2-Dichloroethane	ND
5	1,1,1-Trichloroethane	106
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
6	Trichloroethene	4.9
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
7	Tetrachloroethylene *	0.7
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

98

RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-003
Continued From Above

SAMPLE ID 6A

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram
All results reported in ug/l unless otherwise specified
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
*Bromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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Analytical Serv REPORT LAB # 84-08-003

Results by Sample

SAMPLE ID

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/08/84 ANALYST MCL VERIFIED BY JSG

CONC FACTOR INSTRUMENT b COMPOUNDS DETECTED 6

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	0.4
	1,1-Dichloroethene	ND
2	1,1-Dichloroethane	0.2
	trans-1,2-Dichloroethene	ND
3	Chloroform	1.6
4	1,2-Dichloroethane	0.3
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
5	Trichloroethene	3.1
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
6	Tetrachloroethylene #	0.2
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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Analytical Serv REPORT
Results by Sample

LAB # 84-07-131
Continued From Above

SAMPLE ID 6C

FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 624. (Federal Register, 12/3/79).

RECEIVED: 07/23/84

Analytical Serv REPORT LAB # 84-07-131
Results by Sample

SAMPLE ID 6C

FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/18/84 Category

DATA FILE 4CU07131V03 DATE INJECTED 07/25/84 ANALYST BWB VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 0

NPDES SCAN	EPA	COMPOUND	RESULT	NPDES SCAN	EPA	COMPOUND	RESULT
1V	2V	acrolein	ND	17V	32V	1,2-dichloropropane	ND
2V	3V	acrylonitrile	ND	18V	33V	cis-1,3-dichloropropylene	ND
3V	4V	benzene	ND	18V	33V	trans-1,3-dichloropropylene	ND
6V	6V	carbon tetrachloride	ND	19V	38V	ethylbenzene	ND
7V	7V	chlorobenzene	ND	22V	44V	methylene chloride	ND
15V	10V	1,2-dichloroethane	ND	21V	45V	methyl chloride	ND
27V	11V	1,1,1-trichloroethane	ND	20V	46V	methyl bromide	ND
14V	13V	1,1-dichloroethane	ND	5V	47V	bromoform	ND
28V	14V	1,1,2-trichloroethane	ND	12V	48V	dichlorobromomethane	ND
23V	15V	1,1,2,2-tetrachloroethane	ND	30V	49V	trichlorofluoromethane	ND
9V	16V	chloroethane	ND	13V	50V	dichlorodifluoromethane	ND
4V	17V	bis (chloromethyl) ether	ND	8V	51V	chlorodibromomethane	ND
10V	19V	2-chloroethylvinyl ether	ND	24V	85V	tetrachloroethylene	ND
11V	23V	chloroform	ND	25V	86V	toluene	ND
16V	29V	1,1-dichloroethylene	ND	29V	87V	trichloroethylene	ND
26V	30V	1,2-trans-dichloroethylene	ND	31V	88V	vinyl chloride	ND

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IPLE ID 6D FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

TES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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Analytical Serv REPORT
Results by Sample

LAB # 84-07-090

MPLE ID 6D

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/24/84 ANALYST RGS VERIFIED BY JSG
NC. FACTOR INSTRUMENT b COMPOUNDS DETECTED 7

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
1	Methylene Chloride	2.0
2	Trichlorofluoromethane	1.8
	1,1-Dichloroethene	ND
3	1,1-Dichloroethane	1.7
4	trans-1,2-Dichloroethene	0.4
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
5	Trichloroethene	0.6
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
6	Chlorobenzene	20.5
	1,3-Dichlorobenzene	ND
7	1,2-Dichlorobenzene	8.4
	1,4-Dichlorobenzene	ND

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Analytical Serv REPORT

LAB # 84-08-003

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Results by Sample

Continued From Above

SAMPLE ID 6D

FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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Analytical Serv REPORT
Results by Sample

LAB # 84-08-003

SAMPLE ID :P

FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE b DATE INJECTED 08/08/84 ANALYST MGL VERIFIED BY JSG
CONC FACTOR INSTRUMENT b COMPOUNDS DETECTED 4

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	22.0
2	1,1-Dichloroethene	2.0
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2 Dichloropropane	ND
	trans-1,3 Dichloropropene	ND

SCAN	COMPOUND	RESULT
	Trichloroethene	ND
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
3	Chlorobenzene	21.8
	1,3-Dichlorobenzene	ND
4	1,2-Dichlorobenzene	11.0
	1,4-Dichlorobenzene	ND

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Analytical Serv REPORT
Results by Sample

LAB # 84-08-020
Continued From Above

SAMPLE ID 6D

FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601. (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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Analytical Serv REPORT
Results by Sample

LAB # 84-08-020

SAMPLE ID 6D

FRACTION 03A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B
CONC FACTOR

DATE INJECTED 08/09/84

ANALYST MCL
INSTRUMENT b

VERIFIED BY JSG
COMPOUNDS DETECTED 5

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
1	1,1-Dichloroethane	1.8
	trans-1,2-Dichloroethene	ND
2	Chloroform	0.8
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
3	Trichloroethene	0.5
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
4	Chlorobenzene	34.5
	1,3-Dichlorobenzene	ND
5	1,2-Dichlorobenzene	10.3
	1,4-Dichlorobenzene	ND

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Analytical Serv REPORT
Results by Sample

LAB # 84-07-093
Continued From Above

SAMPLE ID 6D

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/17/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624. (Federal Register, 12/3/79).

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Analytical Serv REPORT LAB # 84-07-043
Results by Sample

SAMPLE ID 6D FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/17/84 Category

DATA FILE 4CU07093V02 DATE INJECTED 07/25/84 ANALYST BWS VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 1

NPDES	SCAN	EPA	COMPOUND	RESULT	NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND	17V		32V	1,2-dichloropropane	ND
2V		3V	acrylonitrile	ND	18V		33V	cis-1,3-dichloropropylene	ND
3V		4V	benzene	ND	18V		33V	trans-1,3-dichloropropylene	ND
6V		6V	carbon tetrachloride	ND	19V		38V	ethylbenzene	ND
7V	481	7V	chlorobenzene	21	22V		44V	methylene chloride	ND
15V		10V	1,2-dichloroethane	ND	21V		45V	methyl chloride	ND
27V		11V	1,1,1-trichloroethane	ND	20V		46V	methyl bromide	ND
14V		13V	1,1-dichloroethane	ND	5V		47V	bromoform	ND
28V		14V	1,1,2-trichloroethane	ND	12V		48V	dichlorobromomethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND	30V		49V	trichlorofluoromethane	ND
9V		16V	chloroethane	ND	13V		50V	dichlorodifluoromethane	ND
4V		17V	bis (chloromethyl) ether	ND	8V		51V	chlorodibromomethane	ND
10V		19V	2-chloroethylvinyl ether	ND	24V		85V	tetrachloroethylene	ND
11V		23V	chloroform	ND	25V		86V	toluene	ND
16V		29V	1,1-dichloroethylene	ND	29V		87V	trichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND	31V		88V	vinyl chloride	ND

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Analytical Serv REPORT
Results by Sample

LAB # 84-08-013
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SAMPLE ID 6D

FRACTION 01B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/31/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624. (Federal Register, 12/3/79).

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Analytical Serv REPORT LAB # 84-08-013
Results by Sample

SAMPLE ID 6D

FRACTION 01B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/31/84 Category

DATA FILE 4CU08013V01 DATE INJECTED 08/02/84 ANALYST BWS VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 1

NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND
2V		3V	acrylonitrile	ND
3V		4V	benzene	ND
6V		6V	carbon tetrachloride	ND
7V	475	7V	chlorobenzene	30
15V		10V	1,2-dichloroethane	ND
27V		11V	1,1,1-trichloroethane	ND
14V		13V	1,1-dichloroethane	ND
28V		14V	1,1,2-trichloroethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND
9V		16V	chloroethane	ND
4V		17V	bis (chloromethyl) ether	ND
10V		19V	2-chloroethylvinyl ether	ND
11V		23V	chloroform	ND
16V		29V	1,1-dichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND

NPDES	SCAN	EPA	COMPOUND	RESULT
17V		32V	1,2-dichloropropane	ND
18V		33V	cis-1,3-dichloropropylene	ND
18V		33V	trans-1,3-dichloropropylene	ND
19V		38V	ethylbenzene	ND
22V		44V	methylene chloride	ND
21V		45V	methyl chloride	ND
20V		46V	methyl bromide	ND
5V		47V	bromoform	ND
12V		48V	dichlorobromomethane	ND
30V		49V	trichlorofluoromethane	ND
13V		50V	dichlorodifluoromethane	ND
8V		51V	chlorodibromomethane	ND
24V		85V	tetrachloroethylene	ND
25V		86V	toluene	ND
29V		87V	trichloroethylene	ND
31V		88V	vinyl chloride	ND

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Analytical Serv REPORT

Results by Sample

LAB # 84-08-003
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SAMPLE ID 8

FRACTION Q4A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,1,2-tetrachloroethane and tetrachloroethylene co-elute.

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Analytical Serv REPORT LAB # 84-08-003

Results by Sample

SAMPLE ID 01 FRACTION 04A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST MCL VERIFIED BY JSG

CONC FACTOR INSTRUMENT b COMPOUNDS DETECTED 0

SCAN	COMPOUND	RESULT	SCAN	COMPOUND	RESULT
	Chloromethane	ND		Trichloroethene	ND
	Bromomethane	ND		Dibromochloromethane *	ND
	Vinyl Chloride	ND		1,1,2-Trichloroethane *	ND
	Chloroethane	ND		cis-1,3-Dichloropropene *	ND
	Methylene Chloride	ND		2-Chloroethylvinyl Ether	ND
	Trichlorofluoromethane	ND		Bromoform	ND
	1,1-Dichloroethene	ND		1,1,2,2-Tetrachloroethane #	ND
	1,1-Dichloroethane	ND		Tetrachloroethylene #	ND
	trans-1,2-Dichloroethene	ND		Chlorobenzene	ND
	Chloroform	ND		1,3-Dichlorobenzene	ND
	1,2-Dichloroethane	ND		1,2-Dichlorobenzene	ND
	1,1,1-Trichloroethane	ND		1,4-Dichlorobenzene	ND
	Carbon Tetrachloride	ND			
	Bromodichloromethane	ND			
	1,2-Dichloropropane	ND			
	trans-1,3-Dichloropropene	ND			

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Analytical Serv REPORT
Results by Sample

LAB # 84-08-167
Continued From Above

SAMPLE ID 6E

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601. (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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Analytical Serv REPORT
Results by Sample

LAB # 84-08-167

SAMPLE ID 6E

FRACTION 01A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE: A
CONC. FACTOR

DATE INJECTED 08/23/84

ANALYST MCL
INSTRUMENT A

VERIFIED BY JSQ
COMPOUNDS DETECTED 0

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
	Trichloroethene	ND
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
	Tetrachloroethylene *	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-013
Continued From Above

SAMPLE ID 6E

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/30/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624, (Federal Register, 12/3/79).

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Analytical Serv REPORT LAB # 84-08-013
Results by Sample

SAMPLE ID 6E

FRACTION 02B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/30/84 Category

DATA FILE 4CU08013V02 DATE INJECTED 08/02/84 ANALYST BWS VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 1

NPDES SCAN	EPA	COMPOUND	RESULT	NPDES SCAN	EPA	COMPOUND	RESULT
1V	2V	acrolein	ND	17V	32V	1,2-dichloropropane	ND
2V	3V	acrylonitrile	ND	18V	33V	cis-1,3-dichloropropylene	ND
3V	4V	benzene	ND	18V	33V	trans-1,3-dichloropropylene	ND
6V	6V	carbon tetrachloride	ND	19V	38V	ethylbenzene	ND
7V	7V	chlorobenzene	ND	22V	44V	methylene chloride	ND
15V	10V	1,2-dichloroethane	ND	21V	45V	methyl chloride	ND
27V	11V	1,1,1-trichloroethane	ND	20V	46V	methyl bromide	ND
14V	13V	1,1-dichloroethane	ND	5V	47V	bromoform	ND
28V	14V	1,1,2-trichloroethane	ND	12V	48V	dichlorobromomethane	ND
23V	15V	1,1,2,2-tetrachloroethane	ND	30V	49V	trichlorofluoromethane	ND
9V	16V	chloroethane	ND	13V	50V	dichlorodifluoromethane	ND
4V	17V	bis (chloromethyl) ether	ND	8V	51V	chlorodibromomethane	ND
10V	19V	2-chloroethylvinyl ether	ND	24V	85V	tetrachloroethylene	ND
11V	23V	chloroform	ND	25V 453	86V	toluene	61
16V	29V	1,1-dichloroethylene	ND	29V	87V	trichloroethylene	ND
26V	30V	1,2-trans-dichloroethylene	ND	31V	88V	vinyl chloride	ND

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Results by Sample

Continued From Above

SAMPLE ID 6F

FRACTION 05A TEST CODE GC 601 NAME EPA Method 601/GC

Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram
All results reported in ug/l unless otherwise specified
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute

RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-003
Results by Sample

SAMPLE ID 6F

FRACTION 05A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST MGL VERIFIED BY JSG
CONC FACTOR 1 INSTRUMENT 6 COMPOUNDS DETECTED 2

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	0.5
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2 Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
2	Trichloroethene	0.1
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

RECEIVED: 08/16/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-167
Continued From Above

SAMPLE ID 6F

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

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Analytical Serv REPORT
Results by Sample

LAB # 84-08-167

SAMPLE ID 6F

FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE A
CONC. FACTOR

DATE INJECTED 08/23/84

ANALYST MCL
INSTRUMENT A

VERIFIED BY JSG
COMPOUNDS DETECTED 0

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	ND
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
	Trichloroethene	ND
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

104

RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-013
Continued From Above

SAMPLE ID 6F

FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/30/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624, (Federal Register, 12/3/79).

501

RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-013
Results by Sample

SAMPLE ID 6F FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/30/84 Category

DATA FILE 4CU08013V03 DATE INJECTED 08/02/84 ANALYST BWB VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 0

NPDES SCAN	EPA	COMPOUND	RESULT	NPDES SCAN	EPA	COMPOUND	RESULT
1V	2V	acrolein	ND	17V	32V	1,2-dichloropropane	ND
2V	3V	acrylonitrile	ND	18V	33V	cis-1,3-dichloropropylene	ND
3V	4V	benzene	ND	18V	33V	trans-1,3-dichloropropylene	ND
6V	6V	carbon tetrachloride	ND	19V	38V	ethylbenzene	ND
7V	7V	chlorobenzene	ND	22V	44V	methylene chloride	ND
15V	10V	1,2-dichloroethane	ND	21V	45V	methyl chloride	ND
27V	11V	1,1,1-trichloroethane	ND	20V	46V	methyl bromide	ND
14V	13V	1,1-dichloroethane	ND	5V	47V	bromoform	ND
28V	14V	1,1,2-trichloroethane	ND	12V	48V	dichlorobromomethane	ND
23V	15V	1,1,2,2-tetrachloroethane	ND	30V	49V	trichlorofluoromethane	ND
9V	16V	chloroethane	ND	13V	50V	dichlorodifluoromethane	ND
4V	17V	bis (chloromethyl) ether	ND	8V	51V	chlorodibromomethane	ND
10V	19V	2-chloroethylvinyl ether	ND	24V	85V	tetrachloroethylene	ND
11V	23V	chloroform	ND	25V	86V	toluene	ND
16V	29V	1,1-dichloroethylene	ND	29V	87V	trichloroethylene	ND
26V	30V	1,2-trans-dichloroethylene	ND	31V	88V	vinyl chloride	ND

GE 5 Analytical Serv REPORT LAB # 84-07-090
CEIVED: 07/18/84 Results by Sample Continued From Above

MPLE ID 6G FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

TES AND DEFINITIONS FOR THIS REPORT.

SCAN = scan number or retention time on chromatogram.
All results reported in ug/L unless otherwise specified.
ND = not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
*Dibromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

101

RECEIVED: 07/18/84

Analytical Serv REPORT LAB # 84-07-090
Results by Sample

SAMPLE ID 6G FRACTION 02A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 07/25/84 ANALYST RGS VERIFIED BY JSG
CONC. FACTOR INSTRUMENT b COMPOUNDS DETECTED 6

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
1	Chloroethane	1.1
2	Methylene Chloride	1.9
3	Trichlorofluoromethane	7.6
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
4	Chloroform	4.6
5	1,2-Dichloroethane	4.9
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
6	Trichloroethene	1.3
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane *	ND
	Tetrachloroethylene *	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

RECEIVED 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-003
Continued From Above

SAMPLE ID [illegible]

FRACTION 06A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN - scan number or retention time on chromatogram
All results reported in ug/L unless otherwise specified
ND - not detected at EPA detection limit method 601. (Federal Register, 12/3/79)
#1 bromochloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#2 1,1,2,2 tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/01/84

Analytical Serv REPORT LAB # 84-08-003
Results by Sample

SAMPLE ID 06 FRACTION 06A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE B DATE INJECTED 08/09/84 ANALYST MCL VERIFIED BY JSG
CONC FACTOR: INSTRUMENT b COMPOUNDS DETECTED 3

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
	Chloroethane	ND
	Methylene Chloride	ND
1	Trichlorofluoromethane	1.7
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
	Chloroform	3.8
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
3	Trichloroethene	0.9
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

RECEIVED: 08/02/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-020
Continued From Above

SAMPLE ID GG

FRACTION 04A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

NOTES AND DEFINITIONS FOR THIS REPORT

SCAN -- scan number or retention time on chromatogram
All results reported in ug/L unless otherwise specified
ND -- not detected at EPA detection limit method 601, (Federal Register, 12/3/79).
#Bromodichloromethane, 1,1,2-trichloroethane and cis-1,3-dichloropropene co-elute.
#1,1,2,2-tetrachloroethane and tetrachloroethylene co-elute.

RECEIVED: 08/02/84

Analytical Serv REPORT LAB # 84-08-020
Results by Sample

SAMPLE ID 6G

FRACTION 04A TEST CODE GC 601 NAME EPA Method 601/GC
Date & Time Collected not specified Category

DATA FILE 6 DATE INJECTED 08/09/84 ANALYST MCL VERIFIED BY JSG
CONC. FACTOR INSTRUMENT 3 COMPOUNDS DETECTED 4

SCAN	COMPOUND	RESULT
	Chloromethane	ND
	Bromomethane	ND
	Vinyl Chloride	ND
1	Chloroethane	0.6
2	Methylene Chloride	0.6
	Trichlorofluoromethane	ND
	1,1-Dichloroethene	ND
	1,1-Dichloroethane	ND
	trans-1,2-Dichloroethene	ND
3	Chloroform	1.6
	1,2-Dichloroethane	ND
	1,1,1-Trichloroethane	ND
	Carbon Tetrachloride	ND
	Bromodichloromethane	ND
	1,2-Dichloropropane	ND
	trans-1,3-Dichloropropene	ND

SCAN	COMPOUND	RESULT
4	Trichloroethene	0.6
	Dibromochloromethane *	ND
	1,1,2-Trichloroethane *	ND
	cis-1,3-Dichloropropene *	ND
	2-Chloroethylvinyl Ether	ND
	Bromoform	ND
	1,1,2,2-Tetrachloroethane #	ND
	Tetrachloroethylene #	ND
	Chlorobenzene	ND
	1,3-Dichlorobenzene	ND
	1,2-Dichlorobenzene	ND
	1,4-Dichlorobenzene	ND

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RECEIVED: 08/01/84

Analytical Serv REPORT
Results by Sample

LAB # 84-08-013
Continued From Above

SAMPLE ID 6G

FRACTION 04B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/30/84 Category

NOTES AND DEFINITIONS FOR THIS REPORT.
SCAN = scan number or retention time on chromatogram.
All results reported in ug/l unless otherwise specified.
ND = not detected at EPA detection limit method 624, (Federal Register, 12/3/79).

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RECEIVED: 07/18/84

Analytical Serv REPORT LAB # 84-07-093
Results by Sample

SAMPLE ID 6G, Bldg 3001 FRACTION 03B TEST CODE MS 624 NAME EPA Method 624/GC-MS
Date & Time Collected 07/16/84 Category

DATA FILE 4CU07093V03 DATE INJECTED 07/25/84 ANALYST BWS VERIFIED BY LAK
CONC. FACTOR 1 INSTRUMENT f4 COMPOUNDS DETECTED 3

NPDES	SCAN	EPA	COMPOUND	RESULT	NPDES	SCAN	EPA	COMPOUND	RESULT
1V		2V	acrolein	ND	17V		32V	1,2-dichloropropane	ND
2V		3V	acrylonitrile	ND	18V		33V	cis-1,3-dichloropropylene	ND
3V	336	4V	benzene	47	18V		33V	trans-1,3-dichloropropylene	ND
6V		6V	carbon tetrachloride	ND	19V		38V	ethylbenzene	ND
7V		7V	chlorobenzene	ND	22V	127	44V	methylene chloride	21
15V		10V	1,2-dichloroethane	ND	21V		45V	methyl chloride	ND
27V		11V	1,1,1-trichloroethane	ND	20V		46V	methyl bromide	ND
14V		13V	1,1-dichloroethane	ND	5V		47V	bromoform	ND
28V		14V	1,1,2-trichloroethane	ND	12V		48V	dichlorobromomethane	ND
23V		15V	1,1,2,2-tetrachloroethane	ND	30V		49V	trichlorofluoromethane	ND
9V		16V	chloroethane	ND	13V		50V	dichlorodifluoromethane	ND
4V		17V	bis (chloromethyl) ether	ND	8V		51V	chlorodibromomethane	ND
10V		19V	2-chloroethylvinyl ether	ND	24V		85V	tetrachloroethylene	ND
11V		23V	chloroform	ND	25V	455	86V	toluene	670
16V		29V	1,1-dichloroethylene	ND	29V		87V	trichloroethylene	ND
26V		30V	1,2-trans-dichloroethylene	ND	31V		88V	vinyl chloride	ND

Reference #14
Record of Communication: Drew Puffer, USEPA to WM Little,
Radian Corp. 1/8/85

RECORD OF COMMUNICATION

☑ PHONE CALL ☐ DISCUSSION ☐ FIELD TRIP ☐ CONFERENCE
☐ OTHER (SPECIFY)

(Record of item checked above)

TO: William Little
Radian Corp., Austin TX

FROM: Drew Puffer

DATE: 1/8/85

TIME: 1:50

SUBJECT: Tinker AFB IRP

SUMMARY OF COMMUNICATION

I called Mr. Little in reference to the Tinker AFB monitor well sampling that took place in the summer of 1984.

Mr. Little confirmed that field blanks had been taken during the sampling effort that included monitor wells 6A through 6G. Mr. Little also confirmed that those blanks did not register any contaminants

CONCLUSIONS, ACTION TAKEN OR REQUIRED

INFORMATION COPIES TO:

EPA Form 1300-6 (7-72) REPLACES EPA NO FORMS ... WHICH MAY BE USED UNTIL SUPPLY IS EXHAUSTED.

Reference #15
Analytical Results, Well 16. Transmitted by E.A. Jeffrey, USEPA to Cpt. D.R. Escoriaza, Tinker AFB on 30 Aug. 1982

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

8 0 AUG 1982

Captain Douglas R. Escoriaza
Bio-Sanitary Engineer
Bio-Medical Services Corp, USAF
Tinker Air Force Base
Oklahoma City, OK 73145

Dear Captain Escoriaza:

I am forwarding the analytical results of the VOC analyses performed on the six samples collected at various points at Tinker Air Force Base during April 1982. Small amounts of THM's were found at Well No. 7, and small amounts of cis/trans-1,2-dichloroethylene, trichloroethylene, and tetrachloroethylene were found in Well No. 16. The latter concentrations are very similar to those found in the initial sample collected in March 1981. I am wondering if Well No. 16 was also the location of the March 1981 sample. Can you confirm this?

These concentrations are low and are of no immediate health concern. Their mere presence in the water, however, should cause concern. If you can determine the source would you please let me know.

Sincerely yours,

Edgar A. Jeffrey, P.E.
State Program Manager
Public Water Supply Section

Enclosures

cc: Mike Harrell, w/enclosures

bcc: Official Files, 6WSP
Branch Reading Files, 6WS
Reading Files, 6WSP

Jeffrey 8/30/82
6WSP:JEFFREY:az:X1762:08/30/82

CONCURRENCES

SYMBOL	6WSP							
SURNAME	GRAHAM							
DATE	8/26/82							

EPA Form 1320-1 (12-70) OFFICIAL FILE COPY

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GRO WATER SUPPLY SURVEY RESAMPLE DATASHEET

SAMPLE SITE: TINKER AFB
WELL #16 - BLDG 862505
OKLAHOMA CITY OK
ATTN: MAJ. MCELWEY

SAMPLE NO: 2641-36 SAMPLING DATE: 04 19 82
PWS NO:

EPA
Health Advisory

PARAMETERS	RESULTS (UG/L)	
CHLOROFORM	<0.2	
BROMODICHLOROMETHANE	<0.2	
DIBROMOCHLOROMETHANE	<0.5	
BROMOFORM	<1.0	
DICHLOROIODOMETHANE	<1.0	
VINYL CHLORIDE	<1.0	
1,1-DICHLOROETHYLENE	<0.2	
1,1-DICHLOROETHANE	<0.2	
CIS- AND/OR TRANS-1,2-DICHLOROETHYLENE	2.1 ✓	70 µg/l long term
1,2-DICHLOROETHANE	<0.5	
1,1,1-TRICHLOROETHANE	<0.2	
CARBON TETRACHLORIDE	<0.2	
1,2-DICHLOROPROPANE	<0.2	
TRICHLOROETHYLENE	4.2 ✓	80 µg/l long term
1,1,2-TRICHLOROETHANE	<0.5	
1,1,1,2-TETRACHLOROETHANE	<0.2	
TETRACHLOROETHYLENE	0.61 ✓	20 µg/l long term
1,1,2,2-TETRACHLOROETHANE	<0.5	
CHLOROBENZENE	<0.5	
1,2-DIBROMO-3-CHLOROPROPANE	<5.0	
BENZENE	<0.5	
TOLUENE	<0.5	
ETHYLBENZENE	<0.5	
BROMOBENZENE	<0.5	
ISOPROPYLBENZENE	<0.5	
M-XYLENE	<0.2	
STYRENE	<0.5	
O- + P-XYLENE	<0.2	
N-PROPYLBENZENE	<0.5	
O-CHLOROTOLUENE	<0.5	
P-CHLOROTOLUENE	<0.5	
M-DICHLOROBENZENE	<0.5	
O-DICHLOROBENZENE	<0.5	
P-DICHLOROBENZENE	<0.5	

< MINIMUM QUANTIFIABLE LIMITS

Reference #16
Letter: David W. McElway, Major, USAF to E.A. Jeffrey, USEPA
30 Sept. 1982

DEPARTMENT OF THE AIR FORCE
USAF HOSPITAL, TINKER (AFLC)
TINKER AIR FORCE BASE, OKLAHOMA 73145

30 SEP 1982

REPLY TO ATTN OF: SGB (Capt Cornell/7844)

SUBJECT: Tinker AFB Well Water-Halogenated Compound Contamination

E.H.

TO: Edgar A. Jeffrey
Public Water Supply Section
U. S. Environmental Protection Agency, Region VI
1201 Elm
Dallas, Texas 75270

1. The analysis of well waters collected in March 1981 and April 1982 do not present significant problems to Tinker AFB. The 1981 sample was taken from the water works laboratory on base while it's companion 1982 sample was obtained from well number 16-located about 400 feet northwest. The 1982 well samples averaged about 30% less and had significantly less toulene and TOC than those taken from the laboratory in 1981 (see attached sheet).

2. Well number 7-which contained the trihalomethanes - is located 900 feet southeast from the pesticide storage and mixing area and is downgradient from the Oklahoma 507TAC Maintenance Operations.

3. We plan to sample well 7 and adjacent well 6 in addition to taking surface stream samples during the next months to insure that chlorinated hydrocarbon levels are not increasing significantly.

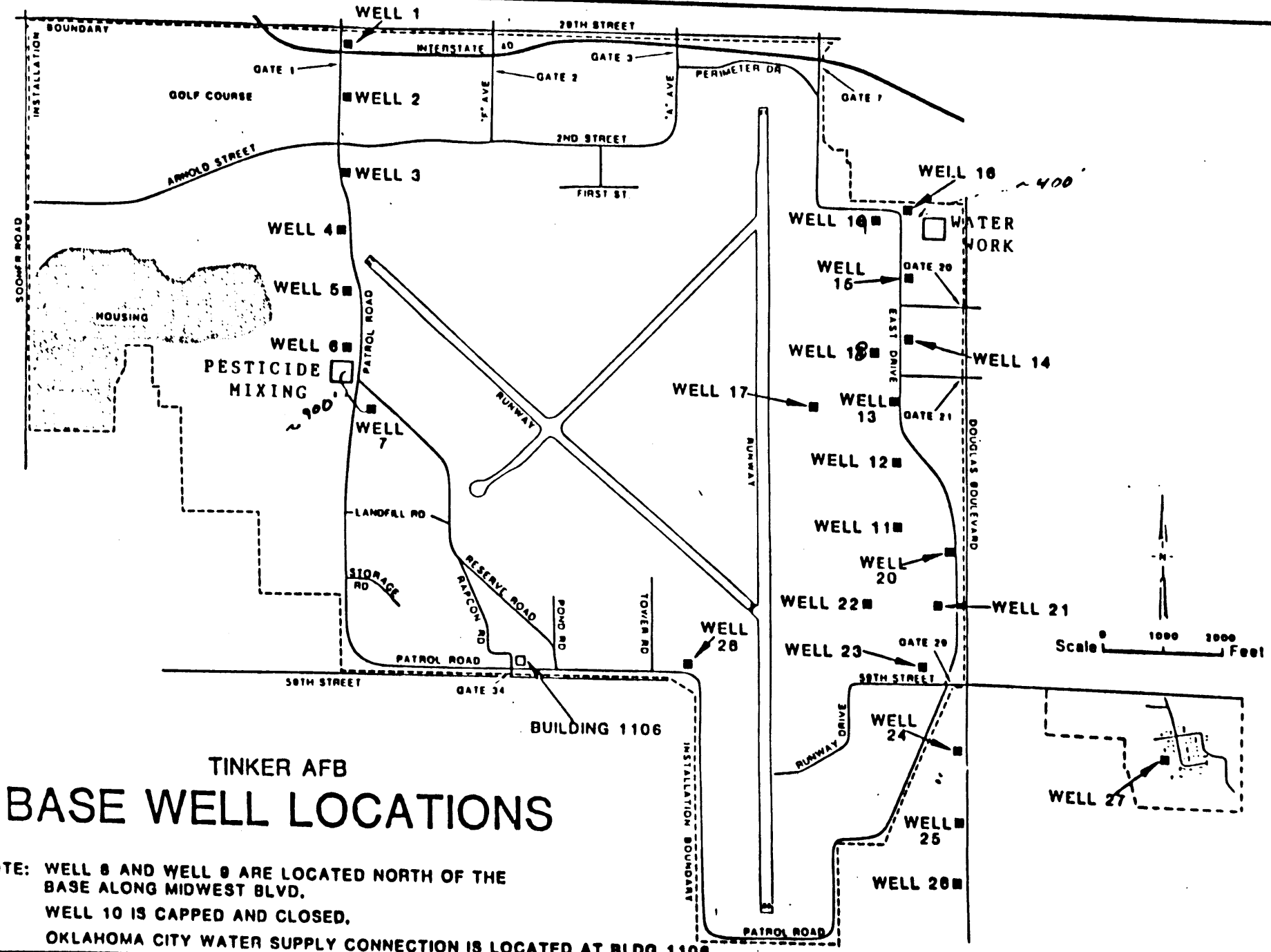
D.W. McElwey

DAVID W. McELWEY, MAJOR, USAF, BSC
Chief, Bioenvironmental Engineering Division

1 Atch: Base Well Locations
Copy to: 2854CES/DEEX

RECEIVED
OCT 04 1982
EPA GAWS
REGION VI

AFLC - Lifeline of the Aerospace Team



TINKER AFB

BASE WELL LOCATIONS

NOTE: WELL 8 AND WELL 9 ARE LOCATED NORTH OF THE BASE ALONG MIDWEST BLVD.
WELL 10 IS CAPPED AND CLOSED.
OKLAHOMA CITY WATER SUPPLY CONNECTION IS LOCATED AT BLDG 1106.

SOURCE: TINKER AFB DOCUMENTS

FIGURE 3.1

Reference #17
Analytical Results from Ground Water Supply Study. Transmitted by Ed. Jeffrey, USEPA, to Mike Harrell. 3/2/82

Date 3/282

ROUTING AND TRANSMITTAL SLIP

TO: (Name, office symbol, room number, building, Agency/Post)	Initials	Date
Mike Harrell		
2.		
3.		
4.		
5.		

Action		File		Note and Return	
Approval		For Clearance		Per Conversation	
As Requested		For Correction		Prepare Reply	
Circulate		For Your Information		See Me	
Comment		Investigate		Signature	
Coordination		Justify			

REMARKS

I am enclosing analytical results of samples collected during the Ground Water Supply Study conducted by EPA during the spring and summer of 1981. Only Tinker AFB had results greater than detectable limits (except for trace of toluene in Woodward). Per our phone conversation, I have contacted Capt. Excoriaza at Tinker to arrange for resamplin there. Enclosed is a copy of guidance prepared by Headquarters for responding to inquires about ~~dected~~ detected con-rations. If you have any questions call me. +e

Tinker, El Reno, USDA SW LvStck, Vance, Moore, Perkins, Roger Mills RWS, Altus, Woodward

DO NOT use this form as a RECORD of approvals, concurrences, dispositions, clearances, and similar actions

FROM: (Name, org. symbol, Agency/Post)	Room No.—Bldg.
Ed Jeffrey EJ	Phone No.

5041-102

OPTIONAL FORM 41 (Rev. 7-76)
Prescribed by GSA
FPMR (41 CFR) 101-11.206

* GPO : 1980 O - 311-116 (34)

GROUND WATER SUP

SAMPLE SITE: WOODWARD WATER

WOODWARD
ATTN:

SAMPLE NO: 0226-36-04
PWS NO: 2007701
POPULATION SERVED: 990
TOTAL PRODUCTION (MGD): 991

POSITIVE PARAMETERS

TOLUENE

GROUND WATER SUP

SAMPLE SITE: TINKER AFB

OKLAHOMA CITY
ATTN: DAVID

SAMPLE NO: 0641-36-04
PWS NO:
POPULATION SERVED: 10000.
TOTAL PRODUCTION (MGD): 5.1

POSITIVE PARAMETERS

CIS- AND/OR TRANS-1,2-DICHLOR
TRICHLOROETHYLENE
TETRACHLOROETHYLENE
TOLUENE

RECEIVE

MAR 0 1 1982

EPA 6AWS
REGION VI

GROUND WATER SUPPLY SURVEY DATASHEET

SAMPLE SITE: WOODWARD WATER

WOODWARD OK
ATTN:

SAMPLE NO: 0226-36-04 SAMPLING DATE: 07 19 81
PWS NO: 2007701
POPULATION SERVED: $$$ NUMBER OF WELLS: $$$
TOTAL PRODUCTION (MGD): $$$ NO. OF WELLS SAMPLED: $$$

POSITIVE PARAMETERS	RESULTS (UG/L)
TOLUENE	2.40

GROUND WATER SUPPLY SURVEY DATASHEET

SAMPLE SITE: TINKER AFB

OKLAHOMA CITY OK 73145
ATTN: DAVID BURRIS

SAMPLE NO: 0641-36-04 SAMPLING DATE: 03 18 81
PWS NO:
POPULATION SERVED: 18000. NUMBER OF WELLS: 27.
TOTAL PRODUCTION (MGD): 5.1 NO. OF WELLS SAMPLED: 1.

POSITIVE PARAMETERS	RESULTS (UG/L)
CIS- AND/OR TRANS-1,2-DICHLOROETHYLENE	2.70
TRICHLOROETHYLENE	5.60
TETRACHLOROETHYLENE	1.10
TOLUENE	1.50

10 5 - 10 6
0 6

125

GROUND WATER SUPPLY SURVEY DATASHEET

SAMPLE SITE: TINKER AFB

OKLAHOMA CITY OK 73145
ATTN: DAVID BURRIS

SAMPLE NO: 0641-36-04 SAMPLING DATE: 03 18 81
PWS NO:
POPULATION SERVED: 18000. NUMBER OF WELLS: 27.
TOTAL PRODUCTION (MGD): 5.1 NO. OF WELLS SAMPLED: 1.

PARAMETERS	RESULTS (UG/L)
CHLOROFORM	<0.2
BROMODICHLOROMETHANE	<0.2
DIBROMOCHLOROMETHANE	<0.5
BROMOFORM	<1.0
DICHLOROIDOMETHANE	<1.0
VINYL CHLORIDE	<1.0
1,1-DICHLOROETHYLENE	<0.2
1,1-DICHLOROETHANE	<0.2
CIS- AND/OR TRANS-1,2-DICHLOROETHYLENE	2.7
1,2-DICHLOROETHANE	<0.5
1,1,1-TRICHLOROETHANE	<0.2
CARBON TETRACHLORIDE	<0.2
1,2-DICHLOROPROPANE	<0.2
TRICHLOROETHYLENE	5.6
1,1,2-TRICHLOROETHANE	<0.5
1,1,1,2-TETRACHLOROETHANE	<0.2
TETRACHLOROETHYLENE	1.1
1,1,2,2-TETRACHLOROETHANE	<0.5
CHLOROBENZENE	<0.5
1,2-DIBROMO-3-CHLOROPROPANE	<5.0
BENZENE	<0.5
TOLUENE	1.5
ETHYLBENZENE	<0.5
BROMOBENZENE	<0.5
ISOPROPYLBENZENE	<0.5
M-XYLENE	<0.2
STYRENE	<0.5
O- + P-XYLENE	<0.2
N-PROPYLBENZENE	<0.5
O-CHLOROTOLUENE	<0.5
P-CHLOROTOLUENE	<0.5
M-DICHLOROBENZENE	<0.5
O-DICHLOROBENZENE	<0.5
P-DICHLOROBENZENE	<0.5
TOC#	1.1
FREE CHLORINE#	<0.1
TOTAL CHLORINE#	<0.1

< MINIMUM QUANTIFIABLE LIMITS
THESE VALUES ARE IN MG/L

Reference #18
Groundwater Supply Survey, by J.J. Westrick et al., Journal AWWA, pages 52-59. May 1964

The Groundwater Supply Survey

James J. Westrick, J. Wayne Mello, and Robert F. Thomas

The results of the US Environmental Protection Agency, Office of Drinking Water, sampling and analysis of volatile organic compounds (VOCs) in finished water supplies that use groundwater sources are discussed. Concentrations of 29 VOCs in addition to five trihalomethanes and total organic carbon from 945 water supplies were measured. The five most frequently found compounds other than trihalomethanes were trichloroethylene, 1,1,1-trichloroethane, tetrachloroethylene, cis- and/or trans-1,2-dichloroethylene, and 1,1-dichloroethane. Approximately half of the samples were taken from a random list of water systems, which were subdivided into two sets of systems—those serving fewer than 10 000 persons and those serving more than 10 000 persons. The nonrandom samples were taken from systems selected by the states, using groundwater sources that were likely to show VOCs in drinking water. Large systems in the random sample had a significantly higher frequency of occurrence of VOC contamination than small systems and were also more likely to have higher levels of contamination.

Volatile organic compounds (VOCs) are a general category of synthetic organic chemicals that include low-molecular-weight, volatile aliphatic and aromatic hydrocarbons, many of which are halogenated. Their presence in groundwater supplies has been reported with increasing frequency. To supplement existing data on the occurrence of VOCs in drinking water for purposes of developing regulatory alternatives,[1] the US Environmental Protection Agency (USEPA), Office of Drinking Water (ODW), Technical Support Division (TSD), Cincinnati, Ohio, conducted a sampling and analysis program in 1981 and 1982. The objectives were: (1) to provide additional data for estimating the nationwide occurrence of VOCs in drinking water supplied from underground sources, and (2) to collect information about the physical characteristics of the well fields and the surrounding areas to develop a predictive capability for locating contaminated groundwater. Only the occurrence data are discussed here.

The survey consisted of two parts. Half of the sampling and analytical program developed data from a random sample of groundwater supplies obtained from the inventory of public water systems maintained in the Federal Reporting Data System (FRDS), from which 500 supplies were selected. Two subsets were developed: 300 of the systems serve fewer than 10 000 persons and 200 of the systems serve more than 10 000 persons. A second randomly selected two-part list provided replacement sampling sites for cases in which the supplies on the primary list of 500 were inappropriate or nonexistent. This occurred if, for example, a utility had recently begun to purchase its water from another utility that uses a surface water source.

Prior data on the occurrence of VOCs were gathered from samples collected from groundwater systems during the Community Water Supply Survey (CWSS) of 1978.[2] These data were used to estimate the necessary sizes of the samples. During the 1978 survey, the frequency of occurrence of the 10 VOCs for which analyses were conducted among the 300 groundwater systems serving fewer than 10 000 persons was 12 percent of the systems. Of the 29 groundwater systems that serve more than 10 000 persons, 45 percent contained at least one VOC. Using these occurrence frequencies as estimates of what might be found in the new survey, it was determined that sampling 300 small systems and 200 large systems would provide 95 percent confidence limits of ±30 percent and ±15 percent for the estimates of frequencies of occurrence for the small systems and large systems, respectively.

The second part of the survey was used to encourage state agencies to try to identify problem supplies. The purpose of this portion of the survey was not only to expand state involvement but also to provide ODW with some information on the frequency and extent of serious problems, based on the state agency's knowledge of local conditions. Each state was assigned a number of sampling sites roughly proportional to its fraction of the total number of groundwater systems nationwide; this was designated the nonrandom sample. The target number of nonrandom sites was also 500. The state agencies were encouraged to select supplies that might be contaminated by VOCs because of the proximity of the well field to industries, landfills, or other potential sources of contamination. The state agencies were also encouraged to choose water supplies which no VOC data were available in; effort to discover previously unknown instances of contamination.

General procedures

To obtain information from a maximum number of systems that use groundwater sources, one sample of finished water from each utility was collected at a point near the entrance to the distribution system. The VOC concentrations in water supplied from a single well that is not pumped continuously can vary depending on the pumping rate, the schedule, and the hydrodynamics of the plume of contamination. If multiple wells supply a system at a single entry point and some wells are contaminated whereas others are not, the VOC concentrations in the sample at the entry point could vary greatly, depending on which wells were in operation at the time of sampling. In systems with more than one entry point, a single sample would obviously represent only those wells contributing to that entry point. With these limitations in mind, the samples of finished water taken at or near a point of entry would provide a reasonable compromise between information obtained from a sample taken from a single well and that from multiple samples taken throughout the system.

State drinking water agencies played a major role in the planning and execution of this survey. Each state with primary public water system enforcement responsibility (primacy) was contacted through the regional USEPA drinking water offices. Most of the states indicated a willingness to assist in the project. State involvement consisted of reviewing the primary random list for errors or for inappropriate or nonexistent systems, filling in missing information on the randomly selected systems, selecting systems for inclusion in the nonrandom portion of the survey, and providing scheduling information to the TSD project engineer. In most cases state personnel traveled to the sampling sites, collected the samples and site information, and shipped the samples on ice to the TSD laboratory in Cincinnati, Ohio, using sampling supplies provided by TSD. In nonprimacy states and states that were unable to assist in the planning or the sampling because of budgetary or

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other constraints, regional USEPA personnel provided the necessary assistance. Personnel from the TSD collected some samples that were obtainable within reasonable driving distance from Cincinnati or if it was not possible for either state or regional USEPA personnel to travel to the sampling locations.

Logistics

A sampling kit was prepared at TSD for each sampling location. Amber bottles of 60 mL and 250-mL capacity were dosed with a preservative (10 mg mercuric chloride/L), capped with PTFE fluorocarbon-faced septa and screw caps, affixed with preprinted labels that had been stamped with the sample identification numbers, and secured in expanded polystyrene boxes. A shipping blank (a 250-mL bottle containing organic-free water and preservative) was also included with the sampling kit. The shipping blanks were to remain with the sampling kit through all stages of transportation and storage so that the possibility of contamination from the surroundings could be investigated by analyzing the shipping blank.

Samples were received at TSD the day after they were collected. They were unpacked and logged in, and any unusual circumstances were noted. The sample bottles were then placed in storage in a cold room, free of organic vapor contamination, until they were repacked for shipment to the chemical analysis contract laboratory.* Since replicate samples were collected at each site, half the bottles were shipped to the contract laboratory and half were held in cold storage at TSD. This was necessary for quality assurance analysis of duplicates by TSD chemists or for quick-response, in-house verification of the contract laboratory's results.

When the samples were shipped to the contract laboratory, the information was entered into the TSD data system for tracking purposes. Primary analysis of the samples was completed by the contractor within 30 days of collection. The contract laboratory had access to the TSD data system, so upon completion of the analyses for a sample, the data were entered at the contractor's terminal and retrieved by the TSD project engineer in Cincinnati. The results for each sample were examined by the TSD project officer and verified by agreement between the project officer and the contract laboratory project leader after review of quality assurance information. The verified data were then entered into a confirmed data file. Reports of verified data for each USEPA region were periodically distributed to the appropriate USEPA regional office. The regional office then distributed two copies of the data to each state, one of which was forwarded by the state to the utility.

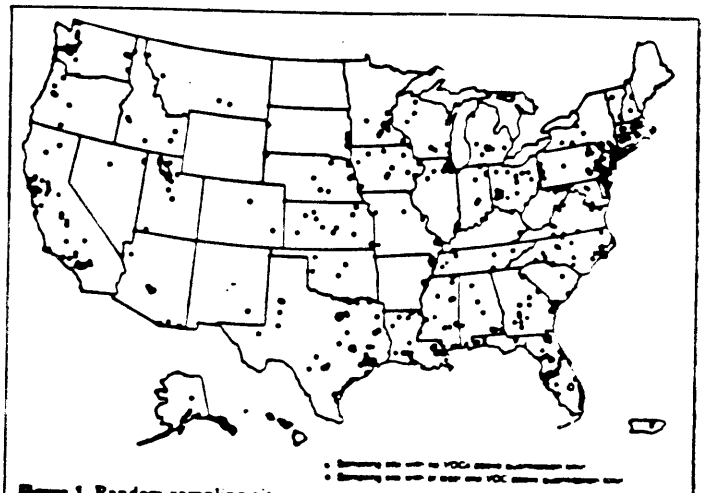

Figure 1. Random sampling sites

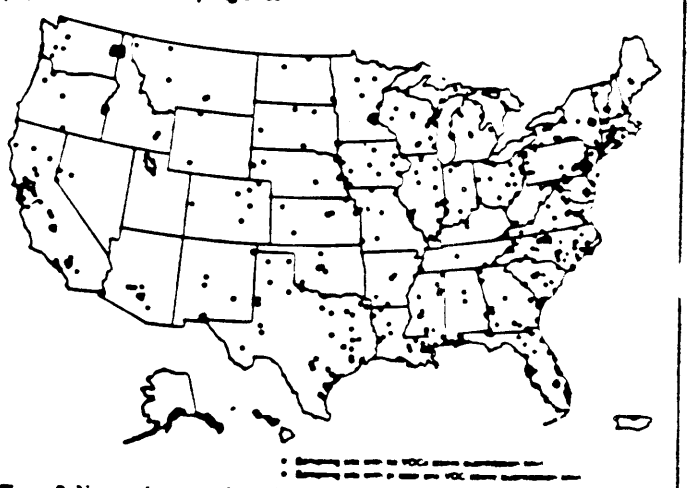

Figure 2. Nonrandom sampling sites

Analytical considerations

A total of 34 parameters were selected for analysis by purge-and-trap gas chromatographic methods (Table 1). However, the emphasis in this article is on the 29 VOCs other than the five trihalomethanes (THMs)—chloroform, bromodichloromethane, dibromochloromethane, dichloroiodomethane, and bromoform. The samples were not dosed with a reducing agent, so the THM formation reaction continued until the time of analysis or until the depletion of either residual chlorine or precursor material.

The two isomers of 1,2-dichloroethylene could not be separately determined by the analysis and thus are considered one parameter. The same is true for ortho- and paraxylenes. Methylene chloride originally was to be determined, but this compound is a widely used laboratory solvent and appears frequently as a laboratory contaminant. Because it was found in all the analyzed shipping blanks, it was impossible to ascertain whether the methylene chloride was originally present in a sample or had come from the surrounding atmosphere. Therefore, results for methylene chloride could not be validated.

The purge-and-trap gas chromatography (GC) analyses were conducted according to USEPA methods 502.1[4] and 503.1[5] with a significant modification. The nondestructive photoionization detector for analysis of aromatics and the

*[illegible] International, Inc., Menlo Park, Calif.

electrolytic conductivity detector for the analysis of halocarbons were coupled in series, allowing analysis for the complete list of 34 compounds with one sample purge. A comparability study conducted prior to the survey showed that serial analysis gave results equivalent to separate analyses for the two types of compounds. This technique proved beneficial in terms of the time and cost required for analysis. An additional benefit resulted from the acquisition of further information by using the two detectors in series. The photoionization detector can assist in identifying and quantifying compounds that coelute from the primary GC column or that have poor responses with the detector.

Quality assurance

When the contract for analytical services was written, a detailed quality assurance protocol was included for monitoring and maintaining the quality of data. This protocol was followed throughout the survey, and the validating data were continually scrutinized by the TSD project officer. Table 2 lists the quality assurances used.

USEPA reference samples. The precision and accuracy of analyses of the halocarbon and aromatic reference samples, which were analyzed weekly, met the quality assurance specifications. This was true for both the primary and confirmatory analytical schemes. The USEPA reference samples contained known concentrations of compounds, including the four common trihalomethanes and nine frequently found VOCs. The precision measure used was the coefficient of variation, the standard deviation of approximately 50 analyses divided by the mean of those values. The precision of the primary analysis of reference samples at levels below 5 μg/L averaged ±13 percent with a range of ±8 percent for tetrachloroethylene to ±22 percent for 1,1,1-trichloroethane. For reference samples containing levels of more than 5 μg/L, the precision ranged from ±6 percent for trichloroethylene to ±20 percent for 1,1,1-trichloroethane. There was an average precision of ±11 percent. Accuracy is indicated by the percent error, that is, the difference between the mean of the measured values and the expected (true) value divided by the expected value. This parameter ranged from 0 percent for tetrachloroethylene at 5.9 μg/L to −19 percent for dibromochloromethane at 2.1 μg/L, with averages of −9 percent below 5 μg/L and −4 percent above 5 μg/L. Negative error indicates that the mean of the measured values was less than the expected value.

Duplicate analyses. As another gauge of precision, the contract called for duplicate analyses to be performed on a minimum of 10 percent of the samples. The duplicates were to agree within 40 percent for compounds present at concentrations of less than 5 μg/L and within 20 percent at concentrations in excess of 5 μg/L. The precision measure used is the percent difference, i.e., 100 times the absolute difference in the duplicate values divided by the mean of the two values. Data were gathered on 16 individual compounds that were present collectively in the duplicate analyses. A total of 84 quantifiable results in concentrations of less than 5 μg/L were duplicated. All but five met the precision criterion. The average percent difference for the quantifiable low-level duplicate results was 17 percent. Eighteen quantifiable pairs of duplicate results in concentrations in excess of 5 μg/L were reported, with four of the 18 falling outside the precision limits. The average precision of the 18 pairs of samples with higher concentrations was 13 percent.

Confirmatory analyses. All samples found or suspected to contain VOCs other than THMs were reanalyzed by using different chromatographic columns that elute the compounds in different orders. In addition, samples containing chloroform at concentrations in excess of 40 μg/L were reanalyzed by using the confirmatory column since chloroform at this level of concentration could mask small quantities of 1,2-dichloroethane. Approximately 33 percent of all samples were reanalyzed by second column chromatography for halocarbons and 6 percent for aromatics. Precision and accuracy of the analyses of the 19 USEPA reference samples for halocarbons and 11 USEPA reference samples for aromatics were documented. All accuracy values were within the contract limits for the primary analyses, and the precision values for all but two of the compounds fell within the error limits of the primary analysis. In addition, approximately 5 percent of all the samples were reanalyzed by gas chromatography-mass spectrometry for additional confirmation and tentative identification of unknown peaks.

Blind samples. Five blind samples were prepared by TSD in the initial phase of the survey to ascertain the contractor's ability to identify particular compounds qualitatively and to measure them quantitatively. The blinds consisted of five different mixtures of compounds, spiked into organic-free distilled water. These were periodically sent to the contractor early in the survey period disguised as survey samples. The mixtures were designed to pose selected anomalies in the analytical system, such as interferences or compounds with similar gas chromatographic retention times. Prior to shipment, the blinds were analyzed by TSD, and these results were compared with those subsequently reported by the contractor. In every case, the contractor correctly identified the spiked compounds. Although no quantitative criteria were established for the blind samples, the percent differences between the contractor's results and TSD-determined concentrations were within the error limits for duplicates for 27 of 32 pairs of values.

TSD analysis of duplicate samples. Replicate samples were collected in separate bottles and stored at TSD so they could be analyzed as an additional check on the contractor's laboratory results. The check samples to be analyzed by TSD were chosen from those that the contractor had reported to contain one or more of the VOCs. The percent differences between the contractor's results and those of TSD were within the error limits for 48 of the 64 pairs of values in excess of the quantitation limits. The error limits used are those established for a single laboratory conducting duplicate analyses of the same sample. Larger percent differences were expected for this comparison since the analyses were done on duplicate samples and analyzed by independent systems. Also, the duplicate samples often contained several compounds at widely varying concentrations, from less than 1 μg/L to more than 100 μg/L.

The quality assurance program was a critical part of the analysis. It consumed a significant portion of the analytical resources and required considerable time and effort from TSD personnel. Careful attention to the monitoring, control, and documentation of the quality of the data resulted in a high degree of confidence that the identification and quantitation of compounds were accurate.

An in-depth description of the analytical quality assurance program for this survey can be found elsewhere.[6,7]

Results

The distribution of all samples is shown in Table 3 and Figures 1 and 2. The final number of random systems was 280 from systems serving fewer than 10 000 persons and 186 from systems serving more than 10 000 persons. The final tally for state-selected sites was 479. The number of random-sample sites in each state was roughly proportional to the number of groundwater systems in that state. The number of nonrandom samples allocated to a state was also based approximately on its number of groundwater systems. Figures 1 and 2 show all sampling locations.

The quantitation limits are not the same for all compounds. In most cases, the quantitation limit is either 0.2 μg/L or 0.5 μg/L. This difference in quantitation limits can confuse the interpretation of the data somewhat, so the results of the survey should be viewed with the differing quantitation limits in mind. Unless otherwise stated, an "occur-

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Random sample occurrences. Tables 4 and 5 summarize occurrences from the random sample for each of the 34 parameters. Table 4 contains data from the random sample of systems serving fewer than 10 000 persons, and Table 5 contains the results for systems serving more than 10 000 persons. These tables list the quantitation limit, the frequency of occurrence, the median concentration of the positive values of each compound, and the highest concentration for each parameter.

Because the two subsets of the random sample were selected independently and because a much higher percentage of large systems than small systems were included (15 percent of roughly 1200 systems serving more than 10 000 and 0.6 percent of nearly 48 000 systems serving fewer than 10 000 persons), the data from the large systems and the small systems were not combined. The normal curve approximation to the binomial distribution for large samples was used to conduct tests of the significance of the difference in frequency of occurrence of compounds in the two subsets of the random sample.[3] The large systems' frequency of occurrence was greater than the small systems' frequency of occurrence for trichloroethylene, cis and/or trans-1,2-dichloroethylene and tetrachloroethylene at the 0.01 significance level and for 1,2-dichloropropane, carbon tetrachloride, and 1,1,1-trichloroethane at the 0.05 significance level. No other significant differences in the occurrence of specific parameters could be discerned between the samples from large systems and those from small systems.

Though the data indicate that the frequency of occurrence of several of the compounds is higher among the larger communities, a similar inference cannot be drawn regarding the severity of contamination from a casual observation of Tables 3 and 4. The highest concentrations of 1,2-dichloropropane, trichloroethylene, and benzene were found in samples from the larger communities, whereas samples from small systems contained the highest levels of 1,1,1-trichloroethane, carbon tetrachloride, and tetrachloroethylene.

Trihalomethanes occurred more frequently in the samples from larger systems, but this could be because a higher percentage of large systems chlorinate their water supplies (85 percent of the large systems versus 56 percent of the smaller systems). The THM concentrations were generally low, although some groundwaters can produce high concentrations of THMs. Again, the different quantitation limits must be considered when the frequency of occurrences and the median of the positive values for THMs are evaluated. Since the samples were normally analyzed after one to four weeks of low-temperature storage, the THM concentrations reported are undoubtedly higher than they would have been had the THM formation reaction been stopped by a reducing agent at the time of sampling. Therefore, the concentrations reported may not be representative of concentrations in the distribution systems. However, the data provide an indication of the tendency for THMs to form in groundwater supplies.

There is no evidence in the literature that chlorination of drinking water

TABLE 1
Specific organic parameters

Contaminant	
Vinyl chloride	1,1,2 Trichloroethane
1,1-Dichloroethylene	1,1,1,2 Tetrachloroethane
1,1-Dichloroethane	1,1,2,2 Tetrachloroethane
cis and/or trans 1,2 Dichloroethylene	Chlorobenzene
1,2-Dichloroethane	1,2-Dibromo-3-chloropropane
1,1,1 Trichloroethane	n-Propylbenzene
Carbon tetrachloride	o-Chlorotoluene
1,2-Dichloropropane	p-Chlorotoluene
Trichloroethylene	m-Dichlorobenzene
Tetrachloroethylene	o-Dichlorobenzene
Benzene	Styrene
Toluene	Isopropylbenzene
Ethylbenzene	Chloroform
Bromobenzene	Bromodichloromethane
m-Xylene	Dibromochloromethane
o + p-Xylene	Dichlorodibromethane
p-Dichlorobenzene	Bromoform

TABLE 2
Quality assurance protocol for the analysis of VOCs

Quality Assurance Analysis	Frequency or Amount	Specified Limits			Source of Sample
		Parameter	<5 μg/L percent	>5 μg/L percent	
USEPA reference samples	1 per week for each instrument	Precision Accuracy	±40 ±40	±20 ±20	Environmental Monitoring Support Laboratory, Cincinnati
Duplicate analyses	10 percent of samples	Agreement	40	20	Survey samples
Confirmatory analyses	100 percent of positives	Qualitative agreement			Survey samples
Blind samples	Variable	None specified			TSD
TSD analyses of duplicate samples	10 percent of positives	None specified			Survey samples

TABLE 3
Number of supplies sampled by state

State	Random	Nonrandom	State	Random	Nonrandom
Alabama	7	5	Nebraska	8	6
Alaska	4	4	Nevada	2	3
Arizona	8	9	New Hampshire	2	4
Arkansas	3	4	New Jersey	17	5
California	34	30	New Mexico	1	6
Colorado	2	6	New York	22	25
Connecticut	8	7	North Carolina	13	31
Delaware	1	1	North Dakota	0	3
Florida	44	31	Ohio	14	15
Georgia	14	13	Oklahoma	4	5
Hawaii	0	2	Oregon	7	7
Idaho	6	8	Pennsylvania	16	26
Illinois	15	12	Rhode Island	1	2
Indiana	8	8	South Carolina	5	11
Iowa	12	13	South Dakota	4	4
Kansas	11	6	Tennessee	6	4
Kentucky	4	3	Texas	41	23
Louisiana	14	10	Utah	8	2
Maine	0	2	Vermont	2	3
Maryland	4	6	Virginia	9	18
Massachusetts	11	4	Washington	19	10
Michigan	8	12	West Virginia	4	5
Minnesota	10	9	Wisconsin	7	13
Mississippi	14	14	Wyoming	0	2
Missouri	6	10	Puerto Rico	2	2
Montana	4	5			

TABLE 4

Summary of occurrences from 280 random sample sites serving fewer than 10 000 persons

Parameter	Quantitation Limit µg/L	Occurrences Number	Occurrences Percent	Median of Positives µg/L	Maximum Value µg/L
Vinyl chloride	1.0	0	0		
1,1-Dichloroethylene	0.2	4	1.4	1.2	6.3
1,1-Dichloroethane	0.2	10	3.6	0.51	3.2
cis and/or trans 1,2-Dichloroethylene	0.2	3	1.1	0.23	1.7
1,2-Dichloroethane	0.5	0	0		
1,1,1 Trichloroethane	0.2	12	4.3	0.32	18
Carbon tetrachloride	0.2	5	1.8	0.37	16
1,2-Dichloropropane	0.2	1	0.4	0.75	0.75
Trichloroethylene	0.2	9	3.2	0.88	40
Tetrachloroethylene	0.2	13	4.6	0.35	23
Benzene	0.5	1	0.4	0.61	0.61
Toluene	0.5	4	1.4	0.62	0.85
Ethylbenzene	0.5	2	0.7	0.94	1.1
Bromobenzene	0.5	3	1.1	1.9	5.8
m-Xylene	0.2	6	2.1	0.32	1.5
o + p-Xylene	0.2	6	2.1	0.34	0.59
p-Dichlorobenzene	0.5	2	0.7	0.60	0.88
1,1,2 Trichloroethane	0.5	0	0		
1,1,1,2 Tetrachloroethane	0.2	0	0		
1,1,2,2 Tetrachloroethane	0.5	0	0		
Chlorobenzene	0.5	0	0		
1,2 Dibromo-3-chloropropane	5.0	1	0.4	5.5	5.5
n-Propylbenzene	0.5	0	0		
o-Chlorotoluene	0.5	0	0		
p-Chlorotoluene	0.5	0	0		
m-Dichlorobenzene	0.5	0	0		
o-Dichlorobenzene	0.5	0	0		
Styrene	0.5	0	0		
Isopropylbenzene	0.5	0	0		
Chloroform	0.2	104	37.1	1.4	140
Bromodichloromethane	0.2	100	35.1	1.4	60
Dibromochloromethane	0.5	87	31.1	2.1	52
Dichloroiodomethane	1.0	2	0.7	2.8	4.1
Bromoform	1.0	44	15.7	2.4	54

TABLE 5

Summary of occurrences from 186 random sample sites serving more than 10 000 persons

Parameter	Quantitation Limit µg/L	Occurrences Number	Occurrences Percent	Median of Positives µg/L	Maximum Value µg/L
Vinyl chloride	1.0	1	0.5	1.1	1.1
1,1-Dichloroethylene	0.2	5	2.7	0.28	2.2
1,1-Dichloroethane	0.2	8	4.3	0.54	1.2
cis and/or trans 1,2-Dichloroethylene	0.2	13	7.0	1.1	2.0
1,2-Dichloroethane	0.5	3	1.6	0.57	0.95
1,1,1 Trichloroethane	0.2	15	8.1	1.0	3.1
Carbon tetrachloride	0.2	10	5.4	0.32	2.8
1,2 Dichloropropane	0.2	5	2.7	0.86	21
Trichloroethylene	0.2	21	11.3	1.0	78
Tetrachloroethylene	0.2	21	11.3	0.52	5.9
Benzene	0.5	2	1.1	9.0	15
Toluene	0.5	2	1.1	2.6	2.9
Ethylbenzene	0.5	1	0.5	0.74	0.74
Bromobenzene	0.5	1	0.5	1.7	1.7
m-Xylene	0.2	2	1.1	0.46	0.61
o + p-Xylene	0.2	2	1.1	0.59	0.91
p-Dichlorobenzene	0.5	3	1.6	0.86	1.3
1,1,2 Trichloroethane	0.5	0	0		
1,1,1,2 Tetrachloroethane	0.2	0	0		
1,1,2,2 Tetrachloroethane	0.5	0	0		
Chlorobenzene	0.5	0	0		
1,2 Dibromo-3-chloropropane	5.0	0	0		
n-Propylbenzene	0.5	0	0		
o-Chlorotoluene	0.5	0	0		
p-Chlorotoluene	0.5	0	0		
m-Dichlorobenzene	0.5	0	0		
o-Dichlorobenzene	0.5	0	0		
Styrene	0.5	0	0		
Isopropylbenzene	0.5	0	0		
Chloroform	0.2	106	57.0	1.6	380
Bromodichloromethane	0.2	101	54.3	1.6	71
Dibromochloromethane	0.5	96	51.6	2.9	89
Dichloroiodomethane	1.0	3	1.6	1.8	4.1
Bromoform	1.0	57	30.6	3.8	50

causes the formation of any of the VOCs other than THMs. There have been reports that commercial chlorine can contain traces of carbon tetrachloride thereby contaminating chlorinated drinking water. Therefore, the carbon tetrachloride occurrence data should be qualified by the possibility that the cause of some occurrences of carbon tetrachloride could be contaminated chlorine.

The data from the random sample of systems serving fewer than 10 000 persons were examined for any other possible effects of chlorination. There was no significant difference in the frequency of occurrences of any VOCs between small systems that chlorinate and those that do not. The larger systems that do not chlorinate are too few in number to provide a valid comparison with larger systems that do chlorinate.

The number and percentage of contaminated supplies in each part of the random sample are listed in Table 6. Of 280 small systems, 47 contained one or more of the 29 VOCs included in the analysis. Of those 47 supplies, 19 had multiple contaminants above the quantitation limit. Of the 186 larger systems, 52 contained at least one contaminant. Of those, 25 supplies contained more than one VOC.

Water samples from 16.8 percent of the systems serving fewer than 10 000 persons and 28 percent of the larger systems' supplies contained at least one VOC. Confidence limits, based on the binomial distribution,[2] were constructed around the point estimates (16.8 and 28 percent) of the probability of VOC occurrences in systems in the two size categories. The confidence interval is simply a function of the observed frequency and the sample size and does not account for uncertainty owing to analytical variability or variation in water quality. The frequency of occurrence in all systems serving fewer than 10 000 persons can be estimated with 95 percent confidence to lie in the range of 12.9–21.7 percent. The large systems' frequency of occurrence can be estimated with 95 percent confidence to lie in the range of 22.1–35 percent. The frequency of occurrence for the large systems was greater than that for the small systems at the 0.01 significance level.

Table 7 shows the supplies by population category with summed VOC concentrations in various ranges of concentrations. For example, there were 88 supplies in the population category of 101–500 persons. Of those 88 supplies, 77 contained no VOC above the quantitation limit, 9 contained one or more of the contaminants with sums of concentrations less than 5.0 µg/L, and 2 had a summed VOC concentration in the range of 11–50 µg/L.

The number and percentage of supplies containing various levels of summed

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VOC concentrations are shown in Table 8. The point estimate of the probability that a system serving more than 10 000 persons contains a summed VOC concentration greater than 5.0 μg/L was 6.5 percent (12 of 186), with a 95 percent confidence interval of 3.8–11 percent. Eight of 280 small systems (2.9 percent) contained a summed VOC concentration greater than 5.0 μg/L, resulting in a 95 percent confidence interval for the estimate of 1.5–5.6 percent. The frequency of occurrence of summed VOC concentrations greater than 5.0 μg/L was higher in large systems than in small systems at the 0.05 significance level.

Nonrandom sample occurrences. The nonrandom sample data are given in Tables 9 through 13. Obviously, higher frequencies and concentrations were found in this sample set than in the random sample. Nearly 25 percent of the large systems and 7 percent of the small systems selected were contaminated with trichloroethylene. Other compounds that appeared frequently included cis- and/or trans-1,2-dichloroethylene, 1,1,1-trichloroethane, tetrachloroethylene, and 1,1-dichloroethane. Of the 131 systems found to be contaminated with VOCs more than half showed the presence of multiple contaminants; the water from one smaller community contained eight VOCs. Trichloroethylene, tetrachloroethylene, and cis- and/or trans-1,2-dichloroethylene were found 18, 11, and 10 times, respectively, in concentrations greater than 5.0 μg/L. Trichloroethylene occurred three times in concentrations greater than 50 μg/L and tetrachloroethylene and cis- and/or trans-1,2-dichloroethylene once each in concentrations greater than 50 μg/L. All xylene occurrences were in supplies serving fewer than 10 000 persons; in fact, only six occurrences of aromatic compounds were found in the larger supplies. Although 1,1,1-trichloroethane was the second most frequently found compound, it was found only four times in concentrations greater than 5.0 μg/L. Of the larger supplies selected, 37 percent had at least one measurable VOC and 18 percent had a summed VOC concentration greater than 5.0 μg/L. Of the smaller systems, 22 percent showed some contamination. The summed VOC concentration exceeded 5.0 μg/L in 5 percent of the samples.

Resampling of contaminated supplies

Approximately 100 contaminated supplies were resampled. The states were asked to resample the finished water and were also given the opportunity to collect several raw water samples of their choosing. In many cases, the original sample point was not resampled or the sampling points were not described well enough to enable comparison of the original sample with the resample.

TABLE 6

Summary of random sample multiple occurrences of contaminants

Number of Contaminants	Population Category: ≤10 000 Persons, Number	≤10 000 Persons, Percent	>10 000 Persons, Number	>10 000 Persons, Percent
0	233	83.2	134	72.1
1	28	10.0	27	14.5
2	10	3.5	8	4.3
3	6	2.1	6	3.2
4	1	0.4	5	2.7
5	1	0.4	3	1.6
6	0	0	2	1.1
7	1	0.4	1	0.5
Total	280		186	

TABLE 7

Summed concentrations[a] of VOCs in random samples

Population	Number of Suppliers With Summed Concentrations of VOCs: Below Quantitation Limit	Quantitation Limit: 5.0 μg/L	5.1–10 μg/L	11–50 μg/L	51–100 μg/L	>100 μg/L
<100	70	9	0	1	0	0
101–500	77	9	0	2	0	0
501–1000	24	2	2	0	0	0
1001–2500	35	4	0	1	0	0
2501–5000	26	8	1	0	1	0
5001–10 000	10	7	0	0	0	0
10 001–100 000	123	38	5	6	1	0
>100 000	11	2	0	0	0	0

[a]Summed concentrations = summation of all VOCs exclusive of THMs.

TABLE 8

Summed concentrations in random samples

Summed Concentrations of VOCs—μg/L	Supplies with Summed Concentrations of VOCs Greater Than Value Shown: Population Category ≤10 000 Persons, Number	≤10 000 Persons, Percent	>10 000 Persons, Number	>10 000 Persons, Percent
>Quantitation limit	47	16.8	52	28.0
>1.0	20	7.1	26	14.0
>5.0	8	2.9	12	6.5
>10	5	1.8	7	3.8
>50	1	0.4	1	0.5
>100	0	0	0	0

An example of data from resampled finished water illustrates some aspects of the groundwater VOC data. Table 14 shows the concentrations of VOCs in two samples of finished water, collected nine months apart, from a single well owned by a small town (city A).

These two samples show much the same pattern of contamination, with a possible slight decrease in concentrations in the second sample. Trichloroethylene, which was counted as an occurrence in the original sample, was not found above the quantification limit in the resample. When the original sample and the resample were from a single well, both usually contained nearly identical patterns of contamination. This increases confidence that the original results were accurate and reinforces the belief that levels of groundwater contamination usually change slowly.

The occurrence of a compound at or near the quantitation limit was often not repeated in the resample. For example, in the 37 supplies resampled from the original point, 25 occurrences in the original sample did not recur in the resample. (Many of the supplies resampled had multiple occurrences.) There were also 16 instances, however, in which a compound that was not found in the original sample was quantified in the resampled finished water. This nonrepeatability occasionally occurred in well samples, such as those shown in Table 14, with low levels of contaminants. This situation could result from either normal analytical variability or from actual changes in concentration at the well. This phenomenon was more common in larger systems in which the finished water was a blend of water from multiple wells with various levels of contamination. In these cases, changes in the concentrations of contaminants could result from changes in the relative contributions of the various wells as

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TABLE 9

Summary of occurrences from 321 nonrandom sample sites serving fewer than 10 000 persons

Parameter	Quantitation Limit µg/L	Occurrences Number	Occurrences Percent	Median of Positives µg/L	Maximum Value µg/L
Vinyl chloride	1.0	0	0		
1,1-Dichloroethylene	0.2	5	1.6	0.35	3.0
1,1-Dichloroethane	0.2	6	1.9	0.62	1.2
cis and/or trans 1,2-Dichloroethylene	0.2	11	3.4	1.3	17
1,2-Dichloroethane	0.5	3	0.9	2.9	3.4
1,1,1-Trichloroethane	0.2	25	7.8	1.2	8.2
Carbon tetrachloride	0.2	9	2.8	0.44	15
1,2-Dichloropropane	0.2	3	0.9	1.2	1.4
Trichloroethylene	0.2	23	7.2	1.2	29
Tetrachloroethylene	0.2	27	8.4	0.79	21
Benzene	0.5	5	1.6	1.6	12
Toluene	0.5	4	1.2	0.67	0.79
Ethylbenzene	0.5	3	0.9	0.87	0.95
Bromobenzene	0.5	2	0.6	0.97	1.2
m-Xylene	0.2	8	2.5	0.38	0.83
o + p-Xylene	0.2	10	3.1	0.44	2.5
p-Dichlorobenzene	0.5	4	1.2	0.74	0.90
1,1,2 Trichloroethane	0.5	0	0		
1,1,1,2 Tetrachloroethane	0.2	0	0		
1,1,2,2 Tetrachloroethane	0.5	0	0		
Chlorobenzene	0.5	1	0.3	2.7	2.7
1,2-Dibromo-3-chloropropane	5.0	0	0		
n-Propylbenzene	0.5	1	0.3	0.98	0.98
o-Chlorotoluene	0.5	0	0		
p-Chlorotoluene	0.5	0	0		
m-Dichlorobenzene	0.5	0	0		
o-Dichlorobenzene	0.5	1	0.3	2.2	2.2
Styrene	0.5	0	0		
Isopropylbenzene	0.5	0	0		
Chloroform	0.2	155	48.3	1.6	100
Bromodichloromethane	0.2	144	44.9	2.0	49
Dibromochloromethane	0.5	135	42.1	3.5	63
Dichlorodibromethane	1.0	5	1.6	1.4	4.2
Bromoform	1.0	88	27.4	3.7	110

TABLE 10

Summary of occurrences from 158 nonrandom sample sites serving more than 10 000 persons

Parameter	Quantitation Limit µg/L	Occurrences Number	Occurrences Percent	Median of Positives µg/L	Maximum Value µg/L
Vinyl chloride	1.0	6	3.8	2.7	8.4
1,1-Dichloroethylene	0.2	10	6.3	0.34	0.64
1,1-Dichloroethane	0.2	17	10.8	0.87	4.2
cis and/or trans 1,2-Dichloroethylene	0.2	27	17.1	2.7	130
1,2-Dichloroethane	0.5	4	2.5	1.8	9.8
1,1,1-Trichloroethane	0.2	26	16.5	0.93	21
Carbon tetrachloride	0.2	6	3.8	0.70	9.4
1,2-Dichloropropane	0.2	4	2.5	0.70	18
Trichloroethylene	0.2	38	24.1	1.5	130
Tetrachloroethylene	0.2	18	11.4	0.86	69
Benzene	0.5	3	1.9	2.7	12
Toluene	0.5	1	0.6	1.5	1.5
Ethylbenzene	0.5	0	0		
Bromobenzene	0.5	0	0		
m-Xylene	0.2	0	0		
o + p-Xylene	0.2	0	0		
p-Dichlorobenzene	0.5	0	0		
1,1,2 Trichloroethane	0.5	0	0		
1,1,1,2 Tetrachloroethane	0.2	0	0		
1,1,2,2 Tetrachloroethane	0.5	0	0		
Chlorobenzene	0.5	0	0		
1,2-Dibromo-3-chloropropane	5.0	0	0		
n-Propylbenzene	0.5	0	0		
o-Chlorotoluene	0.5	1	0.6	2.4	2.4
p-Chlorotoluene	0.5	0	0		
m-Dichlorobenzene	0.5	0	0		
o-Dichlorobenzene	0.5	1	0.6	2.7	2.7
Styrene	0.5	0	0		
Isopropylbenzene	0.5	0	0		
Chloroform	0.2	100	63.3	2.1	430
Bromodichloromethane	0.2	100	63.3	2.2	110
Dibromochloromethane	0.5	87	55.1	4.6	81
Dichlorodibromethane	1.0	8	5.1	1.2	4.1
Bromoform	1.0	60	38.0	5.1	68

determined by their pumping rate. Temporal changes in concentration could also result from a relatively rapid movement of the plume of contamination, which could occur during recharge and withdrawal in a highly permeable aquifer.

The data from resampling of finished water from individual wells reinforced confidence that the identification and quantitation of compounds in the samples were accurate. The data from large multiple-well systems show that concentrations of compounds in a finished water can vary considerably over time. Therefore, sampling a large number of supplies, as in this survey, provides an accurate representation of the percentage of systems with water containing VOCs and an indication of the magnitude of the levels of concentrations.

The variability of the quality of finished water from groundwater supplies is site-specific and not amenable to definition by a national survey such as this. In the face of this variability, the sampling approach was a compromise between providing broad national coverage and obtaining representative samples at each site.

Conclusion

The groundwater supply survey was undertaken primarily to strengthen the body of data on the occurrence of VOCs in groundwater supplies. Careful attention was paid to quality assurance so that a reliable representation of the occurrence of VOCs in US groundwater supplies would result. The frequencies of occurrence of 29 volatile compounds were documented in samples collected from 466 randomly selected communities and from 479 communities selected by the state agencies. The three most frequently detected compounds were trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane. The percentages of supplies containing at least one VOC above the quantitation limit in the subsets of the survey were: random sample of systems serving fewer than 10 000 persons, 16.8 percent; random sample of systems serving more than 10 000 persons, 28 percent; nonrandom sample of systems serving fewer than 10 000 persons, 22.4 percent; and nonrandom sample of systems serving more than 10 000 persons, 37.3 percent. The percentages of supplies containing summed VOC concentrations in finished water greater than 5 µg/L were: random sample of systems serving fewer than 10 000 persons, 2.9 percent; random sample of systems serving more than 10 000 persons, 6.5 percent; nonrandom sample of systems serving fewer than 10 000 persons, 4.7 percent; and nonrandom sample of systems serving more than 10 000 persons, 17.7 percent.

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TABLE 11

Summary of nonrandom sample multiple occurrences of contaminants

Number of Contaminants	Population Category: ≤10 000 Persons, Number	≤10 000 Persons, Percent	>10 000 Persons, Number	>10 000 Persons, Percent
0	249	77.6	99	62.7
1	35	10.9	19	12.0
2	15	4.7	14	8.9
3	11	3.4	7	4.4
4	7	2.2	7	4.4
5	2	0.6	7	4.4
6	0	0	4	2.6
7	1	0.3	1	0.6
8	1	0.3	0	0
Total	321		158	

TABLE 12

Summed concentrations of VOCs in nonrandom samples*

Population	Number of Supplies With Summed Concentrations of VOCs: Below Quantitation Limit	Quantitation Limit: 5.0 µg/L	5.1-10 µg/L	11-50 µg/L	51-100 µg/L	>100 µg/L
<100	24	10	1	0	0	0
101-500	38	4	0	1	0	0
501-1000	27	5	0	2	0	0
1001-2500	62	8	0	1	0	0
2501-5000	43	18	0	2	0	0
5001-10 000	35	12	4	4	0	0
10 001-100 000	85	29	6	13	3	2
>100 000	14	2	0	3	0	1

*Summed concentrations = summation of all VOCs exclusive of THMs

TABLE 13

Summed concentration levels in nonrandom samples

Summed Concentrations of VOCs—µg/L	Supplies with Summed Concentrations of VOCs Greater Than Value Shown: Population Category ≤10 000 Persons, Number	≤10 000 Persons, Percent	>10 000 Persons, Number	>10 000 Persons, Percent
>Quantitation limit	72	22.4	59	37.3
>1.0	41	12.8	43	27.2
>5.0	15	4.7	28	17.7
>10	10	3.1	22	13.9
>50	0	0	6	3.8
>100	0	0	3	1.9

TABLE 14

VOCs found in original sample and resample in city A

Parameter	June 1981 µg/L	March 1982 µg/L
1,1-Dichloroethane	0.62	0.51
1,1,1-Trichloroethane	1.9	1.4
Trichloroethylene	0.21	<0.2
Tetrachloroethylene	1.3	0.94

dom sampling showed significant differences in the frequency of occurrences of VOCs in the larger and smaller community subsets. The results of the random sample were also used to construct statistical confidence limits of estimates of the probabilities of occurrence.

The nonrandom portion of the sample provided additional data on the high side of the occurrence curve, since the sites were selected in hopes of finding a greater frequency of higher levels of contamination. For example, six of the eight supplies with summed VOC concentrations greater than 50 µg/L were from the nonrandom sample, including all three of the supplies with summed VOC concentrations greater than 100 µg/L.

Resampling of contaminated supplies strengthened confidence in the quality of the analytical data. It also showed that finished water quality, with respect to VOCs, can vary over time, especially in systems supplied by multiple wells.

Additional analysis of the data generated by this survey will appear in documents prepared by the USEPA in support of VOC regulatory recommendations.

Acknowledgments

The authors acknowledge those who assisted in this sampling and analysis program: the SRI International analysis team, led by Barbara Kingsley; members of the Office of Drinking Water in Washington, D.C., and Cincinnati, Ohio, who participated in the planning and execution of the project and in the preparation and review of this document, including Victor J. Kimm, Lowell A. Van Den Berg, Joseph A. Cotruvo, Arnold M. Kuzmack, Herbert J. Brass, Craig Vogt, David Schnare, Eric Bissonette, Richard Johnston, Waymon Wallace, Jane Gruber, Audrey Kroner, Dale Ruhter, and William Coniglio; the USEPA regional water supply personnel who coordinated and monitored the survey, and, in some cases, carried out the activities in their regions; and the personnel of the state drinking water agencies.

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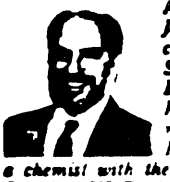

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Reference #19

Oklahoma Water Quality Standards - 1982. Publication 111.
Oklahoma Water Resources Board

OKLAHOMA'S

Water Quality Standards

1982

PUBLICATION 111

OKLAHOMA WATER RESOURCES BOARD
P.O. BOX 53585, 1000 NE 10th, 12TH FLO
OKLAHOMA CITY, OKLAHOMA 73152

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4 Class II irrigation with class I irrigation as a goal if natural conditions permit
5 Class III irrigation with class I irrigation as a goal if natural conditions permit

STREAM ORDER 1 2 3 4 5 6	STREAM SEGMENT	PUBLIC & PRIVATE WATER SUPPLY	EMERGENCY WATER SUPPLY	FISH & WILDLIFE PROPAGATION	AGRICULTURE	HYDROELECTRIC POWER	W & I COOLING WATER	PRIMARY RECREATION	SECONDARY RECREATION	NAVIGATION	AESTHETICS	SMALLMOUTH BASS	TROUT FISHERIES		LIMITATIONS	REMARKS
Okemah Lake and Watershed	520700	●		1	●		●	●	●		●				a	
Salt Creek	520700	●		1	●		●	●	●		●					
Camp Creek below Stroud Lake	520700	●		1	●		●	●	●		●					
Stroud Lake and Watershed	520700	●		1	●		●	●	●		●				a	
Dry Creek	520700	●		1	●		●	●	●		●					
Deer Creek	520700	●		1	●		●	●	●		●					
Robinson Creek	520700	●		1	●		●	●	●		●					
Quapaw Creek	520700	●		1	●		●	●	●		●					
Meeker Lake and Watershed	520700	●		1	●		●	●	●		●				a	
Bellcow Creek	520700	●		1	●		●	●	●		●					
Chandler Lake and Watershed	520700	●		1	●		●	●	●		●				a	
Kickapoo Creek	520700	●		1	●		●	●	●		●					
East Captain Creek	520700	●		1	●		●	●	●		●					
Bear Creek	520700	●		1	●		●	●	●		●					
DEEP FORK OF CANADIAN RIVER from Bear Creek to Coffee Creek	520710	●		●	●		●	●	●		●					△
Coffee Creek	520710	●		●	●		●	●	●		●					△
DEEP FORK OF CANADIAN RIVER above Coffee Creek and watershed	520710	●		1	●		●	●	●		●				a	

W.Q. Basin No. 5, Sheet 3

BENEFICIAL USE CODES

● Indicates designated beneficial use
○ Indicates a goal for the continuous attainment of the beneficial use (the beneficial use applies when dilution capacity is sufficient)
1 Primary warm water fishery
2 Secondary warm water fishery with primary warm water fishery as a goal
3 Class I irrigation
4 Class II irrigation with class I irrigation as a goal if natural conditions permit
5 Class III irrigation with class I irrigation as a goal if natural conditions permit

STREAM ORDER 1 2 3 4 5 6	STREAM SEGMENT	PUBLIC & PRIVATE WATER SUPPLY	EMERGENCY WATER SUPPLY	FISH & WILDLIFE PROPAGATION	AGRICULTURE	HYDROELECTRIC POWER	W & I COOLING WATER	PRIMARY RECREATION	SECONDARY RECREATION	NAVIGATION	AESTHETICS	SMALLMOUTH BASS	TROUT FISHERIES		LIMITATIONS	REMARKS
Bad Creek	520500	●		1	●		●	●	●		●					
Weleetka Lake and Watershed	520500	●		1	●		●	●	●		●				a	
Wewoka Creek	520500	○		2	●		●	○	●		●					
Fish Creek	520500	●		1	●		●	●	●		●					
Grief Creek	520500	●		1	●		●	●	●		●					
Little Wewoka Creek	520500	●		1	●		●	●	●		●					
Wewoka Lake and Watershed	520500	●		1	●		●	●	●		●				a	
Turkey Creek	520510	●		1	●		●	●	●		●					
Tecumseh Lake and Watershed	520510	●		1	●		●	●	●		●				a	
Shawnee Twin Lakes and Watershed	520510	●		1	●		●	●	●		●				a	
North Deer Creek	520510	●		1	●		●	●	●		●					
NORTH CANADIAN RIVER from Lincoln County Line to Portland Street Bridge, Oklahoma City	520520	○		2	4		●	○	●		●					
Choctaw Creek	520520	○		2	●		●	○	●		●					
Crutcho Creek	520520	○		2	●		●	○	●		●					
Crooked Oak Creek	520520			●	●		●		●		●					△
NORTH CANADIAN RIVER from Portland Street Bridge to Lake Overholser Dam	520520	●		1	4		●	●	●		●					
Mustang Creek	520520	○		1	●		●	○	●		●					

Reference #20
Record of Communication: Drew Puffer, USEPA to Capt. Cornell,
Tinker AFB. 11/5/84

RECORD OF COMMUNICATION

☑ PHONE CALL ☐ DISCUSSION ☐ FIELD TRIP ☐ CONFERENCE
☐ OTHER (SPECIFY)
(Record of item checked above)

TO	FROM	DATE / TIME
Captain Cornell Tinker AFB	Drew Puffer	11/5/84 12:30

SUBJECT
Tinker AFB IRP

SUMMARY OF COMMUNICATION

I called Captain Cornell to find out why some areas of concern to EPA had been omitted from the Phase II B workplan, and why other areas did not recieve investigations that were thorough enough to define problems in those areas. Capt. Cornell stated that planning and budgeting are often completed before new information comes into play that might change the workplan. Once work is budgeted, it is costly to revise the plan & budget. This explains why only one monitoring well has been set up at Landfill #6 and the lack of volatile organic sampling by Tinker for all samples. Capt. Cornell says that these plan and budget constraints are the reason more investigation has not been done for Bldg. #3001. Currently there are six monitoring wells to east of Bldg #3001, two of which show TCE (≅ 100 PPB); the two contaminated wells are along East Drive, and are the Northern and middle wells along that drive.

Regarding well #18, which is a contaminated base well, a T.V. scan

CONCLUSIONS, ACTION TAKEN OR REQUIRED

of the casing was performed; the scan showed a significant split in the casing @ 140' with liquid pouring into the well from that split. Smaller cracks in the casing were also found. Capt. Cornell said Tinker is scheduling a meeting for early December to allow EPA and the State of Oklahoma to comment on the Phase II B and up coming work. Tinker will also share

INFORMATION COPIES

TO
Wright, Nott

EPA Form 1320-4 (7-72) REPLACES EPA NO FORM 1320-4 WHICH MAY BE USED UNTIL SUPPLY IS EXHAUSTED.

unpublished data with us at that time.

Note: The Phase II B Draft recieved by EPA is a working draft. The final

Reference #21
Record of Communication: Kelly Nash, USEPA to T. Perdue, USEPA
1/30/85, with attachment of Midwest City well locations

RECORD OF COMMUNICATION

☐ PHONE CALL ☑ DISCUSSION ☐ FIELD TRIP ☐ CONFERENCE
☐ OTHER (SPECIFY)
(Record of item checked above)

Tim Perdue Superfund Compliance (6AW-SC)	FROM: Kelly Nash Ofc. of Groundwater 6W	DATE 1/30/85 TIME 3:45 pm

SUBJECT
Tinker AFB Ranking Info. - Midwest City Well Locations

SUMMARY OF COMMUNICATION

In order to obtain information on groundwater uses near TAFB for MITRE ranking I contacted Ed Jeffrey, Reg. Public Water Supply Sect. (6W-PS) who is the Project Officer for the Okla. PWS program. Mr. Jeffrey showed me an inventory from the Oklahoma State Department of Health which gave the number of users, no. of wells and a general location of the wellfield which indicated that some of the wells may have been within 3 miles of the site. Mr. Jeffrey contacted Bob Crow, PWS engineer with OSDH, who was able to supply locations for 36 wells which were known to be active. Using a USGS 7½' quad. map I was able to find 16 wells w/in 3mi. - these were circled.

CONCLUSIONS, ACTION TAKEN OR REQUIRED

Please let me know if you need more information (x2768)

INFORMATION COPIES TO: Perdue (6AW-SC)

EPA Form 1300-6 (7-72) REPLACES EPA HQ FORM 8300-3 WHICH MAY BE USED UNTIL SUPPLY IS EXHAUSTED.

Midwest City Oklahoma - PWS Well Locations

Info from Bob Crow
OSDH 405-271-7379

Well #	Location			
1	S 1/2	Sec 10	11N	2W
1	S 1/2	10	11N	2W
2				
3	–	10	11N	2W
4	–	10	11N	2W
6	SE 1/4	4	11N	2W
8	NE 1/4	10	11N	2W
9	SE 1/4	3	11N	2W
10	SE 1/4	3	"	"
11	–	3	"	"
12	–	34	"	"
13	–	2	"	"
14	NE 1/4	3	"	"
15				
16	SW 1/4	34	12N	2W
17	SE 1/4	34	11N	2W
18	NW 1/4	34	12N	2W
19	SW 1/4	34	"	"
20	SE 1/4	34	"	"
21	—	11	11N	2W
22	SE 1/4	33	12N	2W
23	—	2	11N	2W
24	NE 1/4	34	12N	2W
25	NW 1/4	4	11N	2W
26	NW 1/4	4	11N	2W
27	SW 1/4	25	"	"
28	SW 1/4	1	"	"
32				
33				
34				
35	NE 1/4	12	11N	2W
37	NW 1/4	35	12N	2W
38	NW 1/4	35	12N	2W
39	NW 1/4	35	12N	"
40	SW 1/4	31	12N	1W
41				
42	NE 1/4	36	12N	2W
44	NW 1/4	22	12N	2W
48	SW 1/4	33	12N	1W
49	NW 1/4	2	11N	2W
50	NE 1/4	2	11N	2W
51	SW 1/4	26	12N	2W
52				

Lot 17 Blk 1

Circled wells are w/in 3 mi. of Tinker Well #16 KW

16 of 43 active wells (at least)

Lot 1 Blk 5

Wells are blended into system. No way of getting # customers/well

Lot 16 Blk 9
1 1
22 1

1 1

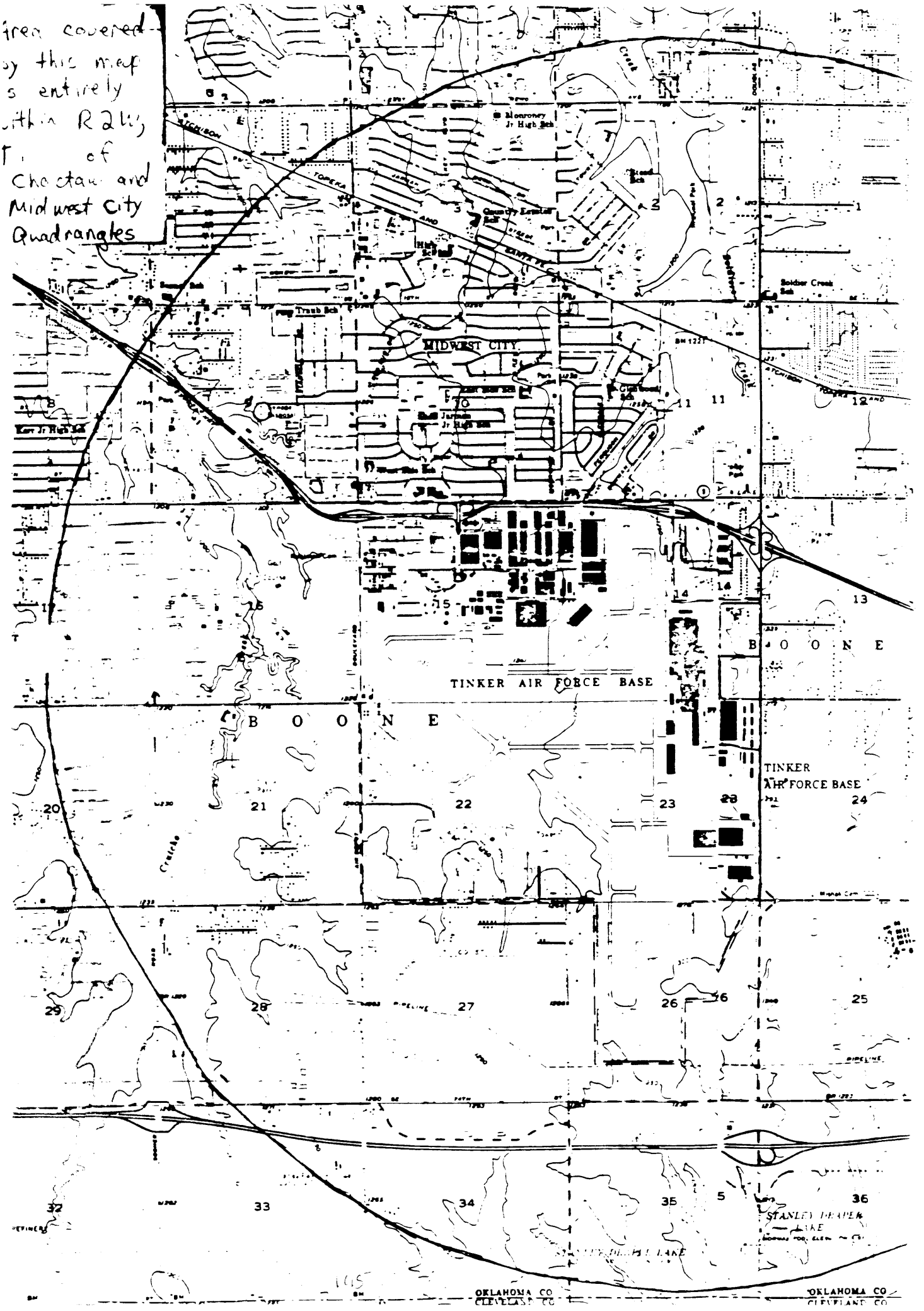
1 1

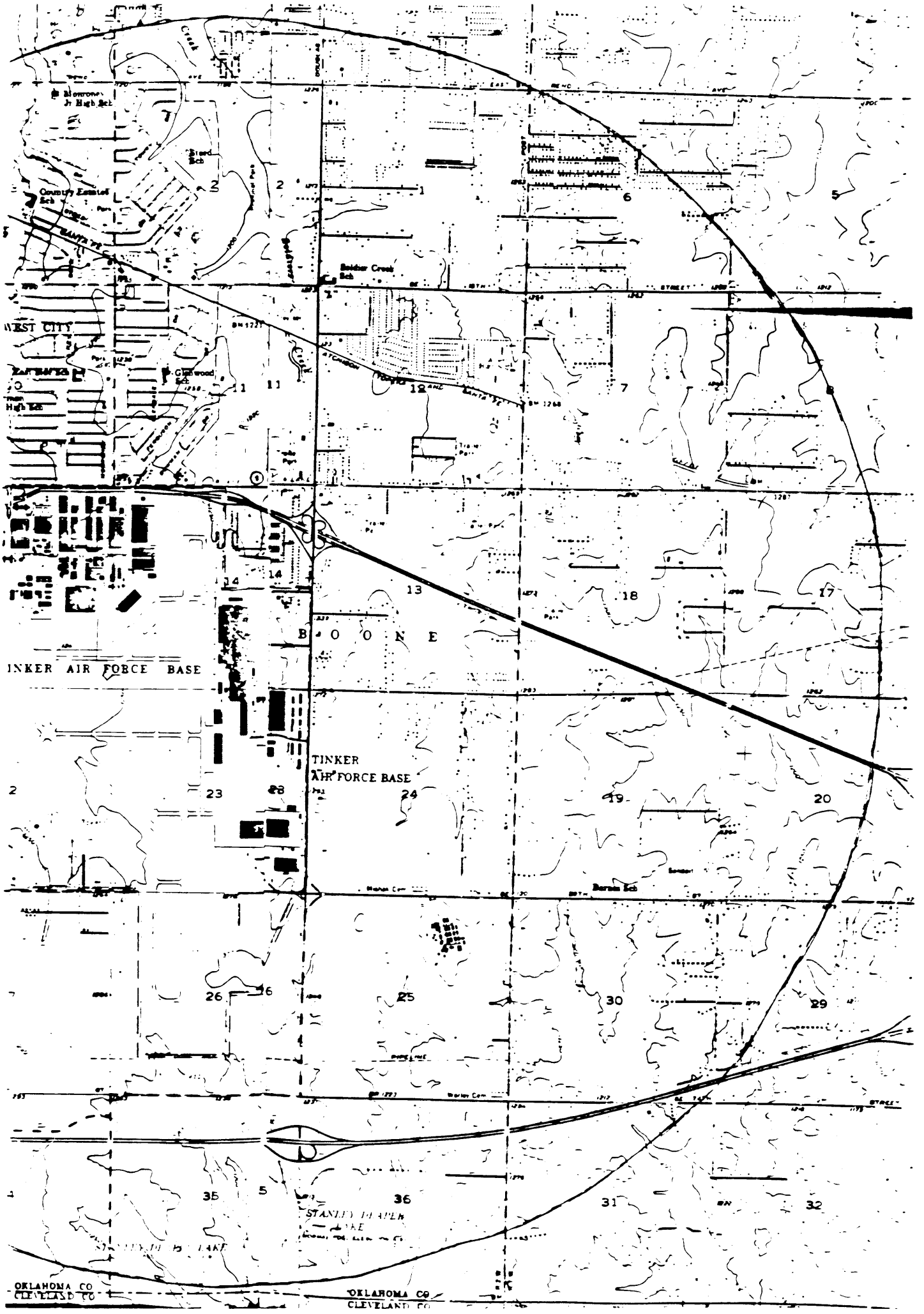
4/24/84 36 wells w/ legals
7 wells w/ legals to be obtained
43 Active

Reference #22

USGS top quad maps: Choctaw and Midwest City, both photorevised to 1975

Area covered by this map is entirely within R2W, T. of Choctaw and Midwest City Quadrangles





Monroney Jr High Sch
Steed Sch
Country Estates Sch
Soldier Creek Sch
WEST CITY
Glenwood Sch
High Sch
B O O N E
INKER AIR FORCE BASE
TINKER
AIR FORCE BASE
Barnes Sch
STANLEY DEAPER LAKE
OKLAHOMA CO
CLEVELAND CO
OKLAHOMA CO
CLEVELAND CO