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INSTALLATION RESTORATION PROGRAM

REMEDIAL INVESTIGATION REPORT

FORBES FIELD AIR NATIONAL GUARD BASE
TOPEKA, KANSAS

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Topeka, Kansas

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at Oak Ridge National Laboratory
P. O. Box 2567
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MARTIN MARIETTA ENERGY SYSTEMS, INC.
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CONTENTS

FIGURES.....	xiii
TABLES.....	xv
APPENDICES.....	xvi
EXECUTIVE SUMMARY.....	xvii
 1. INTRODUCTION.....	 1-1
1.1 PURPOSE OF REPORT.....	1-1
1.2 SITE BACKGROUND.....	1-1
1.2.1 Site Description.....	1-1
1.2.2 Site History.....	1-1
1.2.3 Previous Investigations.....	1-4
1.2.4 Planned Construction Activities.....	1-13
1.3 REPORT ORGANIZATION.....	1-13
1.3.1 Additional Information.....	1-16
 2. REMEDIAL INVESTIGATION.....	 2-1
2.1 REMEDIAL INVESTIGATION ACTIVITIES.....	2-1
2.1.1 Work Plan.....	2-1
2.1.2 Site Characterization.....	2-2
2.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	2-21
2.2.1 Surface Features.....	2-21
2.2.2 Meteorology.....	2-22
2.2.3 Surface Water Hydrology.....	2-22
2.2.4 Geology.....	2-24
2.2.5 Soils.....	2-36
2.2.6 Hydrogeology.....	2-44
2.2.7 Groundwater Quality.....	2-55
2.2.8 Upgradient Monitoring Wells.....	2-61
2.2.9 Air Quality.....	2-62
2.2.10 Subsurface Migration Pathways.....	2-63
2.2.11 Demography and Land Use.....	2-63
2.2.12 Ecology.....	2-65

3. SITE 1, AREA ADJACENT TO JP-4 STORAGE FACILITIES 55122, 55123, AND 55124.....	3-1
3.1 SITE BACKGROUND.....	3-1
3.1.1 Site Description.....	3-1
3.1.2 Site History.....	3-1
3.1.3 Previous Investigations.....	3-3
3.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	3-4
3.2.1 Surface Water Hydrology.....	3-4
3.2.2 Geology.....	3-4
3.2.3 Soils.....	3-4
3.2.4 Hydrogeology.....	3-5
3.2.5 Demographics and Land Use.....	3-5
3.2.6 Ecology.....	3-5
3.3 STUDY AREA INVESTIGATION.....	3-6
3.3.1 Surface Features.....	3-6
3.3.2 Contaminant Source Investigation.....	3-6
3.3.3 Surface Water and Sediment Investigations.....	3-6
3.3.4 Geological Investigation.....	3-6
3.3.5 Vadose Zone and Soil Investigations.....	3-7
3.3.6 Groundwater Investigation.....	3-8
3.4 NATURE AND EXTENT OF CONTAMINATION.....	3-9
3.4.1 Sources.....	3-9
3.4.2 Vadose Zone and Soils.....	3-9
3.4.3 Groundwater.....	3-10
3.4.4 Surface Water and Sediments.....	3-12
3.4.5 Air.....	3-12
3.5 CONTAMINANT FATE AND TRANSPORT.....	3-12
3.5.1 Contaminant Persistence.....	3-12
3.5.2 Potential Routes of Migration.....	3-15
3.5.3 Contaminant Migration.....	3-16
3.6 BASELINE RISK ASSESSMENT.....	3-18
3.6.1 Exposure Assessment.....	3-18
3.6.2 Risk Evaluation.....	3-19
3.7 SUMMARY AND CONCLUSIONS.....	3-20
3.7.1 Summary.....	3-20
3.7.2 Conclusions.....	3-21

4.	SITE 5, PUMPHOUSE E, BUILDING 671.....	4-1
4.1	SITE BACKGROUND.....	4-1
4.1.1	Site Description.....	4-1
4.1.2	Site History.....	4-1
4.1.3	Previous Investigation.....	4-3
4.2	PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	4-3
4.2.1	Surface Water Hydrology.....	4-3
4.2.2	Geology.....	4-4
4.2.3	Soils.....	4-4
4.2.4	Hydrogeology.....	4-4
4.2.5	Demographics and Land Use.....	4-4
4.2.6	Ecology.....	4-5
4.3	STUDY AREA INVESTIGATION.....	4-5
4.3.1	Surface Features.....	4-5
4.3.2	Contaminant Source Investigation.....	4-5
4.3.3	Surface Water and Sediment Investigations.....	4-5
4.3.4	Geological Investigation.....	4-5
4.3.5	Vadose Zone and Soil Investigations.....	4-6
4.3.6	Groundwater Investigation.....	4-7
4.4	NATURE AND EXTENT OF CONTAMINATION.....	4-8
4.4.1	Sources.....	4-8
4.4.2	Vadose Zone and Soils.....	4-8
4.4.3	Groundwater.....	4-9
4.4.4	Surface Water and Sediments.....	4-10
4.4.5	Air.....	4-10
4.5	CONTAMINANT FATE AND TRANSPORT.....	4-10
4.5.1	Contaminant Persistence.....	4-10
4.5.2	Potential Routes of Migration.....	4-10
4.5.3	Contaminant Migration.....	4-11
4.6	BASELINE RISK ASSESSMENT.....	4-11
4.6.1	Exposure Assessment.....	4-12
4.6.2	Risk Evaluation.....	4-13
4.7	SUMMARY AND CONCLUSIONS.....	4-14
4.7.1	Summary.....	4-14
4.7.2	Conclusions.....	4-14

5.	SITE 6, SURFACE DRAINAGE DITCH AND STORM SEWER OUTFLOW.....	5-1
5.1	SITE BACKGROUND.....	5-1
5.1.1	Site Description.....	5-1
5.1.2	Site History.....	5-3
5.1.3	Previous Investigations.....	5-4
5.2	PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	5-5
5.2.1	Surface Water Hydrology.....	5-5
5.2.2	Geology.....	5-5
5.2.3	Soils.....	5-5
5.2.4	Hydrogeology.....	5-6
5.2.5	Demographics and Land Use.....	5-6
5.2.6	Ecology.....	5-6
5.3	STUDY AREA INVESTIGATION.....	5-7
5.3.1	Surface Features.....	5-7
5.3.2	Contaminant Source Investigation.....	5-7
5.3.3	Surface Water and Sediment Investigations.....	5-7
5.3.4	Geological Investigation.....	5-8
5.3.5	Vadose Zone and Soil Investigations.....	5-10
5.3.6	Groundwater Investigation.....	5-11
5.4	NATURE AND EXTENT OF CONTAMINATION.....	5-12
5.4.1	Sources.....	5-12
5.4.2	Vadose Zone and Soils.....	5-12
5.4.3	Groundwater.....	5-13
5.4.4	Surface Water and Sediments.....	5-13
5.4.5	Air.....	5-14
5.5	CONTAMINANT FATE AND TRANSPORT.....	5-14
5.5.1	Contaminant Persistence.....	5-14
5.5.2	Potential Routes of Migration.....	5-16
5.5.3	Contaminant Migration.....	5-18
5.6	BASELINE RISK ASSESSMENT.....	5-18
5.6.1	Exposure Assessment.....	5-18
5.6.2	Risk Evaluation.....	5-21
5.7	SUMMARY AND CONCLUSIONS.....	5-23
5.7.1	Summary.....	5-23
5.7.2	Conclusions.....	5-24

6.	SITE 7, AREA ADJACENT TO REFUELING HYDRANT, LATERAL 3.....	6-1
6.1	SITE BACKGROUND.....	6-1
6.1.1	Site Description.....	6-1
6.1.2	Site History.....	6-1
6.1.3	Previous Investigations.....	6-3
6.2	PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	6-3
6.2.1	Surface Water Hydrology.....	6-3
6.2.2	Geology.....	6-4
6.2.3	Soils.....	6-4
6.2.4	Hydrogeology.....	6-4
6.2.5	Demographics and Land Use.....	6-4
6.2.6	Ecology.....	6-5
6.3	STUDY AREA INVESTIGATION.....	6-5
6.3.1	Surface Features.....	6-5
6.3.2	Contaminant Source Investigation.....	6-5
6.3.3	Surface Water and Sediment Investigations.....	6-5
6.3.4	Geological Investigation.....	6-5
6.3.5	Vadose Zone and Soil Investigations.....	6-6
6.3.6	Groundwater Investigation.....	6-7
6.4	NATURE AND EXTENT OF CONTAMINATION.....	6-7
6.4.1	Sources.....	6-7
6.4.2	Vadose Zone and Soils.....	6-8
6.4.3	Groundwater.....	6-8
6.4.4	Surface Water and Sediments.....	6-8
6.4.5	Air.....	6-9
6.5	CONTAMINANT FATE AND TRANSPORT.....	6-9
6.5.1	Contaminant Persistence.....	6-9
6.5.2	Potential Routes of Migration.....	6-9
6.5.3	Contaminant Migration.....	6-10
6.6	BASELINE RISK ASSESSMENT.....	6-10
6.6.1	Exposure Assessment.....	6-11
6.6.2	Risk Evaluation.....	6-11
6.7	SUMMARY AND CONCLUSIONS.....	6-12
6.7.1	Summary.....	6-12
6.7.2	Conclusions.....	6-12

7.	SITE 8, AREA ADJACENT TO REFUELING HYDRANT, LATERAL 7.....	7-1
7.1	SITE BACKGROUND.....	7-1
7.1.1	Site Description.....	7-1
7.1.2	Site History.....	7-1
7.1.3	Previous Investigations.....	7-3
7.2	PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	7-3
7.2.1	Surface Water Hydrology.....	7-3
7.2.2	Geology.....	7-4
7.2.3	Soils.....	7-4
7.2.4	Hydrogeology.....	7-4
7.2.5	Demography and Land Use.....	7-4
7.2.6	Ecology.....	7-5
7.3	STUDY AREA INVESTIGATION.....	7-5
7.3.1	Surface Features.....	7-5
7.3.2	Contaminant Source Investigation.....	7-5
7.3.3	Surface Water and Sediment Investigations.....	7-5
7.3.4	Geological Investigation.....	7-5
7.3.5	Vadose Zone and Soil Investigations.....	7-6
7.3.6	Groundwater Investigation.....	7-7
7.4	NATURE AND EXTENT OF CONTAMINATION.....	7-8
7.4.1	Sources.....	7-8
7.4.2	Vadose Zone and Soils.....	7-8
7.4.3	Groundwater.....	7-8
7.4.4	Surface Water and Sediments.....	7-9
7.4.5	Air.....	7-9
7.5	CONTAMINANT FATE AND TRANSPORT.....	7-9
7.5.1	Contaminant Persistence.....	7-9
7.5.2	Potential Routes of Migration.....	7-9
7.5.3	Contaminant Migration.....	7-10
7.6	BASELINE RISK ASSESSMENT.....	7-10
7.6.1	Exposure Assessment.....	7-10
7.6.2	Risk Evaluation.....	7-11
7.7	SUMMARY AND CONCLUSIONS.....	7-12
7.7.1	Summary.....	7-12
7.7.2	Conclusions.....	7-12

8.	SITE 9, AREA ADJACENT TO REFUELING HYDRANT, LATERAL 8.....	8-1
8.1	SITE BACKGROUND.....	8-1
8.1.1	Site Description.....	8-1
8.1.2	Site History.....	8-1
8.1.3	Previous Investigations.....	8-3
8.2	PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	8-3
8.2.1	Surface Water Hydrology.....	8-3
8.2.2	Geology.....	8-4
8.2.3	Soils.....	8-4
8.2.4	Hydrogeology.....	8-4
8.2.5	Demographics and Land Use.....	8-4
8.2.6	Ecology.....	8-5
8.3	STUDY AREA INVESTIGATION.....	8-5
8.3.1	Surface Features.....	8-5
8.3.2	Contaminant Source Investigation.....	8-5
8.3.3	Surface Water and Sediment Investigations.....	8-5
8.3.4	Geological Investigation.....	8-5
8.3.5	Vadose Zone and Soil Investigations.....	8-6
8.3.6	Groundwater Investigation.....	8-7
8.4	NATURE AND EXTENT OF CONTAMINATION.....	8-7
8.4.1	Sources.....	8-7
8.4.2	Vadose Zone and Soils.....	8-8
8.4.3	Groundwater.....	8-8
8.4.4	Surface Water and Sediments.....	8-8
8.4.5	Air.....	8-9
8.5	CONTAMINANT FATE AND TRANSPORT.....	8-9
8.5.1	Contaminant Persistence.....	8-9
8.5.2	Potential Routes of Migration.....	8-9
8.5.3	Contaminant Migration.....	8-9
8.6	BASELINE RISK ASSESSMENT.....	8-10
8.6.1	Exposure Assessment.....	8-10
8.6.2	Risk Evaluation.....	8-11
8.7	SUMMARY AND CONCLUSIONS.....	8-12
8.7.1	Summary.....	8-12
8.7.2	Conclusions.....	8-12

9.	SOUTHEAST CORNER OF FORBES FIELD ANGB PROPERTY.....	9-1
9.1	SITE BACKGROUND.....	9-1
9.1.1	Site Description.....	9-1
9.1.2	Site History.....	9-1
9.1.3	Previous Investigations.....	9-3
9.2	PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	9-3
9.2.1	Surface Water Hydrology.....	9-3
9.2.2	Geology.....	9-3
9.2.3	Soils.....	9-4
9.2.4	Hydrogeology.....	9-4
9.2.5	Demography and Land Use.....	9-4
9.2.6	Ecology.....	9-4
9.3	STUDY AREA INVESTIGATION.....	9-5
9.3.1	Surface Features.....	9-5
9.3.2	Contaminant Source Investigation.....	9-5
9.3.3	Surface Water and Sediment Investigations.....	9-5
9.3.4	Geological Investigation.....	9-5
9.3.5	Vadose Zone and Soil Investigations.....	9-7
9.3.6	Groundwater Investigation.....	9-7
9.4	NATURE AND EXTENT OF CONTAMINATION.....	9-8
9.4.1	Sources.....	9-8
9.4.2	Vadose Zone and Soils.....	9-9
9.4.3	Groundwater.....	9-9
9.4.4	Surface Water and Sediments.....	9-10
9.4.5	Air.....	9-10
9.5	CONTAMINANT FATE AND TRANSPORT.....	9-10
9.5.1	Contaminant Persistence.....	9-10
9.5.2	Potential Routes of Migration.....	9-10
9.5.3	Contaminant Migration.....	9-11
9.6	BASELINE RISK ASSESSMENT.....	9-11
9.6.1	Exposure Assessment.....	9-11
9.6.2	Risk Evaluation.....	9-12
9.7	SUMMARY AND CONCLUSIONS.....	9-12
9.7.1	Summary.....	9-12
9.7.2	Conclusions.....	9-12

10. LATERAL 6, HYDRANT 3 - "HOT-SPOT".....	10-1
10.1 SITE BACKGROUND.....	10-1
10.1.1 Site Description.....	10-1
10.1.2 Site History.....	10-1
10.1.3 Previous Investigations.....	10-2
10.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA.....	10-2
10.2.1 Surface Water Hydrology.....	10-2
10.2.2 Geology.....	10-2
10.2.3 Soils.....	10-2
10.2.4 Hydrogeology.....	10-2
10.2.5 Demography and Land Use.....	10-3
10.2.6 Ecology.....	10-3
10.3 STUDY AREA INVESTIGATION.....	10-3
10.3.1 Surface Features.....	10-3
10.3.2 Contaminant Source Investigation.....	10-3
10.3.3 Surface Water and Sediment Investigations.....	10-4
10.3.4 Geological Investigation.....	10-4
10.3.5 Vadose Zone and Soil Investigations.....	10-5
10.3.6 Groundwater Investigation.....	10-5
10.4 NATURE AND EXTENT OF CONTAMINATION.....	10-6
10.4.1 Sources.....	10-6
10.4.2 Vadose Zone and Soils.....	10-7
10.4.3 Groundwater.....	10-7
10.4.4 Surface Water and Sediments.....	10-8
10.4.5 Air.....	10-8
10.5 CONTAMINANT FATE AND TRANSPORT.....	10-8
10.5.1 Contaminant Persistence.....	10-8
10.5.2 Potential Routes of Migration.....	10-8
10.5.3 Contaminant Migration.....	10-9
10.6 BASELINE RISK ASSESSMENT.....	10-9
10.6.1 Exposure Assessment.....	10-10
10.6.2 Risk Evaluation.....	10-10
10.7 SUMMARY AND CONCLUSIONS.....	10-11
10.7.1 Summary.....	10-11
10.7.2 Conclusions.....	10-11

11. CONCLUSIONS AND RECOMMENDATIONS..... 11-1

11.1 MAJOR FINDINGS..... 11-1

11.2 DATA NEEDS..... 11-2

11.3 RECOMMENDATIONS..... 11-2

FIGURES

1.1	Regional location map, Forbes Field Air National Guard Base.	1-2
1.2	Forbes Field ANGB, Weston monitoring wells and soil borings, shown in relation to present sites.....	1-5
1.3	Location of storm sewer manholes and storm water collection points.....	1-9
1.4	Proposed ramp construction project.....	1-14
2.1	Schematic diagram of monitoring well construction.....	2-8
2.2	Regional drainage map, eastern Shawnee County, Kansas.....	2-23
2.3	Surface runoff patterns at Forbes Field ANGB.....	2-24
2.4	Location of glacial deposits, Eastern Shawnee County, Kansas	2-28
2.5	Fence diagram of surface deposits.....	2-30
2.6	Contour map of bedrock surface.....	2-32
2.7	Regional cross section of northeastern Kansas.....	2-33
2.8a	Stratigraphic section of Forbes Field ANGB vicinity.....	2-34
2.8b	Stratigraphic section of Forbes Field ANGB vicinity.....	2-35
2.9	Correlation diagram of bedrock wells.....	2-37
2.10a	Cross section from MW021 to MW007.....	2-38
2.10b	Cross section from MW020 to MW006.....	2-39
2.10c	Cross section from MW024 to MW025.....	2-40
2.11	Position of the Nodaway Coal subcrop.....	2-41
2.12	Soils map of Forbes Field ANGB area.....	2-42
2.13a	Potentiometric map of the unconsolidated aquifer water levels measured in July 1988.....	2-46
2.13b	Potentiometric map of the unconsolidated aquifer water levels measured in September 1988.....	2-47
2.14	Regional wells west and northwest of Forbes Field ANGB.....	2-48
2.15	Domestic gas and water mains.....	2-64
3.1	Map of Site 1, Tank Farm.....	3-2
4.1	Map of Site 5, Pumphouse E.....	4-2
5.1	Map of Site 6, surface drainage ditch and storm sewer outflow.....	5-2
5.2	Location of downstream sediment samples.....	5-9

6.1	Map of Site 7.....	6-2
7.1	Map of Site 8.....	7-2
8.1	Map of Site 9.....	8-2
9.1	Map of southeast corner of Forbes Field ANGB.....	9-2

TABLES

ES.1 Site specific conclusions.....	xxv
1.1 Soil sample analytical results, groundwater contamination study.....	1-7
1.2 Water quality analytical results, groundwater contamination study.....	1-8
1.3 Groundwater analytical results, ORNL/CAT samples from Weston monitoring wells, March 1988.....	1-12
2.1 Schedule of field activities, Forbes Field ANGB, Phase II study.....	2-3
2.2 Sample preservation, container requirements, and holding times.....	2-16
2.3 Types of field QA/QC samples collected at Forbes Field ANGB..	2-17
2.4 Monitoring well elevation data.....	2-20
2.5 Discharge information for local drainage basins.....	2-26
2.6 Average water quality values for area streams.....	2-27
2.7 Forbes Field ANGB soils, principal characteristics.....	2-43
2.8 Unconsolidated aquifer relative hydraulic conductivity values determined from single-well tests.....	2-49
2.9 Regional wells and their hydrologic relationship to Forbes Field ANGB.....	2-51
2.10 Bedrock permeability (K) values determined from core hole packer tests.....	2-56
2.11 Major anions, cations, and metals (mg/L).....	2-57
2.12 Threatened and endangered species occurring in Shawnee County, Kansas.....	2-67
3.1 Comparison of mobility in the environment for contaminants found.....	3-17
5.1 Significant findings from sediment samples.....	5-15
5.2 Comparison of mobility in the environment for contaminants found.....	5-19

APPENDICES

- A. Glossary and acronyms
- B. References
- C. Personal contacts
- D. Soil-gas results
- E. Analytical data
- F. Evaluation of quality assurance/quality control data
- G. Monitoring well and corehole logs
- H. Temperature, conductivity, and pH of groundwater samples
- I. Location and elevation survey
- J. Risk assessment

EXECUTIVE SUMMARY

A remedial investigation was conducted at Forbes Field Air National Guard Base (base) in Topeka, Kansas, by Oak Ridge National Laboratory's Chemical Assessment Team (ORNL/CAT). The investigation is part of the Air National Guard's Installation Restoration Program (IRP) - a program designed to investigate and remediate sites of potential soil and groundwater contamination located on Air National Guard property. The purpose of the remedial investigation is to determine the nature and extent of the contamination associated with each site. Once contamination is identified, the potential impacts on public health and the environment are assessed.

In 1984, prior to the IRP, Roy F. Weston, Inc., performed an investigation to determine if soil and groundwater contamination have resulted from fuel storage, distribution, and use at the base. The 1984 study focused only on fuel contamination (utilizing oil and grease analyses) and showed that contamination existed in backfill within certain trenches and in the unconsolidated sediments and groundwater in several areas.

The first phase of the IRP was a records search and installation inspection conducted by Hazardous Materials Technical Center (HMTc). The report, issued in June 1986, found ten potentially contaminated sites. The HMTc determined that four sites did not have a contaminant migration problem. The following six sites required further study:

- Site 1 - JP-4 bulk storage facility (tank farm)
- Site 5 - Area adjacent to building 671
- Site 6 - Surface drainage ditch and storm sewer outflow
- Site 7 - Area adjacent to refueling hydrant, located on refueling apron at lateral 3
- Site 8 - Area adjacent to refueling hydrant, located on refueling apron at lateral 7
- Site 9 - Area adjacent to refueling hydrant, located on refueling apron at lateral 8

The 1984 study indicated subsurface contamination at Sites 5, 7, 8, and 9. Samples collected by base personnel showed evidence of contamination at Site 6. The Weston discovery of contamination in a well upgradient of all the

known sites suggested that contamination was entering the base from an off-base source. The HMTIC identified this area as the "southeastern corner of Forbes Field ANGB property" and recommended that the area be studied.

Forbes Field Air National Guard Base occupies 180 acres in the northeastern corner of the former Forbes Field Air Force Base. The base lies approximately 2.5 miles south of Topeka, Kansas, on a relatively flat, topographically elevated plain. The base is drained by an unnamed tributary to the South Branch of Shunganunga Creek which flows north to converge with Shunganunga Creek in Topeka. Shunganunga Creek flows east to discharge into the Kansas River five miles east of Topeka.

Groundwater at the base is associated with the unconsolidated glacial veneer overlying the bedrock and a bedrock aquifer in the Nodaway Coal. The aquifer associated with the unconsolidated veneer is not utilized in the area because the yield is low and water is often of poor quality.

During June 1988, ORNL/CAT installed 26 alluvial monitoring wells and 3 bedrock wells (coreholes). A soil-gas study was conducted concurrently with the drilling program. Soil-gas data were used to place several of the monitoring wells in order to optimize the chances of intercepting a contaminant plume. The data were also useful in determining the presence of JP-4 components in the trenches of the refueling laterals located beneath the asphalt and concrete of the aircraft refueling ramp. ORNL/CAT installed one monitoring well in November 1988 to further characterize Site 1.

The monitoring wells were used to determine the site lithology, characterize contamination in the soil, determine the extent of groundwater contamination, and to conduct hydraulic testing useful for predicting contaminant migration. The coreholes were used to determine the bedrock lithology, determine the extent of groundwater contamination, and conduct hydraulic testing to locate aquifers. Groundwater sampling was conducted twice to ensure that results were representative of the area. Sediment samples and surface water samples were collected from the drainage ditch to characterize contamination and determine if contamination was being transported by the water.

GENERAL CONCLUSIONS

Based on the remedial investigation, the following general conclusions can be drawn:

- Groundwater flows toward the northwest at the base, following the dip of the bedrock. Locally, however, the drainage ditch influences this flow and causes groundwater west of the drainage ditch to flow north and northeast. Groundwater from the base discharges to the drainage ditch and provides a slight flow in the ditch even during dry periods.
- The tight clay soils at the base severely inhibit groundwater flow. Most of the wells yielded hydraulic conductivity values below the measurable range (3.5×10^{-5} cm/s) using single well tests. In wells with a measurable value, hydraulic conductivity values range from 4.0×10^{-5} cm/s to 3.4×10^{-4} cm/s.
- Fuel is held within the trench backfill surrounding the fuel laterals under the aircraft parking ramp. The tight clay soils inhibit leaching into surrounding soils and, therefore, the fuel "pools" at low points in the trenches. The water table is 3 to 9 ft below the bottom of the fuel lateral trenches.
- Sediments in the ditch contain total petroleum hydrocarbons (TPHCs), polynuclear aromatics, and pesticides; however, the contamination pattern is not consistent throughout the course of the ditch. The fuel contamination in the sediments is likely the result of isolated spills and not an indication of a larger source. The polynuclear aromatics and pesticides are probably the result of runoff from the aircraft ramp and highway. Low-flow surface water samples do not show fuel contamination, indicating that the discharging groundwater is not contaminated.
- Low-flow surface water samples from the storm sewer outflow at the south end of the drainage ditch show chlorinated hydrocarbons (up to $46 \mu\text{g/L}$). No source has been discovered for the contamination; however, it is unlikely that any of the sites studied in this investigation are the source.

SITE-SPECIFIC RESULTS AND CONCLUSIONS

Following are specific conclusions for each site followed by a table summarizing the conclusions. Plate 1 shows the location of all sites on the base.

Site 1 - JP-4 Bulk Storage Area (Tank Farm)

The tank farm consists of three aboveground jet fuel (JP-4) storage tanks. The tanks are surrounded by a continuous, closed earthen berm designed to impound leaks and spills. In 1981, an estimated 1200 to 1400 gal of JP-4 leaked from the southern tank onto the surrounding soil.

The water bearing unit underlying the tank farm is discontinuous and occurs in unconsolidated sediments of silty clay. Six monitoring wells were drilled to characterize the subsurface at Site 1. JP-4 components were found in the soil at depths of 6 to 12 ft in four wells and in groundwater samples in three wells. The amount of fuel in the groundwater is very low compared to the quantity found in the contaminated soils. For example, a soil sample taken at 6 ft during the drilling of MW021 contained 490,000 $\mu\text{g/kg}$ TPHCs, while a groundwater sample contained only 760 $\mu\text{g/L}$ TPHCs. MW026, located ~50 ft downgradient from MW021, had no detectable TPHCs in soil or groundwater. The tight clay soils and low leachability of the JP-4 constituents make past spills relatively immobile.

Site 1 poses minimal risk to the public or environment.

Site 5 - Area Adjacent to Pumphouse E, Building 671

Site 5 surrounds pumphouse E, building 671, located southwest of the aircraft parking ramp near the center of the base. In 1967, an estimated 2000 to 10,000 gal of JP-4 spilled from the north side of the pumphouse into the surrounding soil.

The water bearing unit is discontinuous and occurs in unconsolidated sediments of tight, silty clay. The four monitoring wells associated with Site 5 are SW005, installed by Weston in 1984, and MW009, MW010, and MW014, installed by ORNL/CAT. Due to the presence of fourteen 50,000 gal underground storage tanks and numerous buried utility lines, there is an abundance of fill material surrounding the spill area.

The Weston SW005, located on the north side of the pumphouse, shows evidence of floating fuel (~0.2 ft measured by Weston in 1984, a thin film measured by ORNL in March 1988, and ~0.16 ft measured by ORNL in September 1988). The borehole log from SW005 states that the core contained sand, sandy clay, and "medium grained fill," indicating that the well was installed in a fuel line or storm sewer trench. Analyses of both soil and groundwater samples from the ORNL/CAT wells found elevated TPHCs in MW009 (26,000 µg/kg and 1100 µg/L, respectively), but the samples from MW010 and MW014 contained no detectable contamination. Five of the six soil-gas samples taken on a 100 ft grid around Site 5 showed elevated hydrocarbons, ranging from 174 to 277 µg/L.

The undisturbed soil around the spill area (MW009) is contaminated, but the concentration appears to decrease sharply with distance from the source. Since SW005 has contained measurable floating product on two occasions, groundwater contamination is apparently confined to nearby trenches and the source area.

The potential for migration is low since the tight clay soils have effectively immobilized the fuel components. Due to the low levels and relative immobility of the contaminants, Site 5 poses minimal risk to the public or environment.

Site 6 - Surface Drainage Ditch and Storm Sewer Outflow

Site 6 consists of the drainage ditch and storm sewer system. The drainage ditch runs northwesterly along the northwest side of the base, eventually flowing into the South Branch of Shunganunga Creek about 1.5 miles downstream. The ditch receives sheet flow runoff from most of the base, including the tank farm. The base's storm sewers converge through successive confluences which finally drain into the ditch at three locations. Since the ditch is topographically lower than nearby U.S. Highway 75, it also receives some surface runoff from the highway. In addition, the drainage ditch serves as a discharge area for the unconsolidated aquifer underlying the base.

Sediment and surface water samples were collected from the ditch both upstream and downstream from the base. MW001, MW002, MW022, and MW025 were installed along the ditch to intercept contaminants migrating from the base and tank farm fuel spills. Subsequent sampling of these monitoring wells showed no contamination.

Surface water samples collected on two occasions at points just below where the ditch emerges from a culvert and begins its surface flow were found to contain small amounts (up to 46 µg/L) of 1,2-dichloroethene. The origin of this chlorinated solvent is unknown. The remaining surface water samples collected farther downstream contained no detectable contamination.

Sediment samples were collected at fifteen points along the drainage ditch system, including locations upstream and downstream from the base. Three samples contained elevated concentrations of TPHCs. A sample taken from the pond sediment and a sample from the ditch east of the tank farm contained low levels of polynuclear aromatics; one of the samples collected at the base boundary contained traces of the pesticides 4,4'-DDE, 4,4'-DDT, and dieldrin. The polynuclear aromatics are typically associated with jet and combustion engines, and road dust. These sampling points are located close to the storm sewer outfall and U.S. Highway 75, both of which contribute surface runoff to the ditch. It is likely that these are sources of the polynuclear aromatics. The pesticides may be from local agricultural activities. The fuel contamination appears to be the result of small spills and leaks--not a surface expression of a larger source.

Due to the low levels and relative immobility of the contaminants at Site 6, there is minimal risk to the public or the environment. Transport of the contaminated sediments would only occur during high energy flood conditions, where dilution would render the concentrations insignificant. Long term monitoring of the surface waters would eliminate most risk.

Site 7 - Area Adjacent to Refueling Hydrant, Lateral 3

Site 7 consists of the area surrounding the southwest fuel hydrant on fuel lateral 3, where, in 1981, an undetermined amount of jet fuel leaked from the fuel hydrant. The water bearing unit is discontinuous and occurs in unconsolidated sediments of tight, silty clay. Groundwater is found only in the lower few feet of the unconsolidated sediments and is completely absent in some places.

MW005, MW006, and MW008 were installed to characterize the subsurface at Site 7. Analysis of both soil and groundwater samples from these wells found no detectable contamination. Soil-gas samples were taken from three locations

along lateral 3. Concentrations of fuel components ranged from background values near the southwest end of the lateral to 169,000 $\mu\text{g/L}$ at a point 400 ft northeast. Apparently, spilled fuel is pooled locally in the trench.

No risk to the public exists from Site 7, but any excavation of the lateral would result in exposure to workers and possible explosion hazards.

Site 8 - Area Adjacent to Refueling Hydrant, Lateral 7

Site 8 consists of the area surrounding the southwest fuel hydrant on fuel lateral 7, where, in July 1982, an undetermined amount of jet fuel leaked from the fuel hydrant. The water bearing unit is discontinuous and occurs in unconsolidated sediments of tight, silty clay.

MW011, MW015, MW016, and Weston's SW004 were drilled to characterize Site 8. Analyses of both soil and groundwater samples from the ORNL/CAT wells found no detectable contamination; groundwater from SW004 (a Weston well) contained 190 $\mu\text{g/L}$ TPHCs. Soil-gas samples were taken in the trench at three locations along lateral 7. One sample contained slightly elevated TPHCs; the other two samples contained only background levels. Apparently, spilled fuel is pooled locally in the trench.

No risk to the public exists from Site 8, but any excavation of the lateral would result in exposure to workers and possible explosion hazards.

Site 9 - Area Adjacent to Refueling Hydrant, Lateral 8

Site 9 consists of the area surrounding the southwest fuel hydrant on fuel lateral 8, where, in 1983, up to 3000 gal of jet fuel leaked from the fuel hydrant. The water bearing unit is discontinuous and occurs in unconsolidated sediments of tight, silty clays.

MW012, MW013, MW017, and the Weston SW002 are associated with Site 9. Analysis of soil and groundwater samples taken from the wells showed no detectable contamination. Three soil-gas samples collected from the sandy backfill of the lateral 8 trench contained only background levels of hydrocarbons. Spilled fuel may be pooled locally in the trench.

No risk to the public exists from Site 9, but any excavation of the lateral would result in exposure to workers and possible explosion hazards.

Southeast Corner of ANGB Property

The southeast corner of the base was included as a study area following discovery of oil and grease in the groundwater of the bedrock aquifer (Weston 1985). No contaminant sources have been reported in this area, which is hydraulically upgradient of the base.

ORNL/CAT completed three alluvial monitoring wells and one bedrock well (corehole) to characterize the site. Soil and groundwater samples from the alluvial wells and groundwater samples from the corehole contained no detectable contamination.

ORNL/CAT collected a groundwater sample from Weston DW001 in March 1988. The sample contained 680 $\mu\text{g/L}$ TPHCs. The presence of TPHCs in the groundwater sample may be the result of leachate from the Nodaway Coal, which the well probably penetrated at a depth of 20 to 30 ft.

Lateral 6, Hydrant 3 "Hot-spot"

This area was investigated as an information source for the IRP sites associated with the aircraft parking ramp. No leaks have been reported in fuel lateral 6; however, the soil-gas survey located an elevated TPHC level at hydrant 3. MW023 was installed downgradient of the elevated soil-gas measurement and upgradient of two sites.

A soil sample collected 3 ft below the aircraft ramp surface (1 ft below the bottom of the concrete pad) contained fuel compounds (16,000 $\mu\text{g/kg}$ TPHCs). Groundwater samples contained no detectable contamination. The soil immediately under the ramp may be contaminated and the trench fill is contaminated, but the contamination is not leaching into the groundwater.

Table ES.1. Site-specific conclusions

Site	Soil contamination	Groundwater contamination	Additional data needs	Comments	Recommendation
1	TPHC at depths of 6 to 12 ft	Yes, but tight clay soils inhibit mobility	None		No action, restricted access *
5	TPHC	Yes, but tight clay soils inhibit mobility	None	Floating product in SW005, installed in trench fill	No action, restricted access *
6	None	None	Collect surface water samples in upstream storm sewer to locate 1,2-DCE source	TPHC, poly-nuclear aromatics, pesticides in ditch sediments; chlorinated solvents but no fuel in surface water	Long-term monitoring
7	None	None	None	TPHC in associated fuel lateral trench backfill	No action, restricted access *
8	None	Yes, Weston's SW004	None	TPHC in associated fuel lateral trench backfill	No action, restricted access *
9	None	None	None	TPHC in associated fuel lateral trench backfill	No action, restricted access *
SE Corner	None	None	None	Hydrocarbons in DW001 and DW002 are apparently from the Nodaway Coal	No action, restricted access *
Lateral 6 Hydrant 3 "Hot-Spot"	TPHC at 3 ft	None	None	Soil contamination under concrete parking ramp and in fuel lateral trenches	No action, restricted access *

* In certain areas near the site, construction projects involving excavation must be prepared to handle contaminated soil.

1. INTRODUCTION

1.1 PURPOSE OF REPORT

This Remedial Investigation Report (RIR) for Forbes Field Air National Guard Base (ANGB), Topeka, Kansas has been prepared by the Oak Ridge National Laboratory/Chemical Assessments Team (ORNL/CAT) in Grand Junction, Colorado. The work was performed under agreement with the Hazardous Waste Remedial Action Program (HAZWRAP) operated by Martin Marietta Energy Systems, Inc., in Oak Ridge, Tennessee; it is part of Phase II of the Installation Restoration Program (IRP) of the U.S. National Guard Bureau (NGB). The IRP has been implemented to investigate and remediate contaminated sites subject to the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). The Phase II investigation confirms and quantifies hazardous substances at locations identified as potentially contaminated in Phase I of the IRP (HMTIC 1986).

This RIR presents the results of the Phase II site characterization performed by ORNL/CAT.

1.2 SITE BACKGROUND

1.2.1 Site Description

Forbes Field ANGB (base) occupies 180 acres in the northeast corner of the former Forbes Field Air Force Base. The base lies approximately 2.5 miles south of the southern boundary of the city of Topeka in Shawnee County, Kansas (Fig. 1.1). U.S. Highway 75 is adjacent to the base on the west. Pauline, Kansas, an unincorporated village, also lies adjacent to the west boundary.

The former Forbes Field Air Force Base belongs to the Metropolitan Topeka Airport Authority (MTAA). The MTAA controls the air field and the commercial airport facilities. Light industrial, residential, and agricultural land surrounds the airport and the base, and several light industries occupy former Air Force facilities.

1.2.2 Site History

Forbes Field Air Force Base was opened in 1942 as the Topeka Army Air Corps Base. The base's mission was to provide operational training of heavy

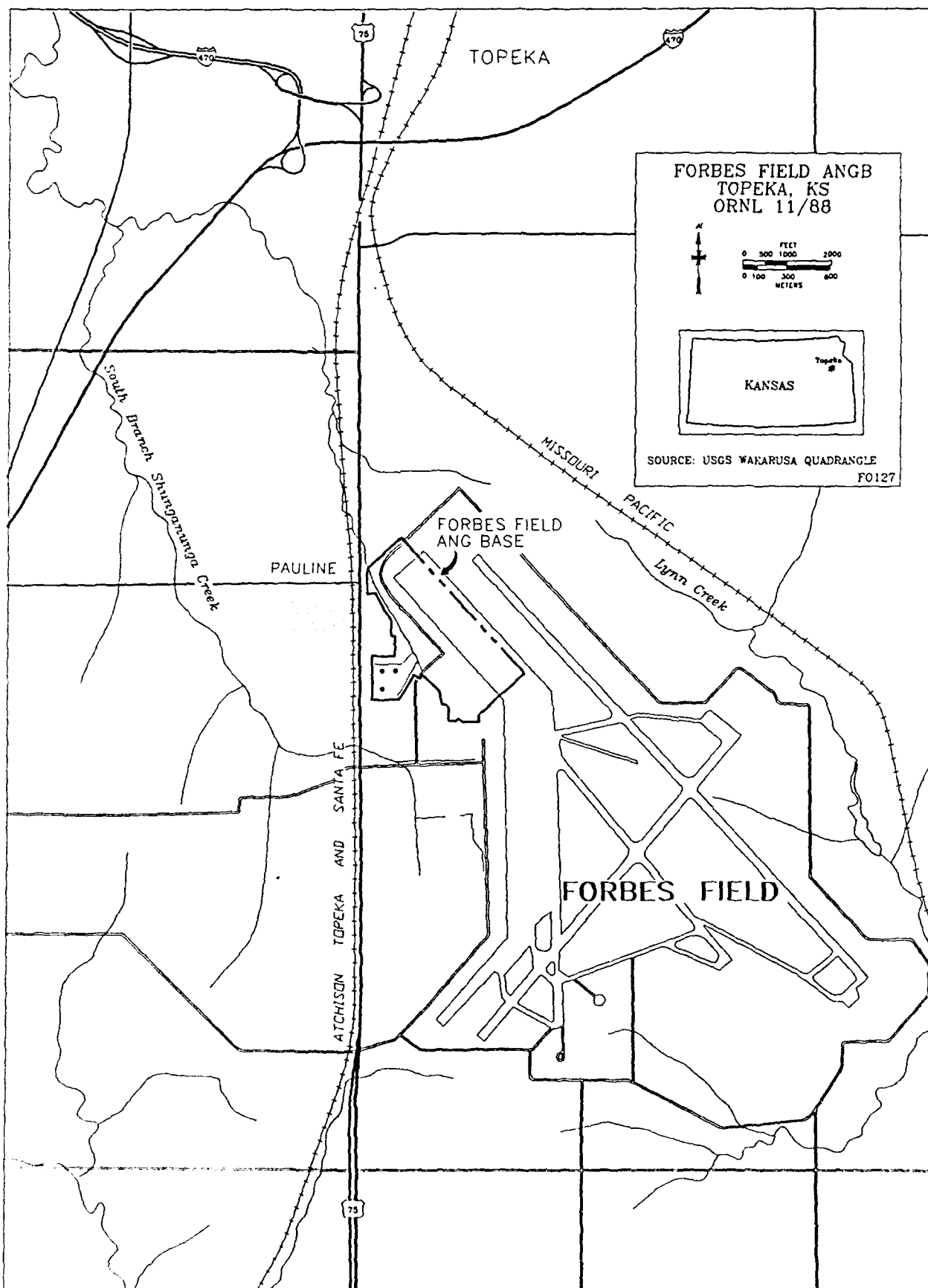


Fig. 1.1. Regional location map, Forbes Field Air National Guard Base.
(Source: USGS, Wakarusa Quad., 1983)

bombardment crews. At the end of World War II, the base was closed and the hangars used for grain storage (Weston 1985).

From 1948 to 1949 the base was reopened for use by reconnaissance and geodetic survey wings of the Army Air Corps. The base was re-named the Forbes Field Air Base during that time.

Forbes Field Air Base was reopened in 1951 with the mission of training bomber crews. In 1954, the Forbes Field Air Base and all existing facilities were transferred to the U.S. Air Force, and the installation was officially designated Forbes Field Air Force Base. The installation was assigned to the Strategic Air Command (SAC) until July 1965, when it was transferred to the Tactical Air Command (TAC). Forbes Field Air Force Base was closed in 1973, at which time the Kansas Air National Guard 190th Air Refueling Group (190th AREFG) became the only remaining activity on base.

The portion of the Air Force Base now occupied by the Kansas Air National Guard (KSANG) was built between 1954 and 1959. Aerial photos in 1954 show the present National Guard Base as agricultural land, and only the aboveground storage tanks are present in the photo. The present aircraft ramp, large hangars, and extended northwest-southeast runway appear in the 1959 photographs.

The 190th AREFG maintains jet fueling and storage facilities on the base. The storage facilities consist of three aboveground storage tanks on the west side of the base and 26 underground storage tanks near the three pumphouses at the west edge of the aircraft parking apron. Total fuel capacity is approximately 14 million gal. Aircraft assigned to the group include large, multi-engine KC-135 tankers.

Operation of the 190th AREFG includes aircraft retrofitting; aircraft maintenance; ground vehicle maintenance; petroleum, oil, and lubricant (POL) management and distribution; and fire department training. These operations involve such activities as corrosion control, nondestructive inspection (NDI), fuel cell maintenance, engine maintenance, and pneudraulics. These activities generate varying quantities of waste oils, recovered fuels, spent cleaners, strippers, and solvents. The Defense Reutilization and Marketing Office (DRMO) is responsible for disposal of these hazardous materials.

1.2.3 Previous Investigations

Roy F. Weston, Inc., performed a groundwater contamination study at Forbes Field ANGB in 1984. The Weston study was requested by the U.S. Occupational and Environmental Health Laboratory (OEHL). The KSANG requested assistance from OEHL in the evaluation of known and suspected releases of jet fuel (JP-4) to the environment of Forbes Field ANGB. Weston recommended detailed studies of certain areas of the base and more extensive sampling. As a result, the base bioenvironmental engineering technician conducts periodic sampling of a drainage ditch adjacent to the base.

The Hazardous Materials Technical Center (HMTTC) was retained in December 1985 to conduct the IRP Phase I Records Search at Forbes Field ANGB. The records search involved reviews of records, personnel interviews, and on-site studies to identify potential sources of contamination and specific sites where contamination is likely.

ORNL/CAT was retained in January 1988 to conduct the Remedial Investigation/Feasibility Study (RI/FS).

1.2.3.1 Roy F. Weston, Inc. - Groundwater Study

Roy F. Weston, Inc., studied soil and groundwater contamination at Forbes Field ANGB in 1984 and 1985. This study included the inspection of the storm sewer system to locate infiltration of jet fuel, soil borings and sampling, installation of twelve groundwater monitoring wells, subsequent sampling of groundwater, and field tests to establish permeability of subsurface layers.

Weston installed twelve monitoring wells and drilled ten soil borings (Fig. 1.2). Six of the monitoring wells were completed in the surface deposits. The other six were deep wells in which 4-in. PVC casing was set and cemented through surface deposits followed by drilling through 50 ft of bedrock. The ten soil borings were not completed as monitoring wells.

The six shallow monitoring wells and the ten soil borings were drilled using hollow stem augers and continuous core samplers. A photoionization detector (PID) and an organic vapor analyzer (OVA) were used to measure volatile components in soil samples immediately after splitting the core. Ten of the soil samples showing elevated measurements were sent to the laboratory for oil and grease analysis; however, only one soil sample was analyzed from each borehole.

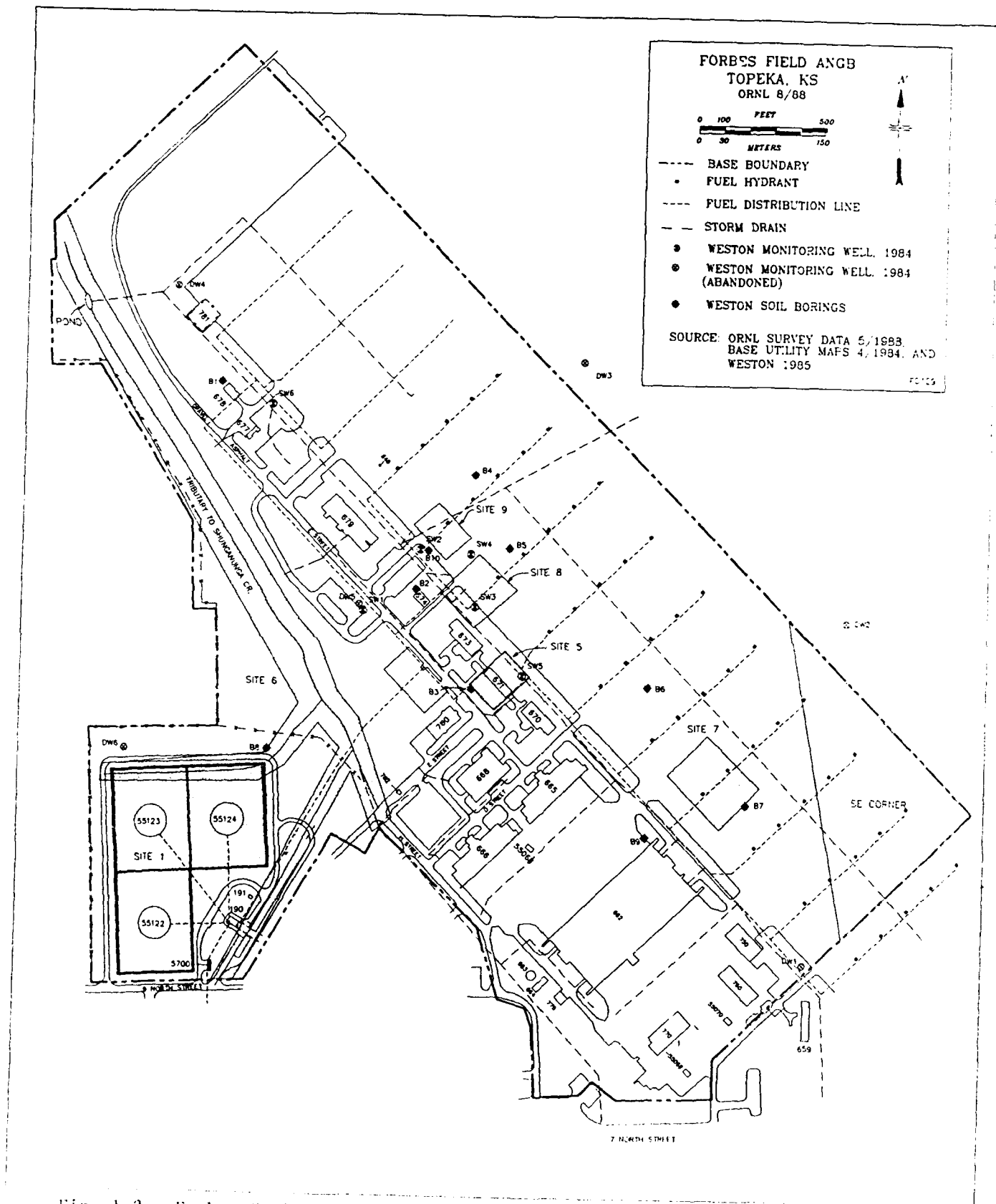


Fig. 1.2. Forbes Field ANGB, Weston monitoring wells and soil borings, shown in relation to present sites.

Oil and grease concentrations ranged from 25,000 to 50,000 $\mu\text{g}/\text{kg}$ in the soil samples; however, soil samples from boring B10 and SW005 contained oil and grease concentrations of 686,000 and 829,000 $\mu\text{g}/\text{kg}$, respectively. No soil samples were taken from the deep wells. Boring B10 is near fuel hydrant 8A, a known location of fuel leaks. SW005 contained a thin layer of floating fuel. Table 1.1 shows the results of the Weston soil sample analyses.

Nine of the twelve water samples (Table 1.2) collected from the monitoring wells contained oil and grease at concentrations above the detection limit of 100 $\mu\text{g}/\text{L}$. Table 1.2 summarizes the water quality analytical results of the Weston study.

Concentrations of oil and grease range from a high of 3,970,000 $\mu\text{g}/\text{L}$ in SW005 to below detection limits in DW002, DW003, and DW004. One deep monitoring well (DW001), located upgradient of most of the base, contained measurable quantities of oil and grease. Those wells finished in the unconsolidated materials above bedrock generally showed greater concentrations than those cased into competent rock.

The inspection of the base storm sewer system with a PID and an OVA revealed no detectable organic vapors in any of the manholes along the ramp (Fig. 1.3). Weston did note the occurrence of organic odors in the central valve pits at the end of laterals 7, 8, and 9. Also, headspace analysis of water samples collected from the storm sewer at the end of lateral 8 showed a concentration of 15 ppm in air.

Weston's studies indicated that groundwater was generally flowing from east to west toward an unnamed tributary of the South Branch of Shunganunga Creek.

Conclusions of the Weston study were:

- 10 to 20 ft of clays and silty clays make up the unconsolidated sediments
- Bedrock consists of shales with interbedded limestone and sandstone stringers
- Groundwater occurs under water table conditions in the unconsolidated sediments and under confined conditions within permeable zones of bedrock
- An upward component of flow exists into the unconsolidated materials
- Trenches dug for construction of storm sewers and fuel lines provide a potential conduit for lateral movement of contaminants.

Table 1.1. Soil sample analytical results, groundwater contamination study
Roy F. Weston, Inc. (1985)

Borehole identification	Sample number	Depth (ft)	Oil and grease concentrations (mg/kg)
B2	S3	8-13	51
B3	S2	5-8	50
B4	S1	1.7-6.7	36
B9	S3	8-12.7	25
B10	S1	1-4	686
SW001	S2	3-8	38
SW003	S4	13-16.5	38
SW004	S1	1.7-3.2	30
SW004	S3	8.2-11	31
SW005	S2	3-7.7	829

Table 1.2. Water quality analytical results, groundwater contamination study
Roy F. Weston, Inc. (1985)

Well	Oil and grease ($\mu\text{g/L}$)
SW001	1,090
SW001 (Duplicate)	3,270
SW002	1,750
SW003	230
SW004	450
SW005	3,970,000
SW006	2,030
DW001	710
DW002	<100
DW003	<100
DW004	<100
DW005	1390
DW006	170
Detection Limit	100

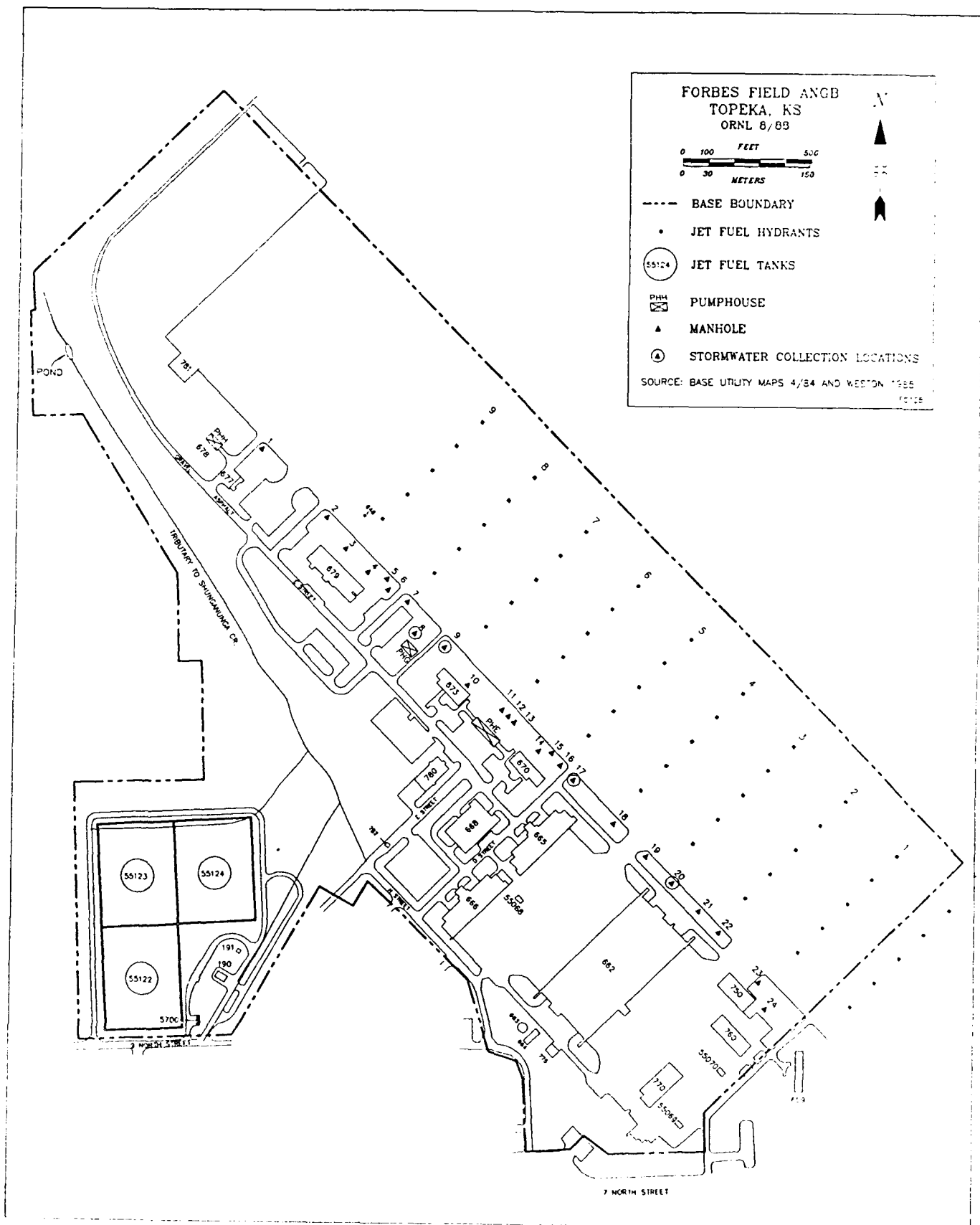


Fig. 1.3. Location of storm sewer manholes and storm water collection points.

The ORNL/CAT study confirmed these general conclusions. However, the upward component of flow into the unconsolidated aquifer occurs only where the permeable Nodaway Coal subcrops into the unconsolidated material (see Sect. 2.2.6). Elsewhere on the base, the unconsolidated aquifer is isolated from bedrock aquifers by impermeable bedrock units.

1.2.3.2 Forbes Field ANGB - Periodic Sampling

In 1985, the base bioenvironmental engineering technician collected water samples at the pond area just before the ditch leaves the base. Analyses by OEHL revealed small amounts of oil and grease ($<300 \mu\text{g/L}$) and an elevated level of manganese ($406 \mu\text{g/L}$). Intermittent sampling of the ditch since 1985 revealed no other contamination. Sample collection has been infrequent because of lack of water in the ditch and a problem with OEHL rejecting the sample bottles used (Tennison 1988).

1.2.3.3 Hazardous Materials Technical Center - Phase I Records Search

The HMTc performed the Phase I records search of the IRP. The HMTc conducted a review of pertinent installation documents, personal interviews with eight base employees, and an inspection of the base. The interviews and research resulted in the identification of ten potentially contaminated sites.

The HMTc determined that Sites 2, 3, 4, and 10 did not present a contaminant migration problem and that no further action was justified. The Air Force's Hazard Assessment Rating Method (HARM) was used to rate the remaining six sites.

The six sites are:

- Site 1 - area adjacent to JP-4 storage facility 55122;
- Site 5 - area adjacent to building 671;
- Site 6 - surface drainage ditch and storm sewer outflow;
- Site 7 - area adjacent to refueling hydrant, located on refueling apron at lateral 3;
- Site 8 - area adjacent to refueling hydrant, located on refueling apron at lateral 7;
- Site 9 - area adjacent to refueling hydrant, located on refueling apron at lateral 8.

The Weston study had already indicated the presence of soil and groundwater contamination at Sites 5, 7, 8, and 9. Samples collected by the base showed evidence of contamination at Site 6.

The Weston discovery of contamination upgradient of all identified sites suggested that contamination was entering the base from an off-base source. The HMTC identified this area as the "southeastern corner of Forbes Field ANGB property" and recommended that the area be studied. Although not a HARM rated site, the southeast corner will be referred to as a "site" throughout this report. Figure 1.2 shows the seven study sites.

Finally, HMTC observed no evidence of off-base environmental stress from the spills or disposal activities at the base.

1.2.3.4 ORNL/CAT Scoping and Preliminary Investigation

In March 1988, groundwater samples were collected by ORNL/CAT from the monitoring wells installed by Weston (1985).

The samples were collected to provide additional information on contamination in the groundwater. The Weston study identified contamination, but used only oil and grease analysis. The oil and grease analysis is a screening technique and results do not always indicate the presence or quantity of contamination. Confirmation of contamination and identification of specific contaminants provided ORNL/CAT with useful information for siting additional monitoring wells. Water from the monitoring wells was analyzed for total petroleum hydrocarbons (TPHCs) and volatile organics (VOAs). Results of the analyses are shown in Table 1.3.

DW001, DW002, DW004, DW005, SW001, and SW004 contained TPHCs, but only trace or undetectable amounts of specific jet fuel compounds. The presence of the TPHCs in the absence of benzene, toluene, ethylbenzene, and total xylenes may be due to coal leachate or other naturally occurring material.

In five of the Weston wells (DW001, DW002, DW004, DW005, and SW005), a film was detected on the stagnant water in the well as determined with a "Scavenger" oil/water interface detecting probe. The floating film was too thin to measure in all of the wells although Weston had reported 0.20 ft of floating product in SW005. In these five wells, water samples were collected without purging in order to identify the compounds in the floating film. The wells were then purged and fresh groundwater samples

Table 1.3. Groundwater analytical results, ORNL/CAT samples from Weston monitoring wells, March 1988

Well number	Sample type	Petroleum hydrocarbons (TPHCs, ug/L)	Benzene (ug/L)	Toluene (ug/L)	Ethylbenzene (ug/L)	Total xylenes (ug/L)
DW001	Stagnant	ND<50	ND<0.5	ND<0.5	ND<0.5	ND<0.5
DW001	Fresh	680	TR<0.5	ND<0.5	ND<0.5	ND<0.5
DW002	Stagnant	100	ND<0.5	ND<0.5	ND<0.5	ND<0.5
DW002	Fresh	TR<50	ND<0.5	ND<0.5	ND<0.5	TR<0.5
DW003	Fresh	ND<50	ND<0.5	ND<0.5	ND<0.5	ND<0.5
DW004	Stagnant	TR<50	ND<0.5	ND<0.5	ND<0.5	ND<0.5
DW004	Fresh	100	TR<0.5	ND<0.5	ND<0.5	ND<0.5
DW005	Stagnant	70	ND<0.5	ND<0.5	ND<0.5	ND<0.5
DW005	Fresh	ND<50	ND<0.5	ND<0.5	ND<0.5	ND<0.5
DW005	Fresh (Repl)	ND<50	ND<0.5	ND<0.5	ND<0.5	ND<0.5
DW006	Fresh	ND<50	ND<0.5	ND<0.5	ND<0.5	ND<0.5
SW001	Fresh	120	ND<0.5	ND<0.5	ND<0.5	1.0
SW002	Fresh	ND<50	ND<0.5	ND<0.5	ND<0.5	ND<0.5
SW003	Fresh	ND<50	ND<0.5	ND<0.5	ND<0.5	ND<0.5
SW004	Fresh	190	TR<0.5	ND<0.5	ND<0.5	TR<0.5
SW005	Stagnant	8,900	180	ND<3	300	390
SW005	Fresh	12,000	640	ND<3	690	750
SW005	Fresh (Repl)	13,000	490	TR<3	670	760

Stagnant - Groundwater sample collected from monitoring well prior to purging. Stagnant samples were only collected from wells which indicated floating product using an oil/water interface detecting probe.

Fresh - Groundwater sample collected after purging at least three well volumes (if possible).

ND - This compound was not detected; the limit of detection for this analysis is less than the amount stated in the table above.

TR - Trace, this compound was present, but was below the level at which concentration could be determined.

Repl - Replicate sample taken to verify results of another sample.

Note: Monitoring well SW006 has been mechanically disturbed; sampling equipment will not penetrate the well.

were collected. The pre-purge samples collected from DW002 and DW005 contained detectable TPHCs while the post-purge samples did not. In DW001 and DW004, the opposite occurred: the pre-purge samples contained no detectable TPHCs while the post-purge samples showed TPHCs. Again, the samples showed only trace or undetectable quantities of benzene, toluene, ethylbenzene, and total xylenes, indicating that a naturally occurring material might have contributed the TPHCs.

1.2.4 Planned Construction Activities

The KSANG intends to modify a significant portion of the aircraft parking ramp in the near future (1989, if possible). Existing laterals 6, 7, and 8 (Fig. 1.4) will be abandoned. A new fuel lateral 7 will be installed south of the present lateral 6 and a new fuel lateral 8 will be installed between the existing fuel lateral 7 and 8. Fuel lateral 9 will be removed from the distribution line to the second fuel hydrant, and will be replaced with a new line. From the second hydrant toward the east, the old fuel line will be abandoned and replaced by a new section offset to the north.

A portion of the asphalt surface of the ramp from fuel lateral 8 to fuel lateral 4 will be removed and replaced. New concrete pads will be installed over the new fuel laterals.

Also planned for the future, but with unknown dates, are several additional projects. These include: (1) redesigning the traffic flow with the main entrance to the base at the northwest corner, (2) enclosing the entire drainage ditch (Site 6) as a storm sewer with catchment basins for storm runoff and a containment system to dam the drainage ditch in the event of a major fuel spill, and (3) possible removal of the 50,000 gal underground storage tanks surrounding the three fuel pumphouses near the aircraft parking ramp.

1.3 REPORT ORGANIZATION

This RIR follows the format suggested in the Draft Guidance for Conducting RI and FS under CERCLA (EPA, October 1988).

Sections 1 and 2 provide an introduction and describe the general site characteristics of the base. Sections 3 through 10 describe the site

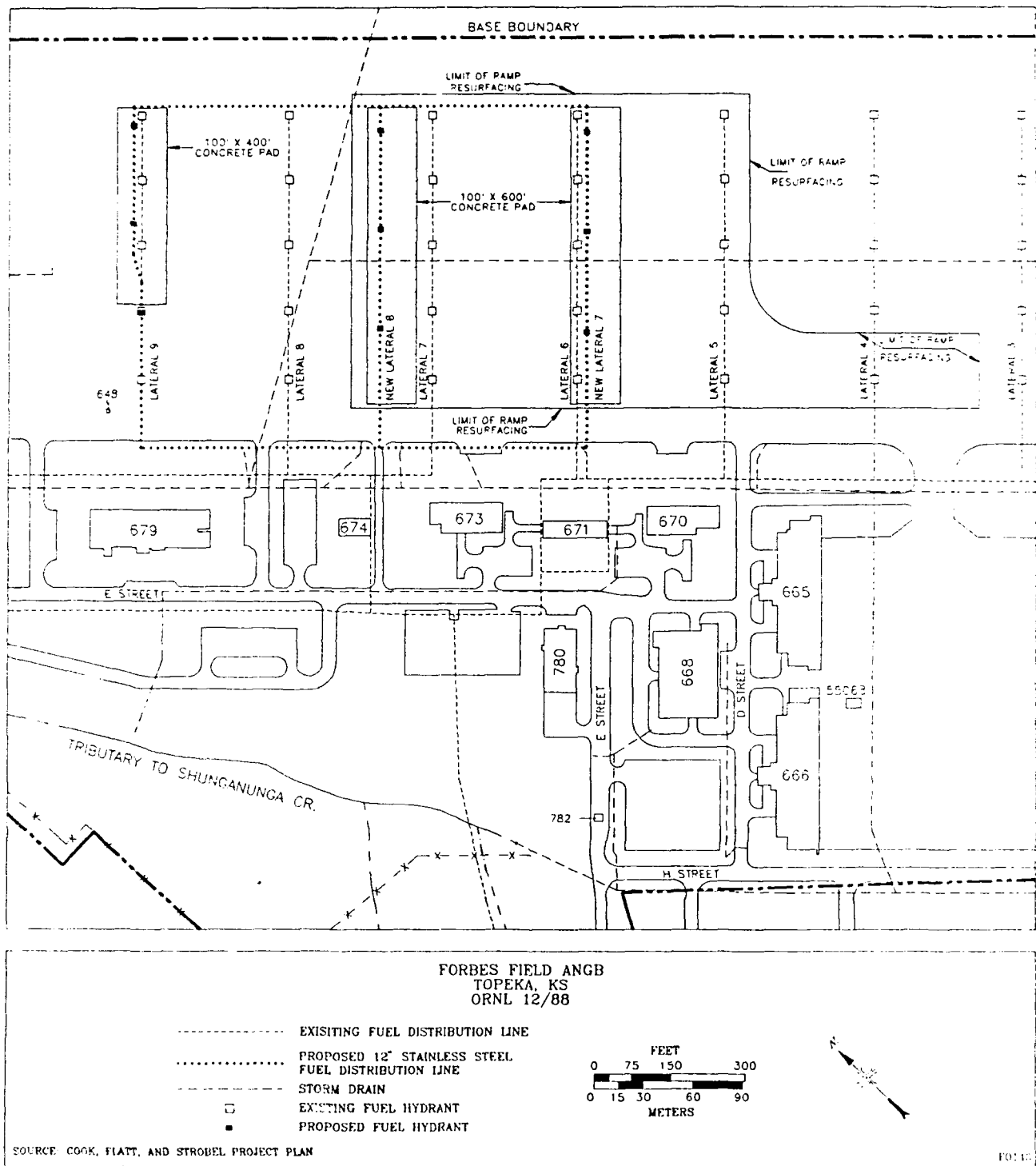


Fig. 1.4. Proposed ramp construction project.

investigation and the results for each potentially contaminated site. Section 11 summarizes findings of the study.

Due to the nature of the base, many characteristics will be the same for several sites. To conserve space, when appropriate, sections have been referenced.

Ten appendices are attached at the end of this report. The information each appendix contains is as follows:

- A: Glossary of terms and acronyms used in the report
- B: Documents and references used in the preparation of the report
- C: Personal contacts referenced in the report
- D: Results of the soil-gas survey conducted at the base
- E: Significant results of chemical analyses of samples collected at the base
- F: Evaluation of quality assurance/quality control measures taken to ensure data reliability
- G: Summary of the monitoring wells and coreholes, including description of the lithology and construction of the well
- H: Field parameters (temperature, pH, and conductivity) of groundwater samples
- I: Description of methods and results of the land survey to define the location and elevation of wells and other base reference points
- J: The full risk assessment used to define the baseline risk assessments in the report

Two large format maps are included with this report. Plate 1 shows the base with all sites, well locations, sample locations, buried fuel and storm sewer lines, and base facilities. Plate 2 is a geologic map with structural contours drawn at the base of the Topeka limestone.

In the text of the report and in the appendices, the monitoring wells, coreholes, Weston wells, surface water sample locations, and sediment sample locations are referred to by two letters followed by three numbers. This is required by the data base containing the analytical results. Because of space constraints on the plates and figures, however, these locations are referred to by two letters and two numbers [i.e. MW001(text) = MW01 (fig.)].

1.3.1 Additional Information

Two supplements to this RIR are available on request. Supplement One contains copies of all chemical sample analytical reports including laboratory quality assurance/quality control (QA/QC) samples. Supplement Two contains copies of all field sample data records which were filled out at the time of sample acquisition. These supplements can be obtained by contacting:

Oak Ridge National Laboratory
Grand Junction Office
P.O. Box 2567
Grand Junction, CO 81502
Attn: Forbes Field ANGB Site Project Manager

or

Hazardous Waste Remedial Action Program
Tri County Mall
831 Tri County Road
Oliver Springs, TN 37840
Attn: Forbes Field ANGB Project Manager

2. REMEDIAL INVESTIGATION

2.1 REMEDIAL INVESTIGATION ACTIVITIES

The remedial investigation (RI) of Forbes Field ANGB was initiated on February 3, 1988 when representatives of the NGB, KSANG, HAZWRAP, and ORNL/CAT met to discuss the key personnel, work plan, and schedule for future activities. A preliminary investigation in March 1988 consisted of sampling several existing wells. The field investigation began in April 1988 and defined the hydrogeologic setting and characterized the presence and extent of contaminants resulting from past activities. The elements of the field investigation included:

- a review of aerial photographs and past activities at the base,
- land surveying,
- soil-gas sampling,
- soil and sediment sampling,
- drilling of monitoring wells and coreholes,
- hydrologic testing,
- groundwater sampling, and
- surface water sampling.

2.1.1 Work Plan

Preliminary sampling plan development began immediately after the February meeting. This plan included sampling of the monitoring wells installed by Weston (1985).

Development of the site characterization work plan (which guided all aspects of the field investigation, including the technical approach), QA/QC, and health and safety plan also began immediately after the February 1988 meeting. The KSANG requested a rapid return of field data due to a planned construction project which involved areas to be investigated during the site characterization.

Recommendations made in the Phase I records search and HAZWRAP's statement of work were used to plan the site characterization. An internal draft of the work plan was submitted to HAZWRAP and was reviewed by HAZWRAP and the NGB. Comments from these organizations were incorporated into the

draft work plan. The draft work plan was resubmitted to HAZWRAP and reviewed by the NGB, HAZWRAP, the U.S. Environmental Protection Agency (EPA), and the Kansas Department of Health and Environment (KDHE).

Comments from the reviewing organizations were received at a meeting on June 7, 1988. The work plan was updated to address all comments and completed in September 1988.

2.1.2 Site Characterization

A phased approach was used for the site characterization. Preliminary samples from the Weston wells provided guidance on groundwater flow and contaminant concentrations. Soil-gas data was collected in fuel line and storm sewer trenches and surrounding known spill sites. The soil-gas information was then used to optimize the location of planned monitoring wells.

Sediment samples were collected at locations in the ditch to determine specific contaminants and source tributaries. Following analysis of these samples, additional sediment and surface water samples were collected to define a contaminant source and determine if contaminants were being transported off-base.

Table 2.1 shows a schedule of the field activities at Forbes Field ANGB. The following sections provide information on individual elements of the site characterization.

2.1.2.1 Aerial Photo Interpretation

Prior to the field investigation, ORNL/CAT assembled and reviewed aerial photographs of Forbes Field Air Force Base and Forbes Field ANGB from 1954 to 1984. These aerial photographs provided information on the chronology of base construction.

2.1.2.2 Soil-Gas Sampling

Soil-gas data was collected from the fuel trenches under the aircraft parking ramp to obtain information on the extent of fuel in the trenches. Soil-gas samples collected along storm sewer trenches and below the intersection of storm sewer and fuel trenches determined if fuel was migrating

Table 2.1 Schedule of field activities, Forbes Field ANGB, Phase II study

DATE	Activity
February 3, 1988	"Kick-off" meeting held at Forbes Field ANGB; set schedule, methods, and located sites
March 7 - 11, 1988	Sampled groundwater from Weston (1985) wells to provide preliminary information on contaminants
April 25 - 26, 1988	Land survey established reference monuments and benchmarks for control of future surveys
May 25 - 27, 1988	Land survey established locations and coordinates for soil-gas samples
June 7, 1988	Regulatory review meeting of the remedial investigation work plan held at Forbes Field ANGB
June 13 - 25, 1988	Drilling program-installation and development of monitoring wells, soil sampling, sediment sampling, soil-gas sampling
July 5 - 15, 1988	First round of groundwater sampling
July 6 - 8, 1988	Land survey of monitoring wells, coreholes, and additional soil-gas sample locations
August 16 - 19, 1988	Hydraulic testing
September 22, 1988	Meeting to review results of sampling, determine analytical needs for the second round of groundwater samples
September 26 - October 8, 1988	Second round of groundwater sampling
October 31 - November 1, 1988	Drilling program - drilled and installed MW028 in tank farm (Site 1)
November 18, 1988	Collected groundwater samples from MW028 and additional surface water samples from the drainage ditch
December 15, 1988	Collected second groundwater sample from MW028

within or between trenches. Soil-gas sampling was also used downgradient of the sites and around the tank farm to select monitoring well locations. Plate 1 shows all sampling points and respective sites. Soil-gas sample results are provided in Appendix D.

Eighty-four soil-gas and eighteen water samples were collected and analyzed by Hydro Geo Chem, Inc., in June 1988. The following compounds were analyzed at each sampling location:

- trichloroethene (TCE)
- chloroethene (vinyl chloride)
- benzene
- toluene
- ortho, meta, and para xylene
- phenylethane (Ethylbenzene)
- total petroleum hydrocarbons (TPHCs)

Samples were collected by driving a 1 in. galvanized pipe tipped by a loosely held disposable steel point to a specified depth, then withdrawing the pipe 6 in. to separate it from the tip and expose the sampling interval. A regulated vacuum pump was attached to the probe and 3 to 5 times the volume of the sample train was purged. The soil-gas was pumped through the probe using a computerized mass-flow controller which regulated flow and measured sample volume. The sample was trapped and concentrated in a glass cartridge contained in a stainless steel housing. The concentrating cartridge was packed with 3 activated carbons: Carbotrap, Carbopak-B, and Carbosieve S-III, selected to quantitatively trap organics with widely differing vapor pressures. After sampling, the cartridges were brought to the on-site mobile laboratory for analysis by gas chromatography.

The glass cartridges were desorbed using a thermal desorption unit. Samples were injected by a desorber into a capillary column which was followed by quantification with photoionization and Hall conductivity detectors. A split from the thermal desorber was sent to an additional gas chromatograph equipped with a flame ionization detector for analysis of TPHCs.

Due to the high clay and moisture content of the soil, it was not always possible to withdraw soil-gas. In those instances, the pipe was capped and left in the ground overnight. If water had entered the hole the following day, a water sample was collected in a 40 mL volatile organic sample vial.

Water samples were analyzed with a purge and trap system. Helium was injected into the volatile organic sample vial through a needle at 200 mL/min for 15 min. The gas stream exiting the volatile organic sample vial through another needle purged the volatile components from the water and carried them to a three layer carbon-packed glass trap. The cartridge was then analyzed in the same manner as the soil-gas samples.

All parts of the collection system that came in contact with a sample were cleaned before each use. A system blank and three calibration runs were performed at the beginning of each day, and additional calibrations were done after every ten samples. Following the initial calibration runs, field blanks of the entire sampling apparatus were taken to check background contamination in the sampling system and cartridges. Serial duplicates were taken from at least 10% of the sampling locations as a measure of reproducibility.

Detection limits were 0.01 µg/L for all compounds analyzed.

2.1.2.3 Monitoring Well Drilling/Soil Sampling

Monitoring well locations were selected such that both the source and extent of contamination could be determined at each site. A monitoring well was also installed upgradient of each site to evaluate upgradient water quality. In addition, two upgradient wells were drilled southeast of the base, east of the airport taxiway "B". These wells provided upgradient water quality data and geologic information.

Twenty-seven borings were drilled in June 1988; 26 were completed as monitoring wells. The remaining hole, being dry, was plugged and abandoned. One well was drilled in October 1988 to further study a contaminant source near Site 1. An ORNL/CAT geologist supervised the drilling and kept a detailed lithologic log of the core brought up in the continuous sampler. These lithologic logs were described and compiled using a modified version of the unified soil classification system for unconsolidated materials. The Munsell soil color system provided color description.

Drilling was accomplished with a B-61 Mobile rig owned and operated by Layne-Western, Inc., of Kansas City, Kansas. Hollow stem augers were 7 5/8 in. outside diameter (OD) by 4 1/4 in. inside diameter (ID). A 5-ft continuous core barrel was used to obtain samples. Continuous samples were taken from surface to total depth using the continuous sampler inside the

augers. Wells drilled through the aircraft parking apron were pre-drilled through the concrete pad with a coring machine. The ramp was approximately 2 ft thick; therefore, continuous sampling began at 2 ft.

The continuous sampler had to be removed from the auger flight prior to total depth in several of the wells. This occurred when the weathered bedrock was too hard to push the sampler through. In these cases, the sampler was removed and drilling continued until auger refusal.

Ambient air, annular headspace, and the soil samples were screened with and HNU model PI-101 PID for the presence of volatile organic vapors. No elevated measurements were encountered from any of the samples.

The drill-rig, associated augers, bits, samplers, etc., were cleaned with hot water wash and Liquinox laboratory detergent prior to drilling. The equipment was similarly cleaned between wells and at the end of the project. Water was obtained from the domestic water supply at the base fire station. Water for decontamination of sampling equipment was obtained from the domestic supply at the civil engineering building.

All sampling equipment which directly contacted the samples was scrubbed with a solution of tap water and Liquinox. This was followed by rinsing with tap water, pesticide grade methanol, pesticide grade hexane, and analyte free water.

Soil samples for chemical analysis were collected at 3-ft intervals, except in MW024 and MW027, which were collected at 9-ft intervals. Soil samples were submitted for VOA and TPHC analysis. An additional soil sample was collected from a coal zone at a depth of 8 ft in MW022. This soil sample was submitted for oil and grease analysis. Section 2.1.2.13 provides details on this sample.

Samples were shipped to the International Technology (IT) Corporation laboratory in Knoxville, Tennessee, for analysis. Detailed sampling procedures are provided in the ORNL/CAT Procedures Manual, Sect. 2; analytical data from sampling is presented in Appendix E; an evaluation of the analytical data and quality assurance results is presented in Appendix F; and well summary logs are provided in Appendix G.

2.1.2.4 Monitoring Well Installation

Twenty-six monitoring wells were completed in the unconsolidated aquifer. Because of the single, thin, water-bearing alluvial zone, all wells were single completions.

The unconsolidated material wells were constructed of 2 in. ID, schedule 40, flush-threaded PVC. Figure 2.1 shows a typical completion diagram for a monitoring well.

The augers were pulled from the well prior to installation of the PVC. In several of the monitoring wells, the continuous sampler would not penetrate the weathered bedrock. The continuous sampler was removed and drilling continued until auger refusal. This action causes the hollow stem of the auger to become plugged and the auger must be removed prior to well installation. The unconsolidated material was competent and the monitoring wells remained open during well installation. Sand was poured from the top of the well. Volume calculations and depth measurements ensured the sand pack and bentonite seals were adequate.

All wells were screened from bedrock to a minimum of 1-ft above the water bearing zone with 0.01 in. milled slotted screen. Sand pack in the annular space consisted of 20 to 40 mesh (0.022 to 0.14 in.) well-rounded silica, extending at least 1 ft above the screen. One foot of sand was used due to the tight soils and shallow depths of the wells. In many cases, more than 1 ft of sand above the screen would not have allowed an adequate seal above. Two feet of hydrated sodium bentonite (1/4 in. pellets) was placed on top of the filter pack. The remaining annulus was grouted to the ground surface with a mixture of 6 parts Portland cement to 1 part bentonite.

All wells finished above ground were protected with a 5-ft length of 6 in. diameter steel casing extending about 2.5 ft above ground and set in grout. Protective casing was secured by a padlocked outer protective cap. Additional protection was provided by three 3 in. diameter steel posts erected radially 2 ft from each well, installed 2 ft below ground surface and at least 3 ft above ground surface. A mortar collar extending 0.3 to 0.5 ft above ground surface was placed around the protective casing. The collar continued radially, sloping away from the protective casing approximately 3 ft, encompassing the steel posts. A 1/4 in. diameter hole (drainage port) was drilled through the protective casing above the mortar collar. For wells located in areas of aircraft or vehicle traffic, a watertight manhole assembly was installed. The manhole cover was set flush with the concrete to protect the wells and to prevent interference with daily activities. MW003, MW005, MW006, MW007, MW011, MW012, MW013, MW014, and MW023 required the flush mount installation.

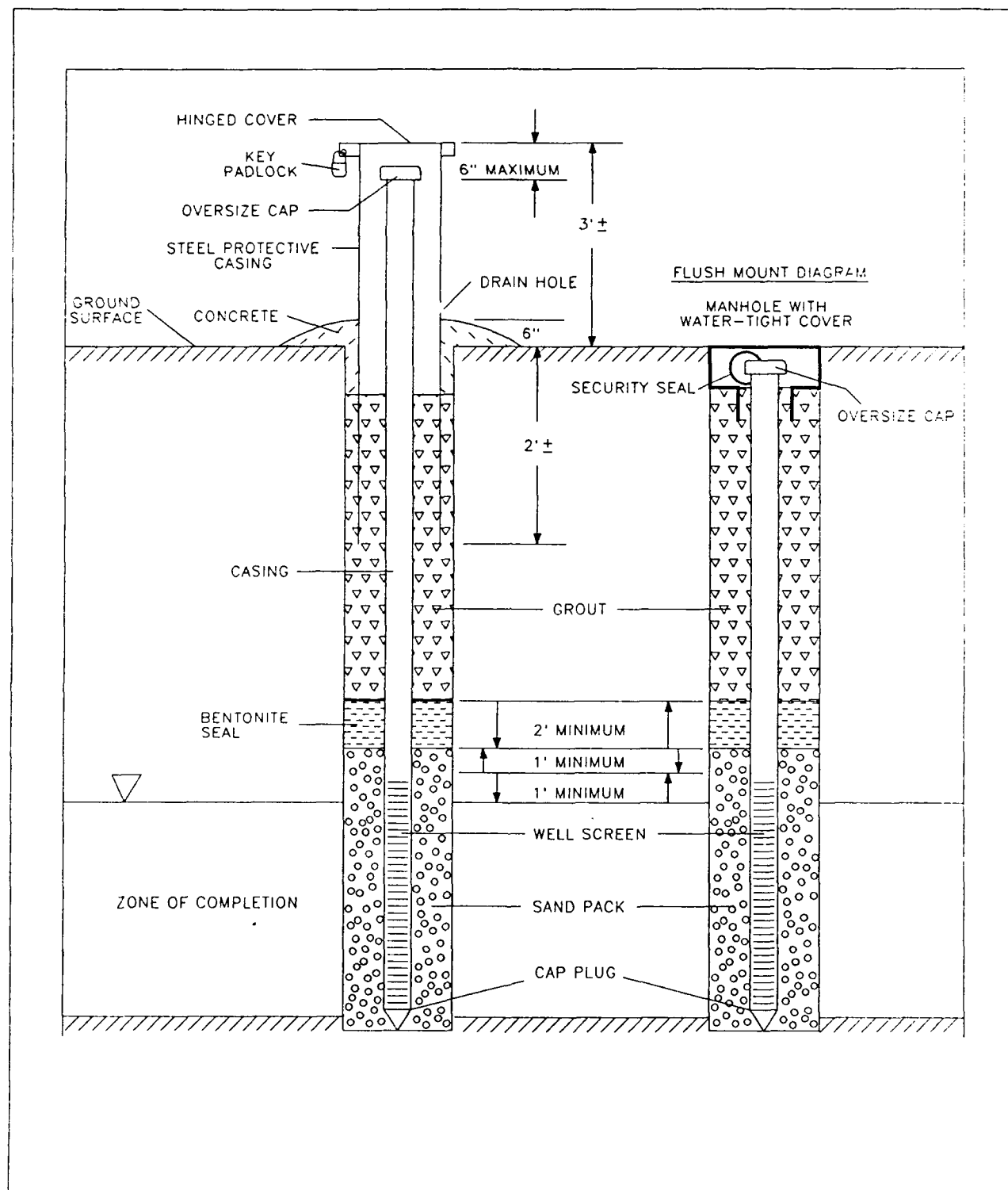


Fig. 2.1. Schematic diagram of monitoring well construction.

Well Development

Alluvial wells were developed by jetting the screen and sandpacking with nitrogen, followed by pumping at a rate equal to the recharge rate until the water was clear. In cases where recharge rate was too slow, the wells were jetted and repeatedly pumped to dryness until clean water was obtained. Since nitrogen is an inert gas, the impact of well development on the groundwater quality is assumed to be negligible.

2.1.2.5 Corehole Drilling

Three bedrock coreholes were drilled and cased through the unconsolidated materials and then cored 50 ft into the underlying bedrock formation. These holes were drilled in the southeast corner, west boundary, and northwest corner to characterize the bedrock lithology and determine the potential for contaminant migration in permeable bedrock units.

A 9 7/8 in. hole was drilled from the surface into competent bedrock; 6 5/8 in. OD threaded and coupled steel casing was then installed. The hole annulus from the casing seat to the ground surface was cemented by pumping a calculated volume of cement through the casing and under the casing seat to the surface. A drillable displacement plug and a calculated fluid volume were used to displace the cement from inside the casing. After the cement had properly bonded and cured, the displacement plug, along with any remaining cement, were drilled out. The casing seat was then water pressure tested to 250 PSI for 30 min. Upon completion of a successful pressure test, coring continued into the bedrock by means of a 3.5 in. OD double tube core barrel. Total depth from ground surface to the bottom of the uncased borehole was about 70 ft.

Drilling was accomplished using standard rotary methods to bedrock and wireline core methods to total depth. This provided complete core recovery from bedrock for accurate lithologic description and stratigraphic correlation. Well summaries are provided in Appendix G.

No soil samples were collected from the coreholes.

Because of the potential for dust blowing into aircraft engines, water was used for cutting transport during rotary drilling. No additives were used. Water for drilling was obtained from the domestic supply through a fire hydrant at the base fire station. To ensure that no contamination was

introduced by this water, samples of the water were collected from the hydrant and from the driller's tank. These samples were analyzed for VOAs, TPHCs, semi-volatiles, PCBs/Pesticides, metals, and major cations and anions. Lab results indicate expected levels of chloride (about 170,000 $\mu\text{g/L}$), fluoride (1900 $\mu\text{g/L}$), and sulfate (150,000 $\mu\text{g/L}$), plus chloroform (55 $\mu\text{g/L}$), bromodichloromethane (28 $\mu\text{g/L}$), and dibromochloromethane (17 $\mu\text{g/L}$). No fuel components were present.

These last three compounds (chloroform, bromodichloromethane, and dibromochloromethane) are found in fire fighting foams (Verschuere 1983). The water truck was filled using a canvas fire hose attached to the fire hydrant. This hose was also used to fill the fire trucks by dropping the hose into the top of the tank. This would cause the foaming agent to absorb on the canvas hose. Thus, the ORNL/CAT samples collected from this hose and the driller's tank were apparently contaminated with these foaming agents. Subsequent samples of groundwater from the wells revealed no detectable levels of chloroform, bromodichloromethane, and dibromochloromethane.

CH001 and CH002 were completed with protective casing above ground using locking caps, concrete aprons, and bucking posts. CH003 was on the aircraft ramp and was completed with a watertight manhole assembly.

2.1.2.6 Bail and pumping test procedures

Bail tests

The bail-test involves the instantaneous change in the pressure or fluid head in a single well that penetrates a water-bearing formation. The change in pressure is induced in the well by removing a column of water. The water level in the well will return to the original hydrostatic conditions by formational water flowing into the well. The rate at which this occurs is dependent upon the permeability of the formation and the well-bore conditions. By measuring the change in the water level as a function of time, it is possible to compute the permeability of the formation. This method of interpreting water level versus time data was developed by Hvorsler (1951).

Two individuals were required to conduct the bail test using the following procedures. The water level in the well is measured, in feet, from the top of the well casing. An air hose, attached to a nitrogen bottle, is inserted into the well. The nitrogen is turned on to the air hose and the

water is air-lifted from the well. The nitrogen is then turned off and the air hose is removed from the well. As soon as possible, the depth to water was measured using a water-level indicator, recorded in the field logbook, and the stopwatch started. As rapidly as possible, water level measurements and the time the measurements were made are both recorded in the field logbook until the well recovers to the initial water level. When recovery was slow, water level readings were taken at appropriate time intervals as significant water-level changes occurred.

The water level as a function of time data are plotted on semi-logarithmic paper. The water level data is normalized using the following equation where H is the initial water level, H_0 is the water level at time = 0, h is actual head readings during the test, e is the base of natural logarithms ≈ 2.718 , and T_0 is the basic lag time:

$$\frac{H - h}{H - H_0} = e^{-t/T_0} \quad (\text{equation 1})$$

Once T_0 is determined from the graph, the hydraulic conductivity, K , is calculated using the following formula, assuming that the ratio of L (intake length) to r (borehole radius) is greater than 8 to 1.

$$K = \frac{r^2/n (L/r)}{2L T_0} \quad (\text{equation 2})$$

Pumping test

The pumping test involves pumping water from a well for a certain period of time at a certain rate. The effect on the water table from the pumping is measured at both the pumping well and the observation well. A pumping test was performed using MW025 as the pumping well and MW022 as the observation well. The observation well is located 7.75 ft to the north of the pumping well.

The pumping well was equipped with a peristaltic pump. Water from the pumping well was conducted away and downgrade from the test area via rubber tubing to prevent it from returning to the aquifer.

Water level measurements were taken before starting the pump. After starting the pump, water level measurements were taken at timed intervals from both MW025 and MW022.

The length of the pumping test, originally planned for 24-hr, was reduced because of the limited capacity of the well.

Drawdown data as a function of time are plotted on logarithmic paper at the same scale as the type curves presented in Kearl et al. (1988). Using curve matching techniques presented by Neuman (1975), aquifer transmissivity and storativity were determined.

2.1.2.7 Groundwater Sampling

Collection of groundwater samples took place on five occasions. Eleven Weston wells were sampled in March 1988 to provide data to guide the site characterization. (Weston's SW006 had been struck by a vehicle and sampling equipment would not penetrate the well.) In July 1988, groundwater samples were collected from 25 monitoring wells and 3 coreholes installed by ORNL. During September and October 1988, groundwater samples were collected from the 3 coreholes, 25 ORNL/CAT monitoring wells, and the 5 shallow wells installed by Weston. MW028 was sampled in November and December 1988. Significant analytical results are presented in Appendix E.

Monitoring wells were checked for evidence of floating film and sampled prior to purging, when appropriate. An oil indicating-water level measuring probe was used to check for floating films. At least three borehole volumes were pumped from the monitoring wells before collecting fresh samples. In a few cases where the recharge rate was too slow to purge the required volume, the wells were pumped until dry and allowed to recover before sampling.

All groundwater samples collected in July 1988 were analyzed for VOAs, TPHCs, hazardous substance list (HSL) metals, and major cations/anions. In addition, groundwater samples from MW001, MW003, MW021, MW025, CH002, and CH003 were analyzed for semi-volatiles and PCBs/pesticides. Groundwater samples collected in March, September, October, November, and December were analyzed for VOAs and TPHCs only. The reduced list of analytes was a result of no other contaminants being identified in the initial groundwater samples.

Samples for organic analyses were taken from the alluvial wells with a Teflon^{*} bailer. Samples for inorganic compounds were collected from the alluvial wells with a small, battery-powered peristaltic pump. Specific procedures for sampling are contained in the ORNL/CAT Procedures Manual, April 1988.

*Teflon is a registered trademark of E. I. duPont de Nemours and Co.

Corehole groundwater samples for both organic and inorganic analyses were collected with a stainless steel/Teflon non-gas contact bladder pump and Teflon tubing. Corehole wells which were too muddy for the bladder pump were sampled with a Teflon bailer.

Field measurements of pH, conductivity, and temperature were made on all wells sampled in March, July, November, and December 1988 except MW008, which did not have a sufficient volume of water. During September 1988, conductivity and temperature were measured on all wells; however, a malfunction in the instrument caused the loss of pH measurement on all wells. Conductivity measurements were taken with an Amber Science Model 604. A Horiba Water Checker was used to measure the pH and the temperature in July and the temperature in September. In all cases, calibrations were performed with buffer solutions and standard solutions just before measurement of the sample. During March and July, all measurements were taken by pumping groundwater into an air-exclusion flow-through cell. September, October, November, and December samples were checked using an open cell. The open cell method, although less precise than the air exclusion cell, was deemed adequate since no pH sensitive contaminants have been found. Information on sample parameters is available in Appendix H.

Replicate groundwater samples were collected at MW003, MW019, MW025, CH002, and CH003; these replicate samples were analyzed at Oak Ridge Gaseous Diffusion Plant (ORGDP) and by the KDHE.

2.1.2.8 Sediment Sampling

In June and September 1988, stream sediment samples were collected from the drainage ditch. These samples provide information on contaminants being transported in the drainage ditch, Site 6. The sediment samples were analyzed for VOAs, TPHCs, semi-volatile organics, PCBs/pesticides, and metals. Sediment sample locations are shown on Plate 1.

Soft sediments were taken by inverting the sample jar and pushing in the sediment until full, then quickly capping the jar. Drier, more consolidated sediments were collected with a stainless steel scoop and placed in the sample jars. Significant analytical results are presented in Appendix E.

2.1.2.9 Surface Water Sampling

Surface water samples were collected from the drainage ditch to determine if contaminants were being transported in the stream. Three low-flow samples were collected in September 1988: one near the head of the ditch (WS001, Plate 1), one near the center of the base (WS002), and one at the base boundary (WS003). Low-flow is defined as natural flow in the stream resulting from groundwater discharge. These three samples were analyzed for VOAs, TPHCs, semi-volatile organics, and PCBs/pesticides.

Following the return of sample results, three additional water samples were collected near the head of the ditch: one at the original point (WS001), one at the first surface water in the ditch (WS004), and one about midway between WS001 and WS002 (WS005). These samples were analyzed for VOAs and TPHCs.

Surface water samples during high-flow conditions were planned to determine contaminant transport during a storm. High-flow is defined as flow resulting from a storm of sufficient intensity to cause a significant increase in the ditch flow. Due to the drought experienced by northeast Kansas during 1988, high-flow condition water samples have not been collected.

Samples for VOA and TPHC analysis were collected by bailing with a clean sample bottle. Samples for semi-volatile organics and PCBs/pesticides were collected by bailing with a clean sample bottle in shallow areas or by immersing the appropriate bottle in deeper areas. Analytical results are presented in Appendix E.

2.1.2.10 Field QA/QC

Analytical results of field QA/QC samples are presented in Appendix F.

Field Procedure Documentation

The field supervisor kept a daily logbook documenting field activities; this logbook became part of the permanent project files. In addition, each member of the field crew kept a daily log which was copied and placed in the project files.

Each phase of the field work, including soil cores, was photographed. Each photograph was labeled and archived in project notebooks. After each phase of field work, the field supervisor wrote a trip report summarizing the activities.

Equipment Decontamination

Before use, all sampling equipment which directly contacts the sample was scrubbed with a solution of tap water and Liquinox, then rinsed with tap water, pesticide grade methanol, pesticide grade hexane, and analyte-free deionized water. Pump tubing was cleaned by pumping Liquinox solution, tap water, and deionized water through the line. After cleaning, Tygon^{*} tubing was dedicated to the sampling site at which it was used. Drill string and auger flights were steam cleaned before each use.

Sample Containers

All sample containers were purchased pre-cleaned from I-Chem, Inc. Specific container requirements are shown in Table 2.2.

Field QA/QC Samples

The types of samples collected to ensure accuracy, precision, representativeness, and comparability are summarized in Table 2.3.

Sample Preservation and Holding Times

Sample preservation and holding times are also summarized in Table 2.2. Immediately following collection, all soil and water samples were placed in an iced cooler. At the end of each day, the samples were transferred to coolers containing fresh Blue Ice^{**} or its equivalent, and the chain-of-custody form was initiated. The coolers were sealed with custody tape and shipped via overnight courier to the IT Corporation laboratory in Knoxville, Tennessee.

*Tygon is a registered trademark of the Norton Co.

**Blue-Ice is a registered trademark of the Gott Co.

Table 2.2. Sample preservation, container requirements,
and holding times

Analyte	Container	Preservation	Maximum holding time
Water			
Volatile organic analytes (VOAs)	2-40 mL glass vials with Teflon septa	4°C, pH<2 with HCl	14 days
BNAs	1-1000 mL glass, with Teflon-lined cap	4°C, store in dark	7 days until extraction, 40 days after extraction
PCBs/pesticides	1-1000 mL glass, Teflon-lined cap	4°C, pH 5-9	7 days until extraction, 40 days after extraction
Total petroleum hydrocarbons (TPHCs)	1-125 mL glass jar, Teflon-lined cap	4°C, pH<2 with HCl	28 days
Priority pollutant metals (Sb, Ba, Be, months for others Cd, Cr, Cu, Pb, Ni, Ag, Zn, Hg, Se, As) Cations (Ca, K, Mg, Na)	1-250 mL polyethylene	filter .45u, HNO ₃	28 days for Hg, 4°C, pH<2 with 6
Anions (Cl, F, NO ₃ , PO ₄ , SO ₄)	2-250 mL polyethylene	filter .45u, 4°C (all anions), pH<2 with H ₂ SO ₄ - NO ₃ and PO ₄ only	28 days
Soil/Sediment			
BNAs, PCBs/pesticides TPHCs, hazardous substance list, metals,	1-500 mL wide mouth glass jar with Teflon-lined lid	4°C	Same as above for corresponding water samples
VOAs	1-125 mL wide mouth glass jar with Teflon-lined lid	4°C	7 days until extraction, 40 days after extraction

Table 2.3. Types of field QA/QC samples collected at Forbes Field ANGB

QA/QC sample type	Matrix	Origin	Purpose	Frequency
Trip blank	Deionized water to be used for equipment decon	DOE Compound Grand Jct., CO	Determine if volatile organics entered the sample by an airborne route	2-40 mL vials in each cooler shipped to the lab
Field blank	Deionized water used for equipment decon, poured directly from container in field into the appropriate sample bottles	Field sampling station	Determine if contamination was introduced due to the sampling technique and from the best decontamination water	1 sample/water source
Equipment rinse	Deionized water used for equipment decon, poured or pumped through sampling equipment into sample bottles immediately following equipment decontamination	Field sampling station	Determine if equipment decon is adequate	1 sample/day; analysis requested on every second rinseate blank.

NOTE: In the case of field blanks and equipment rinseate blanks, preference shall be shown for sampling locations which are suspected of having elevated contaminant concentrations.

2.1.2.11 Laboratory QA/QC

Level C quality control was utilized at the base. Requirements for level C are defined in Requirements for Quality Control of Analytical Data (HAZWRAP 1988). Results of laboratory QA/QC samples and an evaluation of those results are presented in Appendix F.

Method Blanks

Blank samples were analyzed to ensure that reported analytical results are not the results of laboratory contamination.

Matrix Spike

A matrix spike is an aliquot of a matrix (water or soil) spiked with known quantities of compounds and subjected to the entire analytical procedure. This is done to indicate the appropriateness of analytical methods for the matrix by measuring its recovery.

Matrix Spike Duplicate

A matrix spike duplicate is a second aliquot of the same matrix as the matrix spike. It is spiked to determine the precision of analytical methods.

Surrogates

Compounds added to every blank, sample, matrix spike, matrix spike duplicate, and standard and used to evaluate analytical efficiency of the method by measuring recovery. Surrogates are brominated, fluorinated, or isotopically labelled compounds not expected to be detected in environmental media. These are used in organic analytical methods.

2.1.2.12 Location and Elevation Survey

Land surveys at Forbes Field ANGB by ORNL/CAT personnel provided preliminary reference monuments, locations for the soil-gas samples, and general location information for landmarks. The monitoring wells and

coreholes were surveyed by ORNL/CAT personnel then verified by a land surveyor certified in the state of Kansas. All check locations were satisfactory except for one elevation measurement. The Kansas certified surveyor performed a new survey through the loop containing the disagreement and measurements from this survey were used for final data. All locations were tied to the state-plane coordinate system.

Table 2.4 shows the measured elevations and water levels in the monitoring wells. Appendix I contains details of methods, equipment, and coordinates of the land survey.

2.1.2.13 Additional Field Work Performed

Soil Samples of Coal Bed

Groundwater samples collected from the Weston deep wells by both Weston and ORNL/CAT produced results which were difficult to explain. Weston's DW001, DW002, and DW003 (Plate 1) were installed upgradient of the base. Groundwater samples collected by Weston were analyzed using oil and grease analysis--a screening technique. The Weston (1984) sample from DW001 contained 710 $\mu\text{g/L}$ of oil and grease; the samples from DW002 and DW003 contained no detectable oil and grease.

In March 1988, ORNL/CAT collected groundwater samples from these wells. DW001 was bridged off 14 ft below the casing, but a groundwater sample contained 680 $\mu\text{g/L}$ TPHCs. Two groundwater samples from DW002 revealed 100 $\mu\text{g/L}$ prior to purging and <50 $\mu\text{g/L}$ (detection limit) after purging the well. DW003 was bridged off just below the casing (22 ft). Thus, the sample from this well (<50 $\mu\text{g/L}$) represents groundwater which has leaked in from the unconsolidated material.

In CH003 (Plate 1), ORNL/CAT encountered the Nodaway Coal at a depth of 32 ft. The coal was approximately 2 ft thick and contained claystone and shale stringers. Based on the geology of the area, as determined from CH003, the Weston wells DW001, DW002, and DW003 were also drilled through the coal. Unfortunately, the three Weston wells were logged by cuttings and drilling rate. Due to the claystone and shale stringers in the coal, a log using cuttings and drilling rate may not have detected the coal bed. Indeed, the coal does not appear in the Weston logs of DW001 or DW002, although a black shale was noted in DW003 at 28.5 ft.

Table 2.4. Monitoring well elevation data

Location	Collar	Ground	<u>Elevation</u>			
			Water (3/88)	Water (7/88)	Water (9/88)	Water (11/88)
MW001	1030.66	1028.5		1025.21	1024.97	
MW002	1027.85	1025.9		1020.10	1019.81	
MW003	1053.41	1053.7		1040.95	1040.09	
MW004	Abandoned					
MW005	1046.96	1047.4		1038.61	1037.96	
MW006	1048.62	1048.9		1039.23	1038.73	
MW007	1048.45	1048.8		1038.17	1037.57	
MW008	1046.53	1045.0		1035.30	1035.27	
MW009	1040.36	1038.5		1035.55	1032.76	
MW010	1039.38	1037.5		1033.38	1031.76	
MW011	1040.50	1040.8		1034.00	1032.37	
MW012	1040.39	1040.7		1030.76	1030.12	
MW013	1040.81	1041.2		1031.32	1031.05	
MW014	1034.60	1035.0		1031.23	1029.19	
MW015	1036.58	1034.7		1027.36	1025.73	
MW016	1036.54	1032.9		1025.80	1024.39	
MW017	1039.65	1037.2		1024.89	1024.50	
MW018	1041.30	1039.4		1032.54	1031.64	
MW019	1037.39	1035.5		1029.80	1027.33	
MW020	1038.94	1036.9		1031.91	1029.24	
MW021	1035.45	1033.4		1027.59	1026.14	
MW022	1018.91	1017.4		1016.91	1015.28	
MW023	1043.63	1043.9		1034.96	1034.61	
MW024	1064.37	1062.8		1039.55	1039.05	
MW025	1019.61	1017.8		1017.06	1015.38	
MW026	1036.53	1033.1		1027.35	1025.87	
MW027	1061.32	1059.9		1040.38	1039.78	
MW028	1041.03	1037.9				1031.75
SW001	1034.42	1032.5	1025.32	1025.50	1024.38	
SW002	1040.06	1038.3	1035.14	1033.58	1030.88	
SW003	1039.87	1037.8	1031.01	1031.40	1030.44	
SW004	1039.40	1039.6	1030.18	1030.65	1029.96	
SW005	1042.03	1039.6	1031.83	1035.85	1033.91	
SW006	1034.42	1033.1	1024.21	1023.77	1022.48	
CH001	1029.66	1028.5		1015.93	1021.02	
CH002	1018.11	1017.8		1000.73	1003.88	
CH003	1059.95	1060.0		1038.75	1041.76	

Since the Nodaway Coal subcrops into the weathered bedrock near the center of the base (Sect. 2.2.6), a soil sample was collected from the Nodaway Coal by ORNL/CAT. This sample was sent for oil and grease analysis and yielded 360,000 $\mu\text{g/kg}$. Thus, the source for contamination in DW001 and DW002 is probably hydrocarbons leaching from the Nodaway Coal.

Well Abandonment

The depth to sediment in the six deep wells installed by Weston (1985) was measured by ORNL/CAT in March 1988. All of the deep wells were partially filled with sediment. DW002, DW004, and DW005 had lost between 4 and 5 ft of hole each; wells DW001, DW003, and DW006 had lost 20, 27, and 18 ft, respectively. Considering the normally competent Pennsylvanian formations which these wells penetrated, this sedimentation indicated that the cement seal around the surface casing was suspect. If this seal was leaking, groundwater from the aquifer in the unconsolidated material was entering the wells.

Since the integrity of these six wells was suspect, the wells were abandoned in June 1988. The KDHE and HAZWRAP agreed with the assessment of the six deep wells. The six deep wells were abandoned by filling with grout. The steel protective casing was removed from the four above ground completed wells (DW001, DW004, DW005, and DW006). Kansas abandonment laws specify cutting casing off 3 ft below ground level and backfilling with soil. KDHE stated that this is only required in agricultural areas and agreed that the procedure was not necessary at the base (Taylor 1988, personal communication).

2.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

2.2.1 Surface Features

The study area lies in the southeast part of Shawnee County which is divided into north and south physiographic sections by the Kansas River. The region lies in the western part of the Forest City basin, part of the Dissected Till Plains section of the Central Lowland physiographic province (Johnson 1967). In the area, glacial drift ranges in thickness from a thin veneer to 40 ft and in many places masks bedrock topography by creating gentle rolling hills. South of the Kansas River, glacial drift is generally thin and discontinuous as far south as the Wakarusa River (USDA 1970).

The topography is nearly level to gently sloping with a total relief of 50 ft at the base and 270 ft in the Topeka area. The highest elevation in the region is 1140 ft, west of Forbes Field ANGB, and the lowest elevation is 870 ft on the flood plain of the Kansas River.

2.2.2 Meteorology

Shawnee County has a climate typical of the Great Plains environment. Frontal air masses provide for wide ranges between maximum and minimum seasonal temperatures. The summer season has temperatures near or in excess of 100°F brought about by frontal air masses from the desert southwest, producing hot, dry air. Air masses from the Gulf of Mexico, also common in the summer, produce warm, moist air. Winter temperatures can drop to -20°F, brought about by inflows of cold, dry polar air. Shawnee County has a growing season of approximately 200 days with the average first frost occurring on October 26 and the average last frost occurring on April 9.

The normal annual precipitation for Shawnee County is 32 in. During the growing season, about 70% of the average annual precipitation falls as morning or evening thundershowers. The precipitation during the winter months of December to February occurs as rain or snowfall and accounts for only 10% of the annual average precipitation.

2.2.3 Surface Water Hydrology

2.2.3.1 Surface Water Hydrology

Forbes Field ANGB is located on a drainage divide between two creeks and an unnamed tributary of the Wakarusa River (Fig. 2.2). Lynn Creek drains southeast into the Wakarusa River. The South Branch of Shunganunga Creek drains north into the Kansas River. The drainage divide between Lynn Creek and the South Branch of Shunganunga Creek runs through the center of the Forbes Field Airport, following the main runway in the vicinity of the base. All surface runoff from the potentially contaminated sites at Forbes Field ANGB drains to an unnamed tributary of the South Branch of Shunganunga Creek.

Surface runoff at Forbes Field ANGB occurs dominantly as sheet flow, due to the relatively flat topography, and either directly discharges to the unnamed tributary or is routed through the storm sewer and then eventually into the creek. Figure 2.3 shows surface runoff patterns for the base.

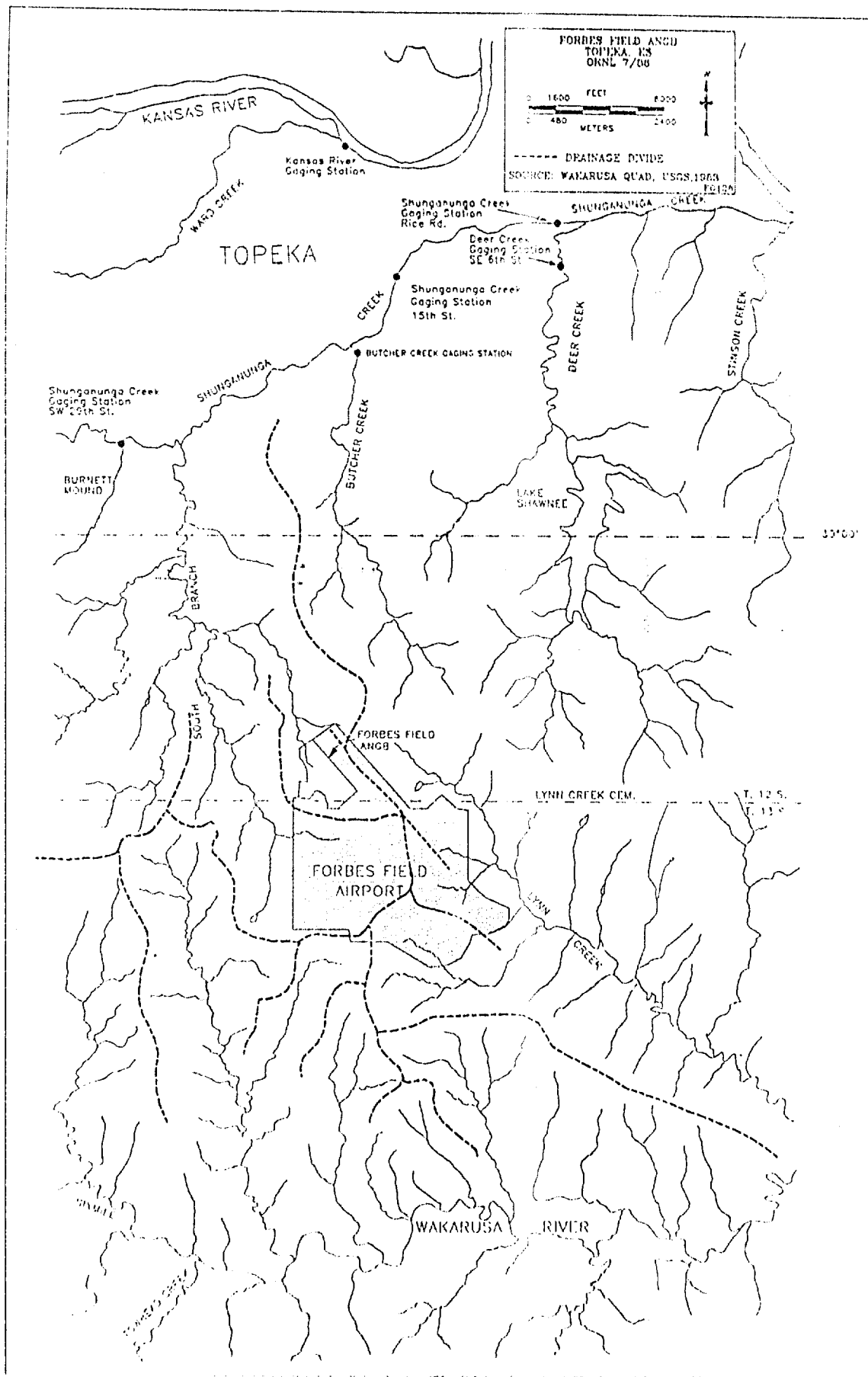


Fig. 2.2. Regional drainage map, eastern Shawnee County, Kansas.

There are seven U.S. Geological Survey gaging stations located north of the base. Information concerning mean, minimum, maximum, and total discharge, along with the size of the drainage basins, is presented in Table 2.5. Most of these gaging stations are no longer in use, but available data indicates that periods of no flow occur in the South Branch of Shunganunga Creek. During this field investigation, however, water was always observed in the unnamed tributary. This was true even during the summer months when the area was experiencing a severe drought. The water observed flowing in the creek is base flow because the creek is a discharge point for groundwater underlying the base (Sect. 2.2.6).

Although the maximum 24-h precipitation recorded at Topeka was 8.08 in., the flood potential at the site is negligible because of its location on a topographic high in the upper portion of the drainage basin. Sheet flow would not become channelized until the water collected in the creek channels, which are predominantly off-site.

2.2.3.2 Surface Water Quality

Average water quality data for the streams in the area are presented in Table 2.6. According to Pope and Bevans (1987), the water in the area streams is generally unfit for domestic purposes due to high coliform bacteria counts, high total dissolved solids, and hardness.

2.2.4 Geology

2.2.4.1 Surface Geology

Surface geology in the general vicinity of Forbes Field ANGB consists of glacial clays and silts with lesser amounts of sands and gravels. Plate 2 shows a geologic map of the surrounding area. During the Kansan Glaciation, large ice sheets migrated southward across Kansas and terminated along a southeasterly trending line extending from Shunganunga Creek, through the town of Pauline, and along Lynn Creek to the Wakarusa River (Fig. 2.4). As the glaciers retreated, sediment-laden meltwaters deposited glacial material over much of the area north of the Kansas River southward to the Wakarusa River. Deposits along the main drainages consist of clays, silts, sands, gravels, and

Table 2.5. Discharge information for local drainage basins

Water year	Total discharge		Mean	Maximum	Minimum	Drainage
	ft ³ /sec	Acre-feet				
Sauganunga Creek - SE 15th Street	'80 7,249.02	14,380	19.8	1,030	0.20	37.9
	'81 12,129.25	24,060	33.2	1,930	0.08	
Rice Road	'80 10,399.98	20,630	28.4	1,500	0.38	60.3
	'81 16,851.36	33,420	46.2	3,020	0.37	
SW 29th Street	'80 2,296.21	4,550	6.27	319	0.00	14.10
	'81 2,631.49	5,220	7.21	614	0.00	
Butcher Creek	'80 668.08	1,330	1.83	127	0.00	4.65
Deer Creek	'81 3,301.61	6,550	9.05	995	0.00	14.3
South Branch Sauganunga	'80 3,260.90	6,470	8.91	406	0.00	11.6
	'81 3,910.96	7,760	10.70	844	0.00	
Kansas River	1919-1987	5,708.43				
Tributaries to Wakarusa River (directly south of Forbes Field)						
						13.29

Table 2.6. Average water quality values for area streams
(after Pope and Bevans, 1987)

Constituent	mg/L
sodium	62.7 to 133
chloride	89.7 to 223
TDS	472 to 718
total organic nitrogen	1.0 to 1.7
phosphorus	0.3 to 0.4
zinc	0.022-0.077

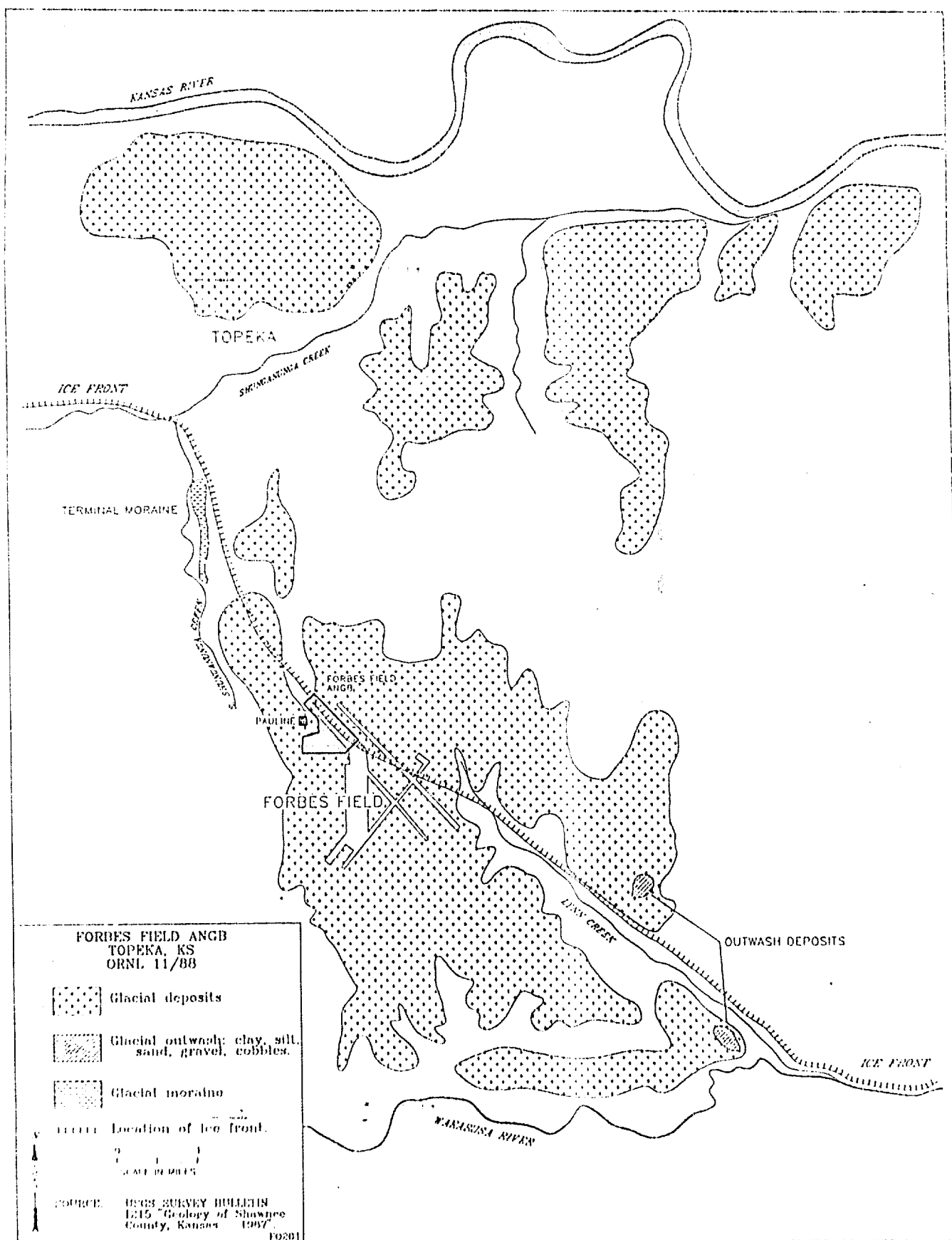


Fig. 2.4. Location of glacial deposits, eastern Shawnee County, Kansas.

cobbles, which are derived from claystone and limestone outcrops in northern Kansas. These deposits range from 76 ft in the area north of the Kansas River to 25 ft near the Wakarusa River. On the flat upland areas between the drainages, large amounts of glaciolacustrine clays and silts were deposited. Loess material was no doubt incorporated into these deposits. The sediments vary from a thin veneer to 25 ft (Johnson and Adkison 1967).

Field investigation by ORNL/CAT personnel showed the surface lithology to be consistent with the above description. The unconsolidated material is composed of tight glacial silty-clays with widespread sand stringers and limestone and chert gravels. Silty-clays occur as varying shades of grays and browns with greenish-gray mottling. The majority of the sediments are unstratified, very plastic, and have considerable limonite staining. The sediments are glaciolacustrine in origin, having been deposited evenly over the weathered claystone bedrock. The few limestone and chert gravels are most likely glacial erratics.

The sediments range from 16.5 ft near the southeast corner of the base (MW003) to 5.5 ft in the northwest corner (MW022, Fig. 2.5). Differences in sediment thicknesses can be attributed to the location of the base with respect to the drainage pattern of the area and to the topographic relief.

Just southeast of the base, the two monitoring wells drilled to investigate upgradient water quality discovered considerably thicker sediments (25 ft in MW027 and 43 ft in MW024). At 38 ft in MW024, a 5.5-ft, medium grained, well sorted sand was found overlying the sandstone bedrock. MW027 revealed this same sand at 23 ft, although the sand had thinned to approximately 8 in. These thicker sediments and the basal channel sand found overlying the bedrock in MW024 and MW027 can best be explained as a pre-existing paleo-channel which had scoured the bedrock before any glacial sediments were deposited.

Forbes Field ANGB is situated just to the west of a northeast-southwest trending drainage divide. Drainage to the northwest is towards Shunganunga Creek. Drainage to the southeast is towards Lynn Creek and the Wakarusa River (Fig. 2.2). The thinner deposits found near the northwest corner of the base are the result of more severe erosional patterns associated with a steeper topographic gradient towards Shunganunga Creek. The thicker, less eroded sediments encountered in the southeast corner are due to a more gentle topographic relief.

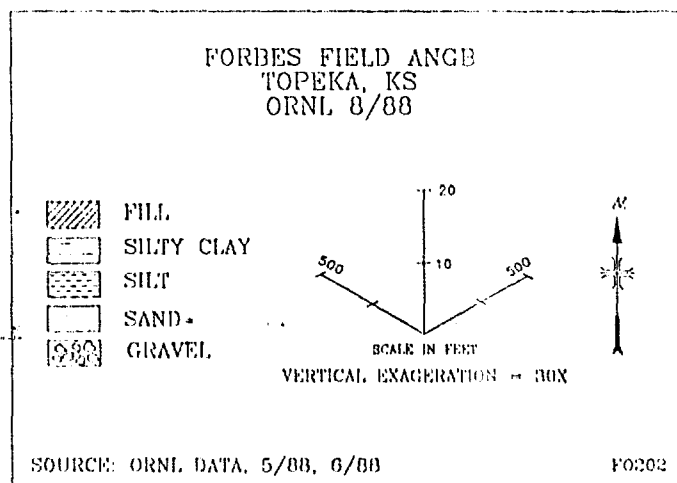
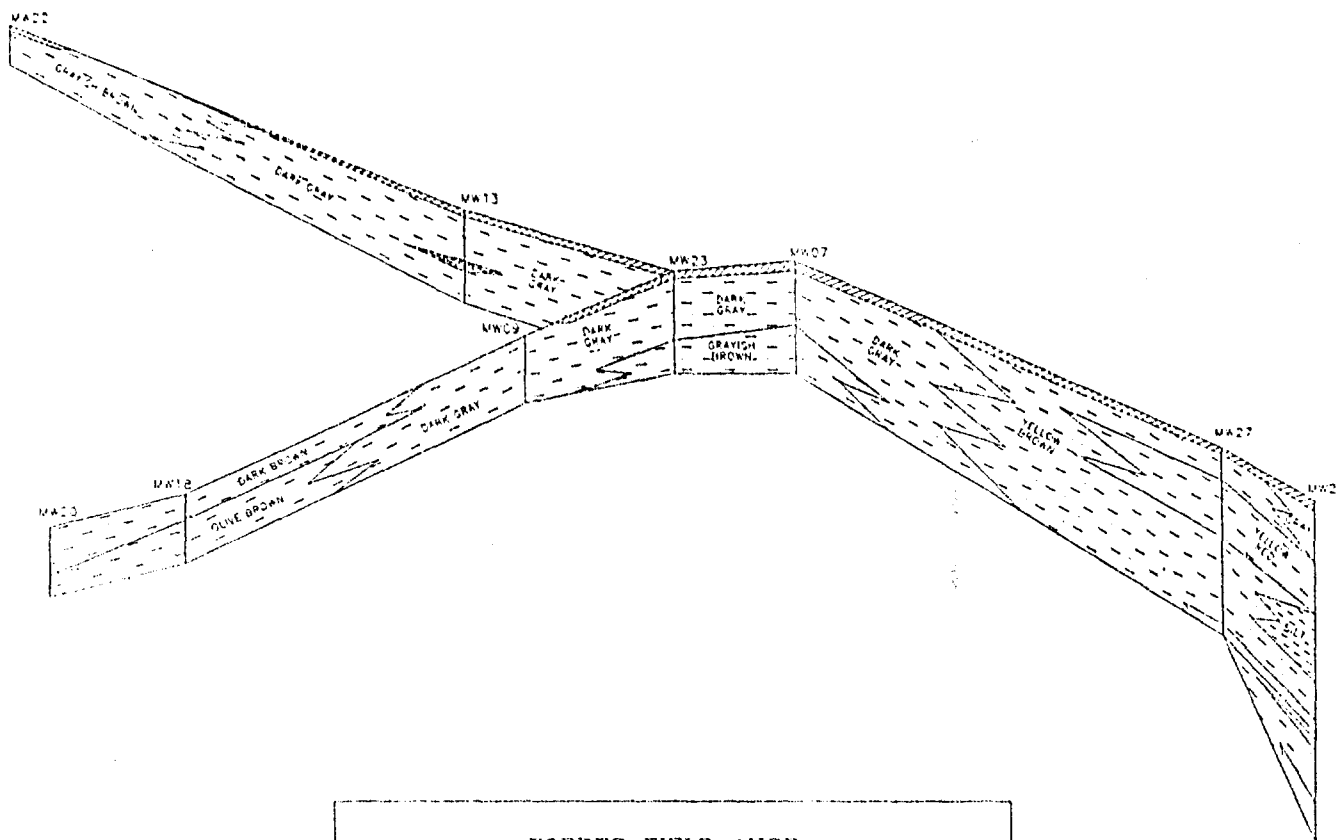


Fig. 2.5. Fence diagram of surface deposits.

It should be noted that during the construction of Forbes Field ANGB, excavation and compaction reworked much of the area. If, during the construction, fill material was used, it most likely originated from the base vicinity and has similar characteristics to the original glacial material-making distinction difficult. In some areas, what has been mapped as glacial sediments may be construction fill; however, obvious signs of fill were infrequent.

2.2.4.2 Bedrock Geology

Structure

Shawnee County lies east of the axis of the Forest City basin which is a structural basin east of the Nemaha uplift (Lee 1954). The Forest City basin and Nemaha Uplift control the regional and local structural features of the Shawnee County area. Bedrock units underlying the base strike N20E to N30E and dip northwest at 20 to 40 ft/mile, interrupted by minor folds trending northwest. There is no evidence in literature indicating significant regional fracturing. Locally, however, certain limestone units (the Church member of the Howard Limestone and the DuBois member of the Topeka Limestone) have been described as vertically jointed. Also, in western Shawnee County, two major sets of vertical joints are reported trending N20W to N30W (Johnson and Adkison, 1967). Figure 2.6 shows a contour map of the bedrock surface underlying Forbes Field ANGB.

Stratigraphy

The geology at Forbes Field ANGB is dominated by two major geologic groups: the Pennsylvanian Wabaunsee and Shawnee Groups (Fig. 2.7, 2.8a, and 2.8b). The formations within these groups exhibit the transgressive-regressive sedimentation characteristic of cyclothems in which largely nonmarine sandy shales with coals alternate with sandstones, marine shales, and limestones (Heckel 1978). Of the Wabaunsee Group, the Howard Limestone and Severy Shale formations were encountered in the three coreholes. In descending order, the Howard Limestone consists of the Utopia Limestone, the Winzeler Shale, the Church Limestone, and the Aarde Shale members. The Severy Shale formation underlies the Howard Limestone. The Shawnee group is

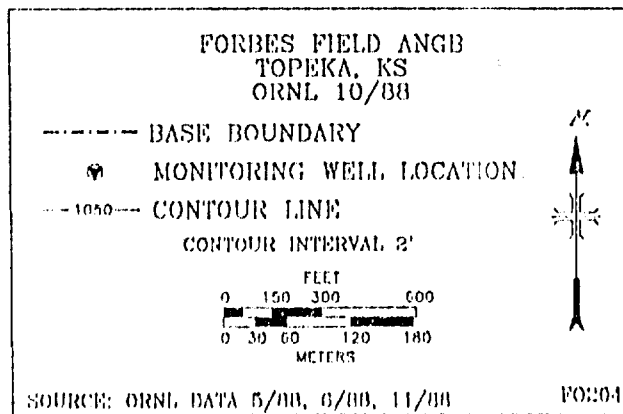
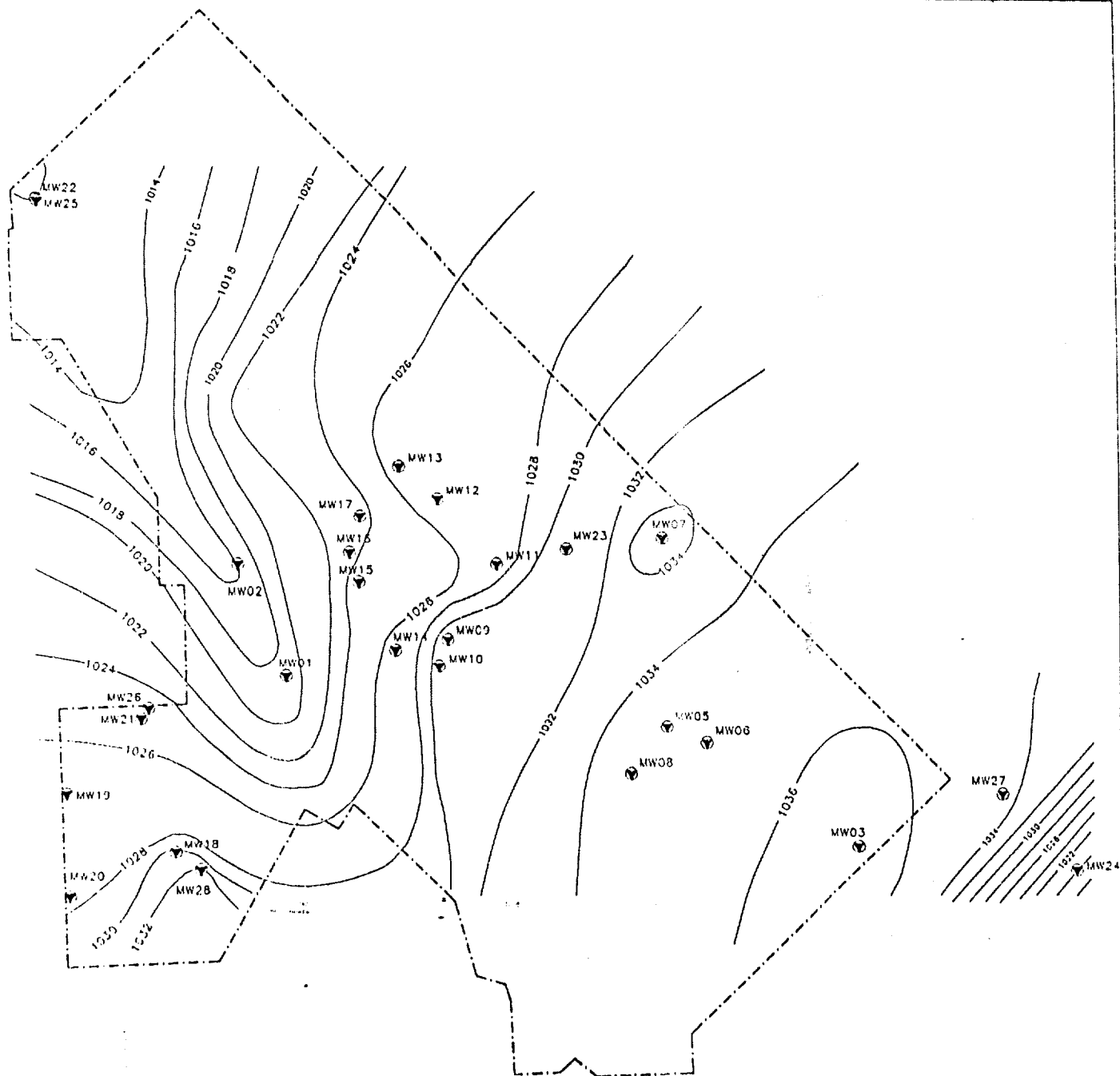


Fig. 2.6. Contour map of weathered bedrock surface.

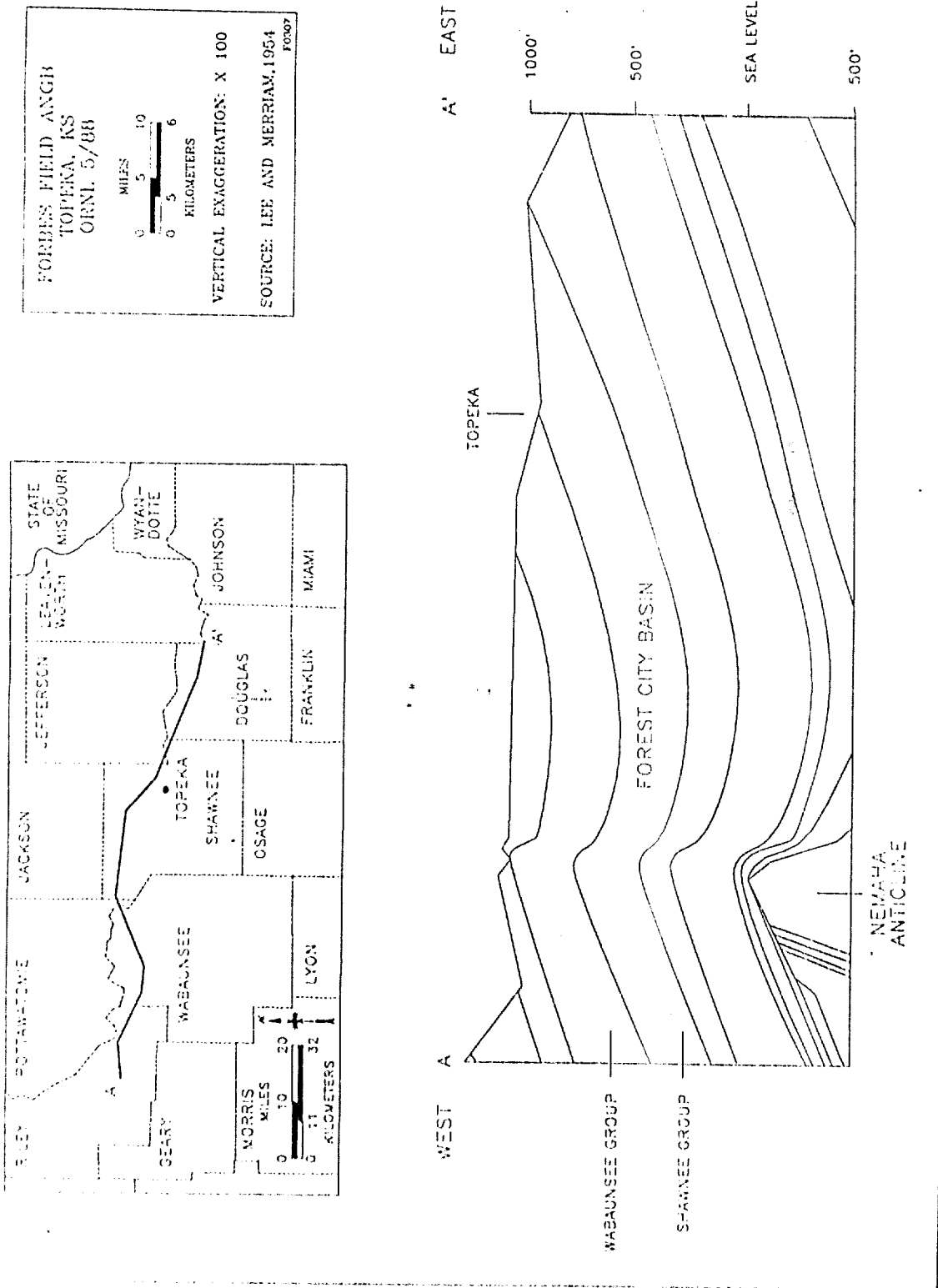
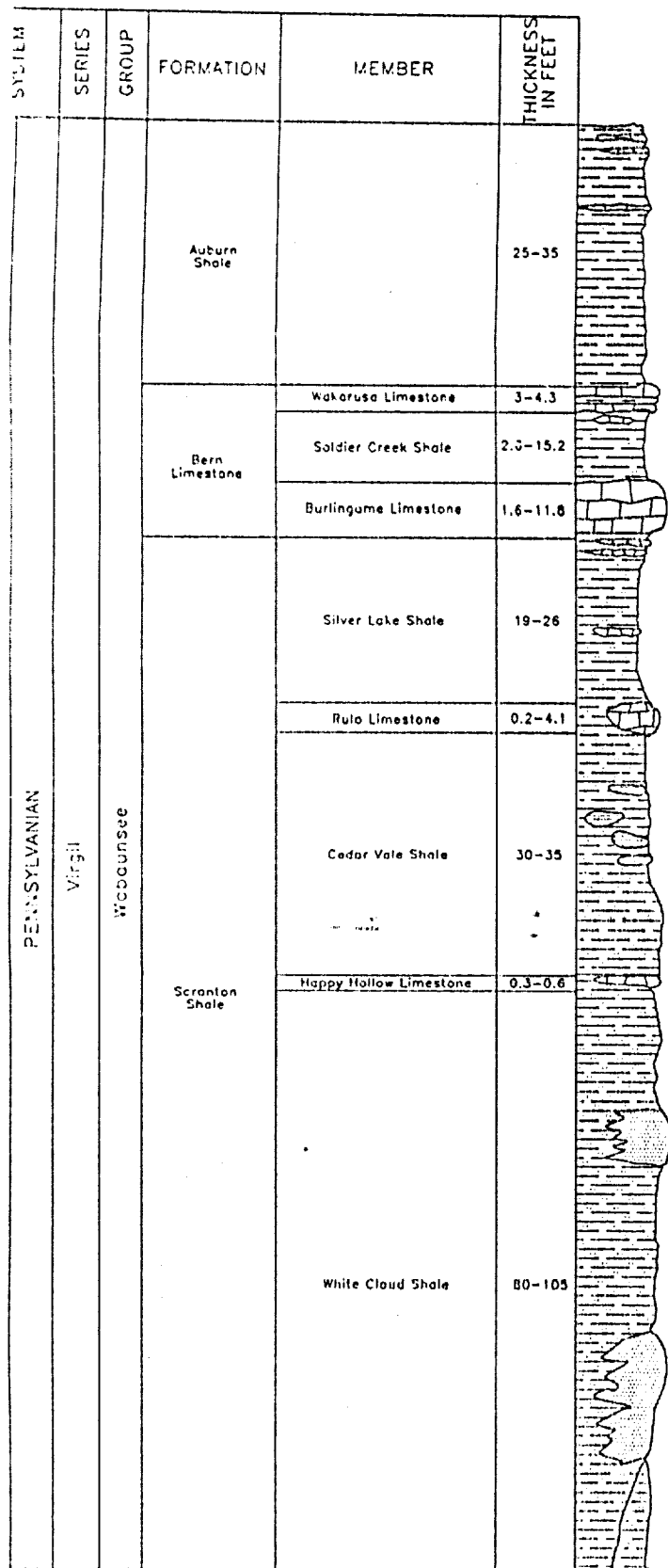


Fig. 2.7. Regional cross section of northeastern Kansas.



FORBES FIELD ANGB
TOPEKA, KS
ORNL 10/88

PAGE 1 OF 2

SOURCE: USGS BULLETIN 1215A

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STRATIGRAPHIC SECTION EXPLANATION

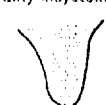
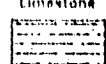
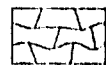
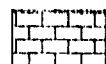
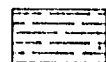
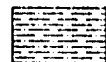
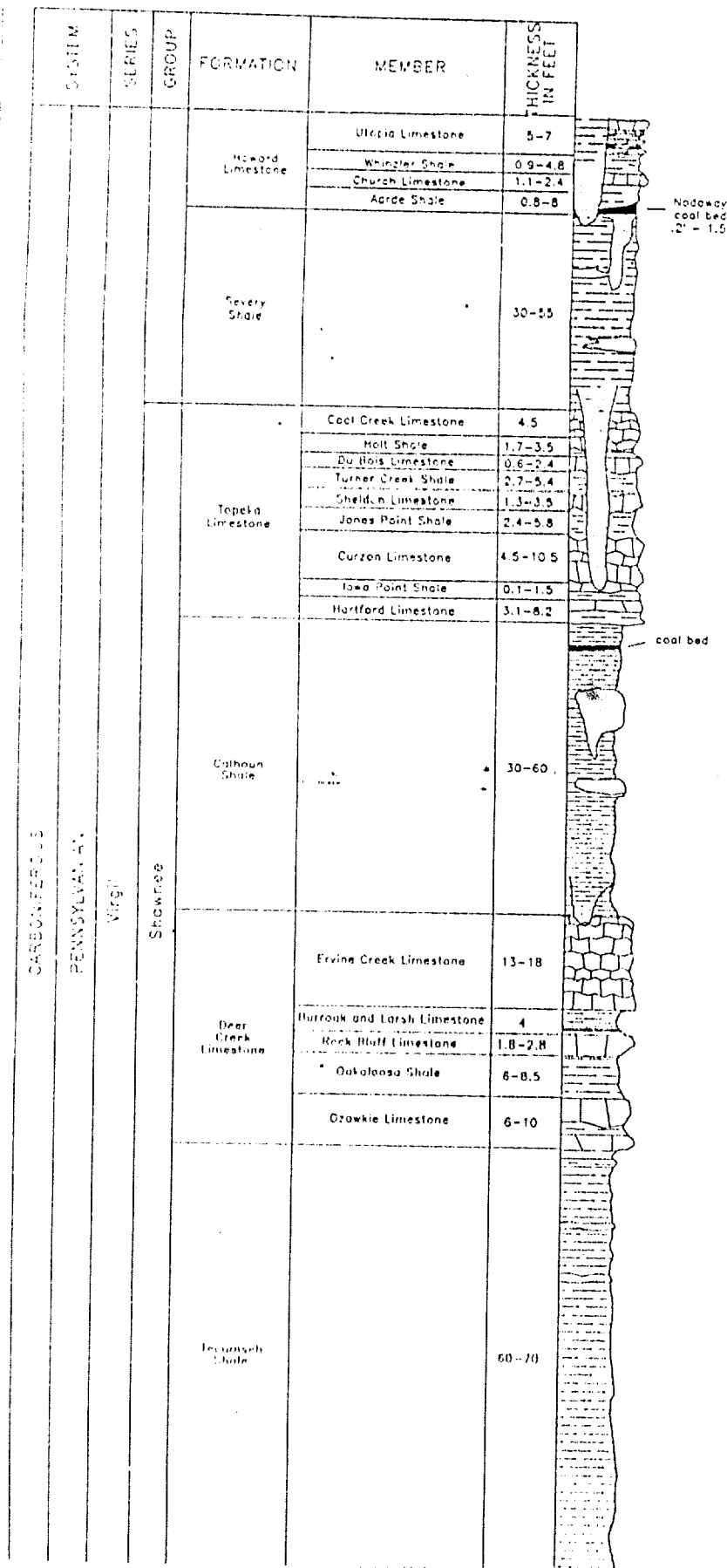


Fig. 2.8a. Stratigraphic section of Forbes Field ANGB vicinity.



FORBES FIELD ANGB
TOPEKA, KS
ORNL 10/68

PAGE 2 OF 2

SOURCE: USGS BULLETIN 1215A

170325

Fig. 2.8b. Stratigraphic section of Forbes Field ANGB vicinity.

represented by the upper and middle members of the Topeka Limestone formation. In descending order, the Topeka Limestone consists of the Coal Creek Limestone, the Holt Shale, the DuBois Limestone, the Turner Creek Shale, the Sheldon Limestone, the Jones Point Shale, the Curzon Limestone, the Iowa Point Shale, and the Hartford Limestone members.

Figure 2.9 shows the correlation between bedrock CH001, CH002, and CH003. The correlation is based primarily on the occurrence of the Nodaway Coal member of the Howard Limestone. In CH003, the Nodaway Coal is part of the competent bedrock. To the west, down dip from CH003, the Nodaway Coal becomes part of the weathered bedrock portion of the unconsolidated aquifer (Fig. 2.10a, b, and c), as shown in lithology logs from MW001, MW002, MW022, and MW025 (Appendix G). The Nodaway Coal subcrops at the weathered/competent bedrock contact in a roughly south to north band across the base (Fig. 2.11). This subcrop terminates south of MW001, where the weathered bedrock surface rises following the topography.

The correlation of the bedrock geology underlying the base was also based on the field description of CH002, which matches the stratigraphic description of the Topeka Limestone (Johnson and Adkison 1967) in terms of member thickness and rock type. In addition, CH001 and CH002 clearly display the Holt Shale member of the Topeka Limestone.

2.2.5 Soils

The USDA Soil Conservation Service (SCS) and the Kansas Agricultural Experiment Station have mapped the surface soils for the Forbes Field ANGB area (USDA 1970). Eight soil types have been identified and mapped on Fig. 2.12. Table 2.7 summarizes their principal characteristics.

Alluvial soils occur on flood plains less than 300 ft wide; often, these areas are dissected by stream channels. The alluvium generally has a loam to silty-clay loam texture and may be stratified (Campbell 1979). The Breaks alluvial soil complex is characterized by floodplains with steep sides in rocky outcrops (Campbell 1979). Both Breaks and alluvial soils are well drained, nearly-level to steep soils with high available moisture capacity. Breaks soils are on uplands and alluvial soils are on lowlands (USDA 1970).

Labette soils occur on uplands as well-drained, nearly-level to steep soils. The surface layer is silty-clay loam and the subsoil is clay loam to clay or silty-clay. These soils have high available moisture capacity (USDA 1970).

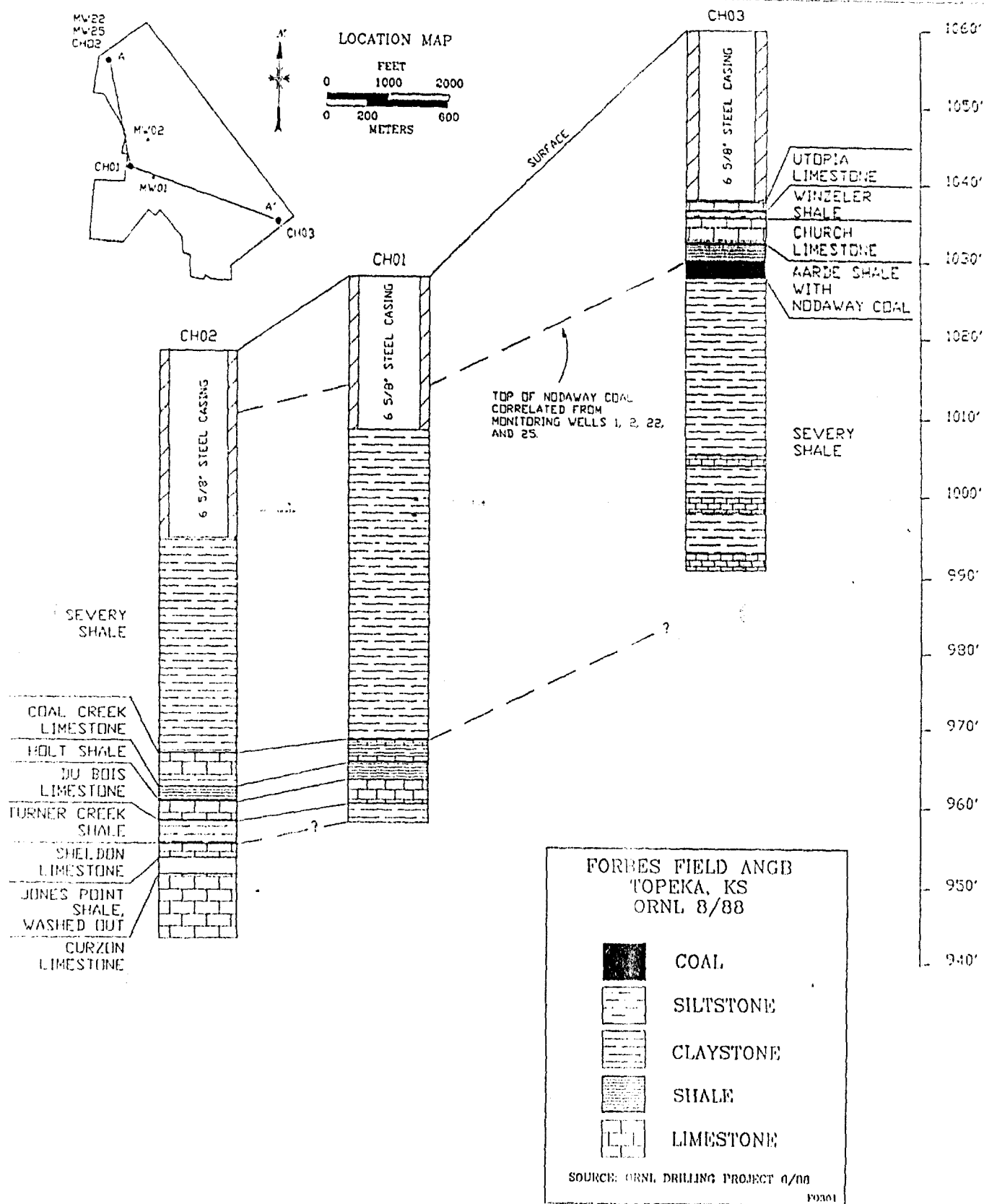


Fig. 2.9. Correlation diagram of bedrock wells.

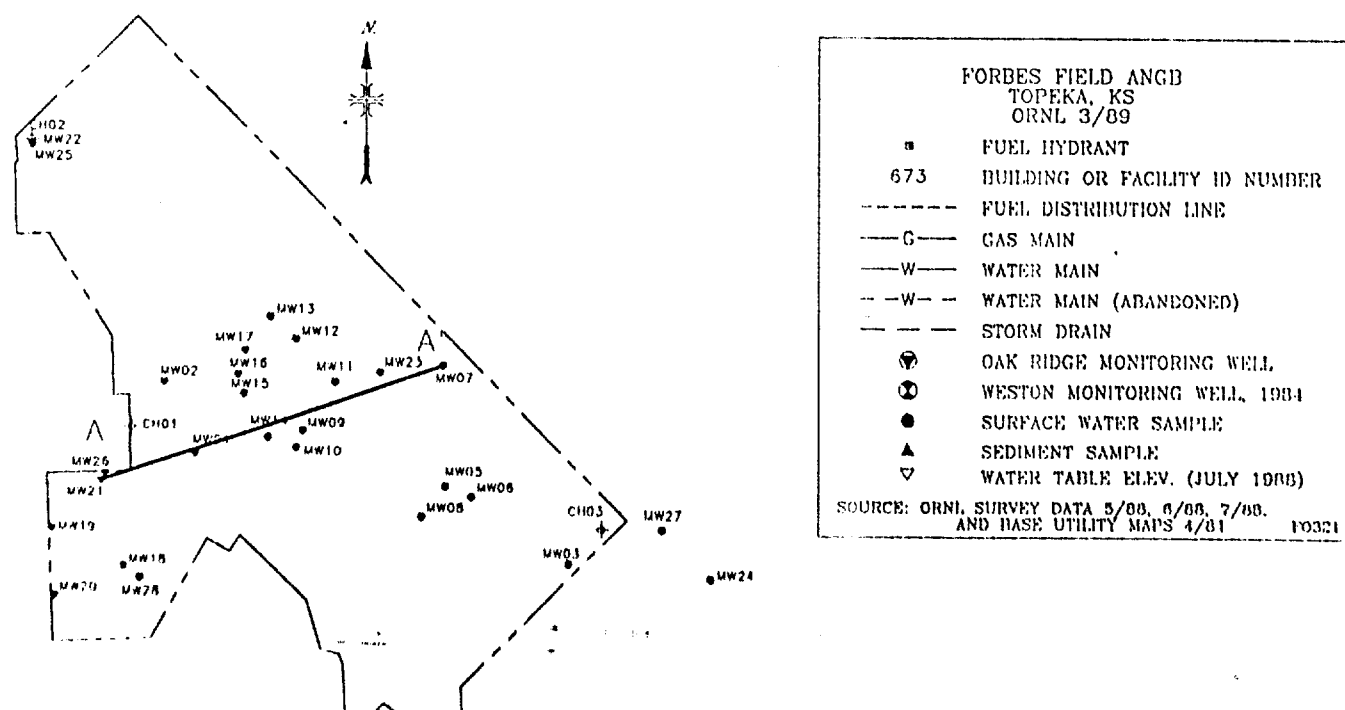
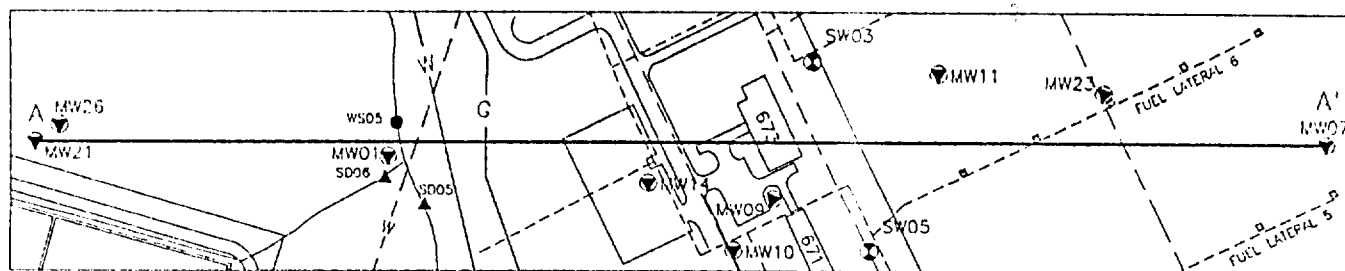
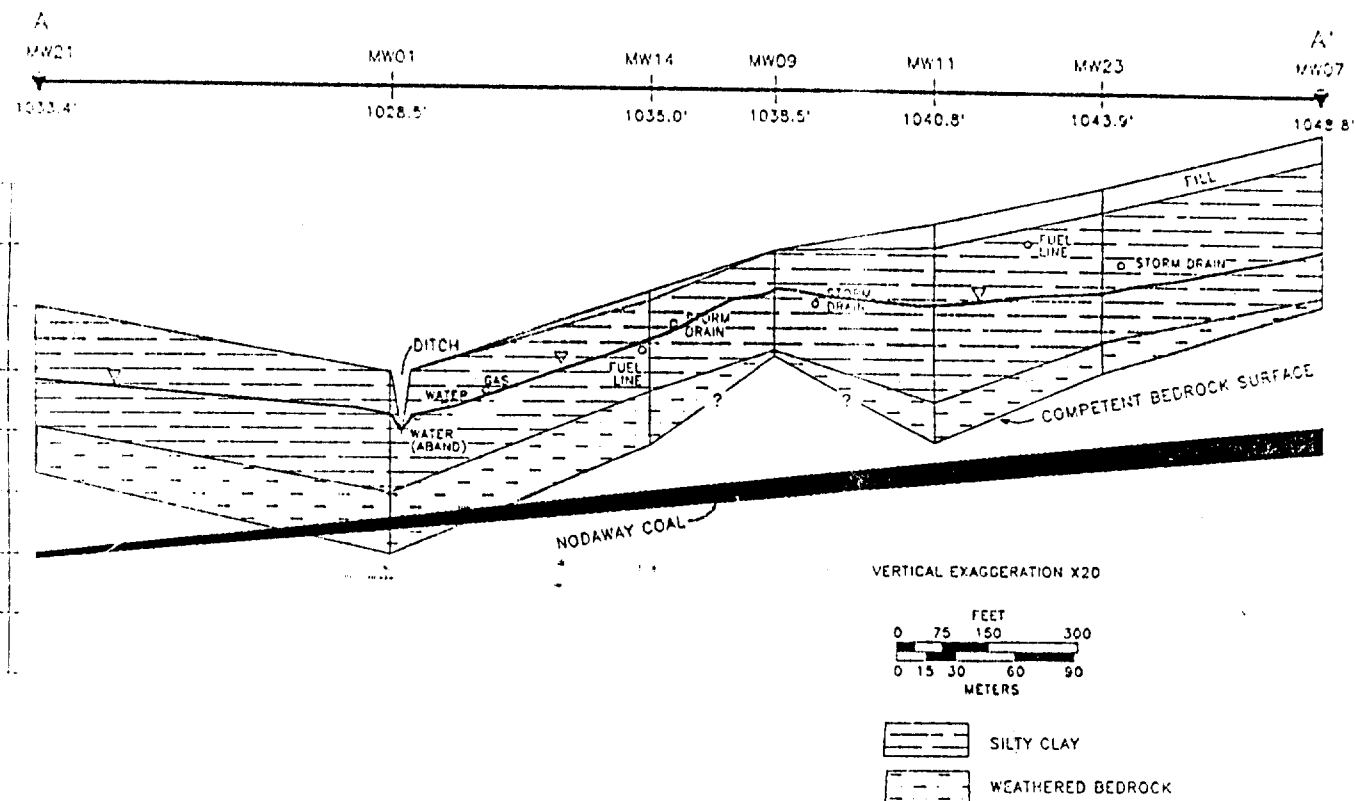


Fig. 2.10a. Cross section from MW021 to MW007.

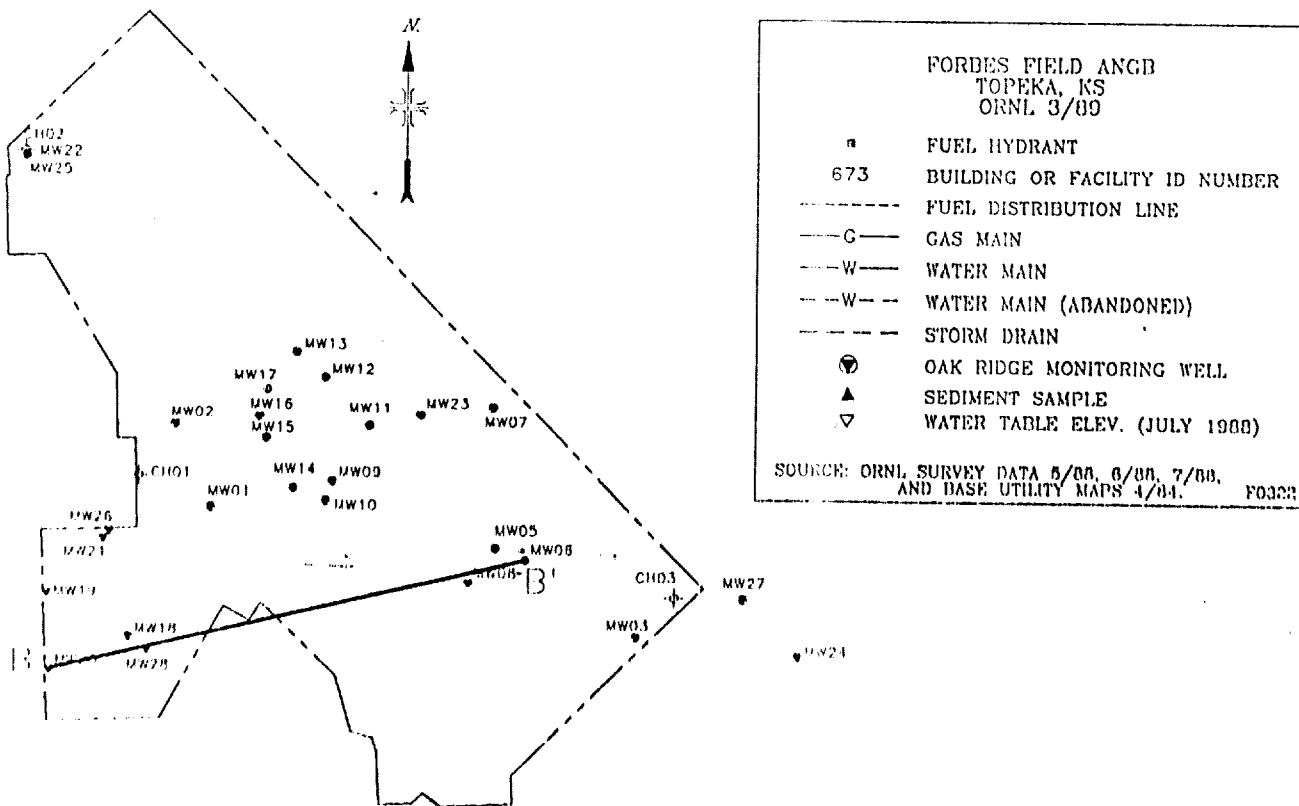
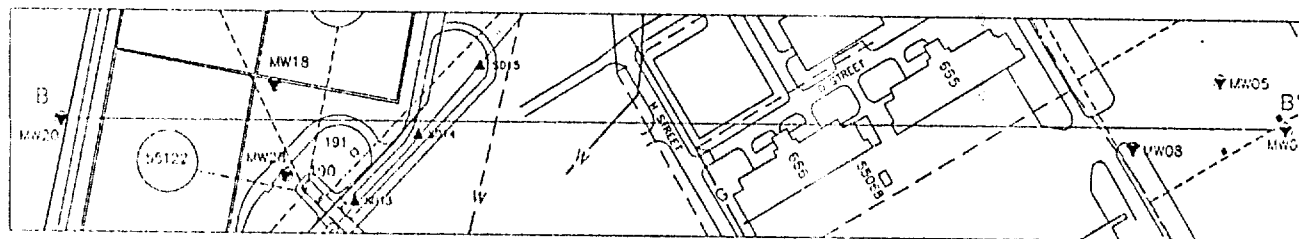
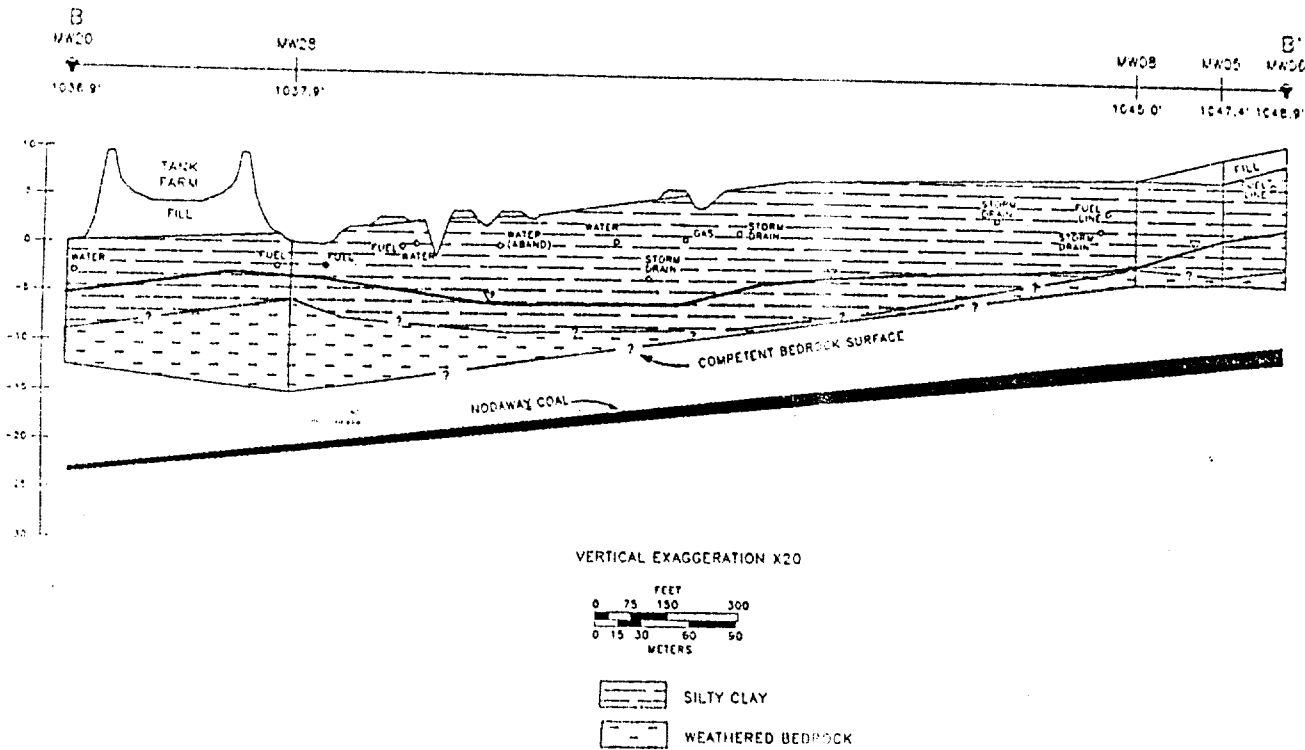


Fig. 2.10b. Cross section from MW020 to MW006.

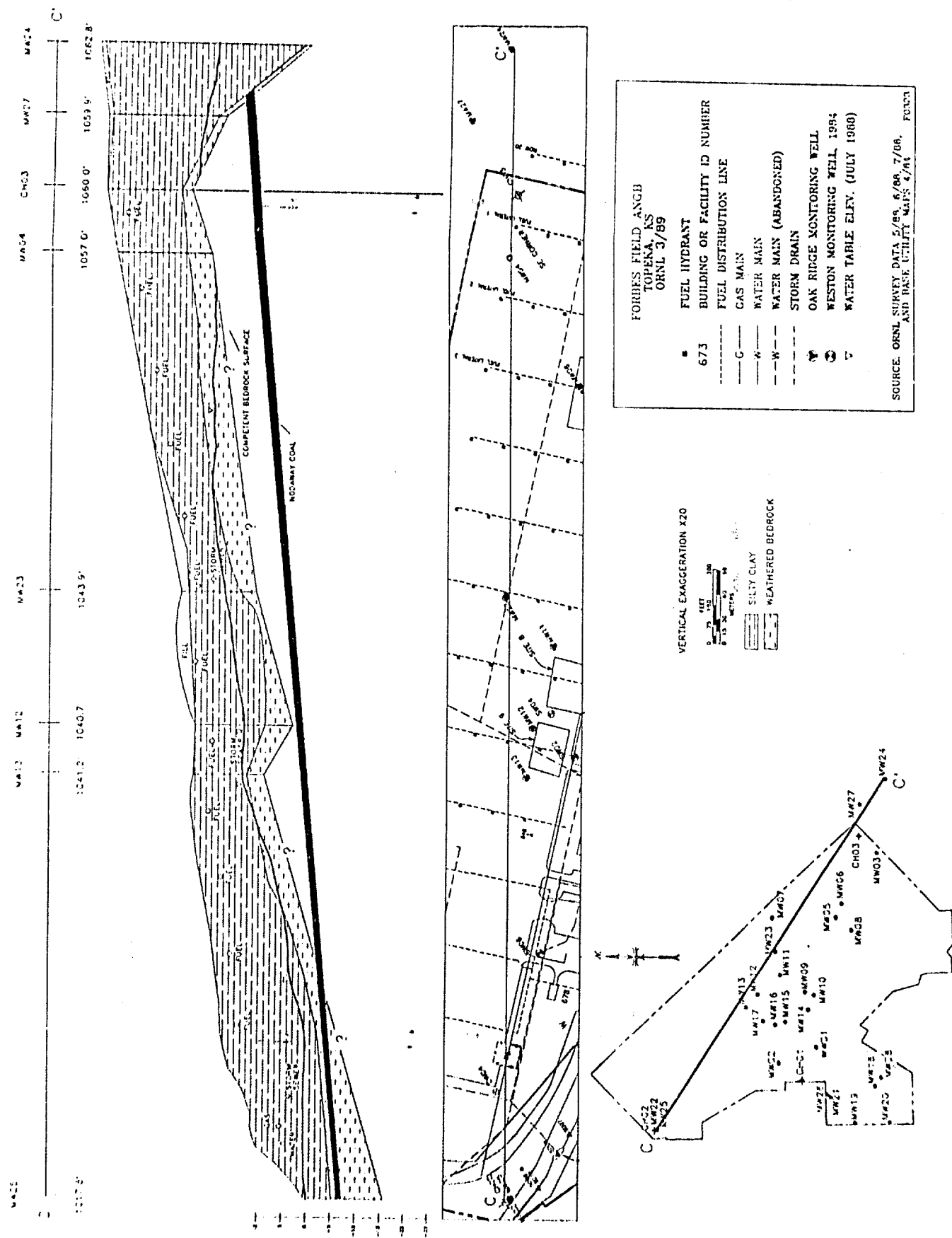
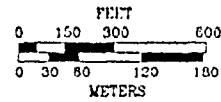


Fig. 2.10c. Cross section from MW024 to MW025.

FORBES FIELD ANGB
TOPEKA, KS
ORNL 8/88

- BASE BOUNDARY
- MW05 MONITORING WELL LOCATION
- ⊕ CH03 CORE HOLE LOCATION
- ▨ COAL SUBCROP



SOURCE: ORNL DATA 5/88, 6/88 AND
BASE UTILITY MAPS 4/84 F0306

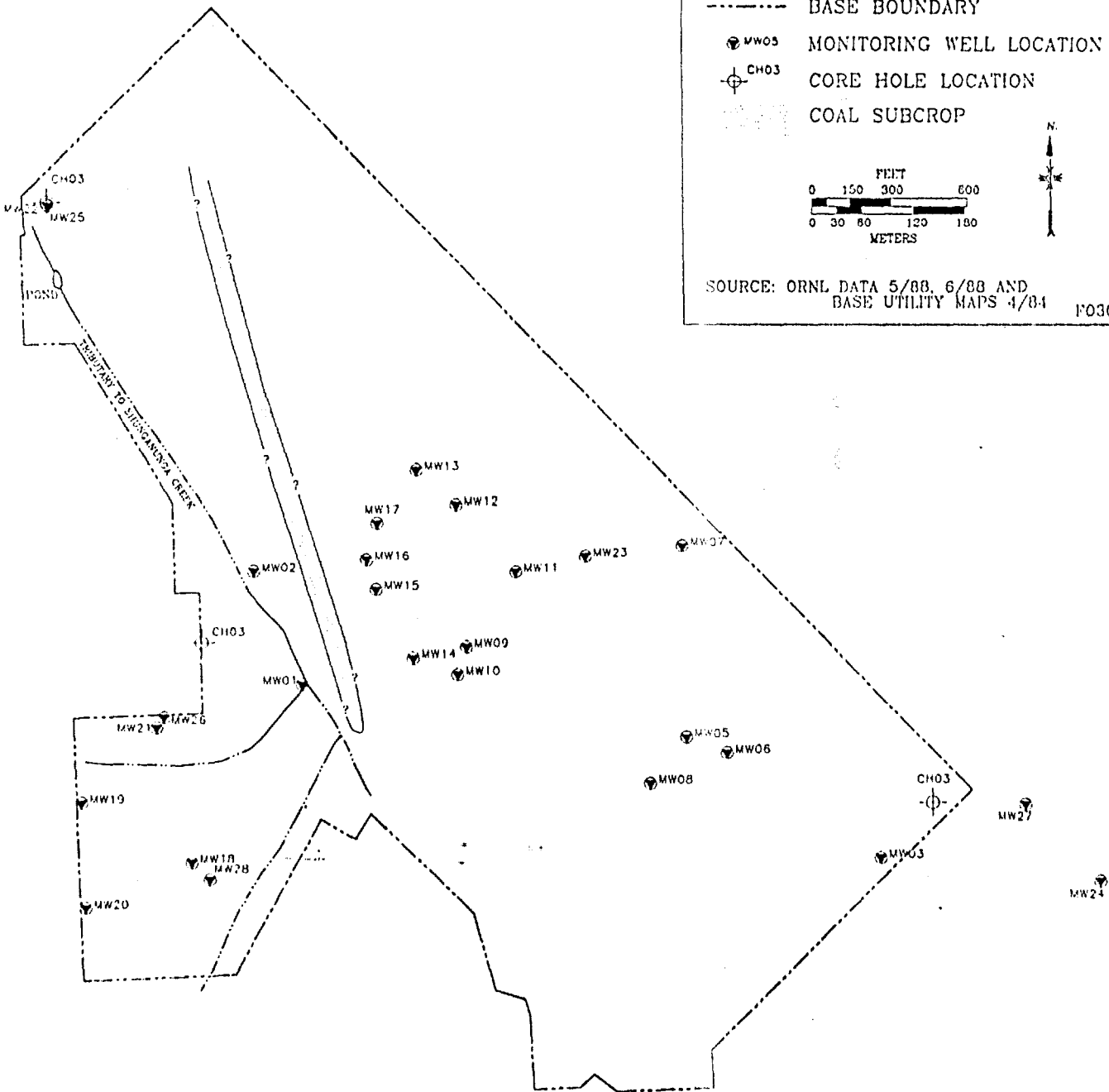


Fig. 2.11. Position of the Nodaway Coal subcrop.

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AIR NATIONAL GUARD BASE

FORBES FIELD ANGB
TOPEKA, KS
ORNL 4/88

An ALLUVIAL LAND
Bk BREAKS-ALLUVIAL LAND
COMPLEX
La LABETTE 1-3% SLOPES
Ld LADYSMITH 0-1% SLOPES
Lm LADYSMITH 1-3% SLOPES
Pc PAWNEE 3-7% SLOPES
Pe PAWNEE 3-7% SLOPES
ERODED
Sv SOGN-VINLAND COMPLEX

--- BASE BOUNDARY
--- AIRPORT BOUNDARY

FEET
0 1000 2000
METERS
0 200 600

SOURCE: AERIAL PHOTO, 1984 AND USDA, 1974
FO304

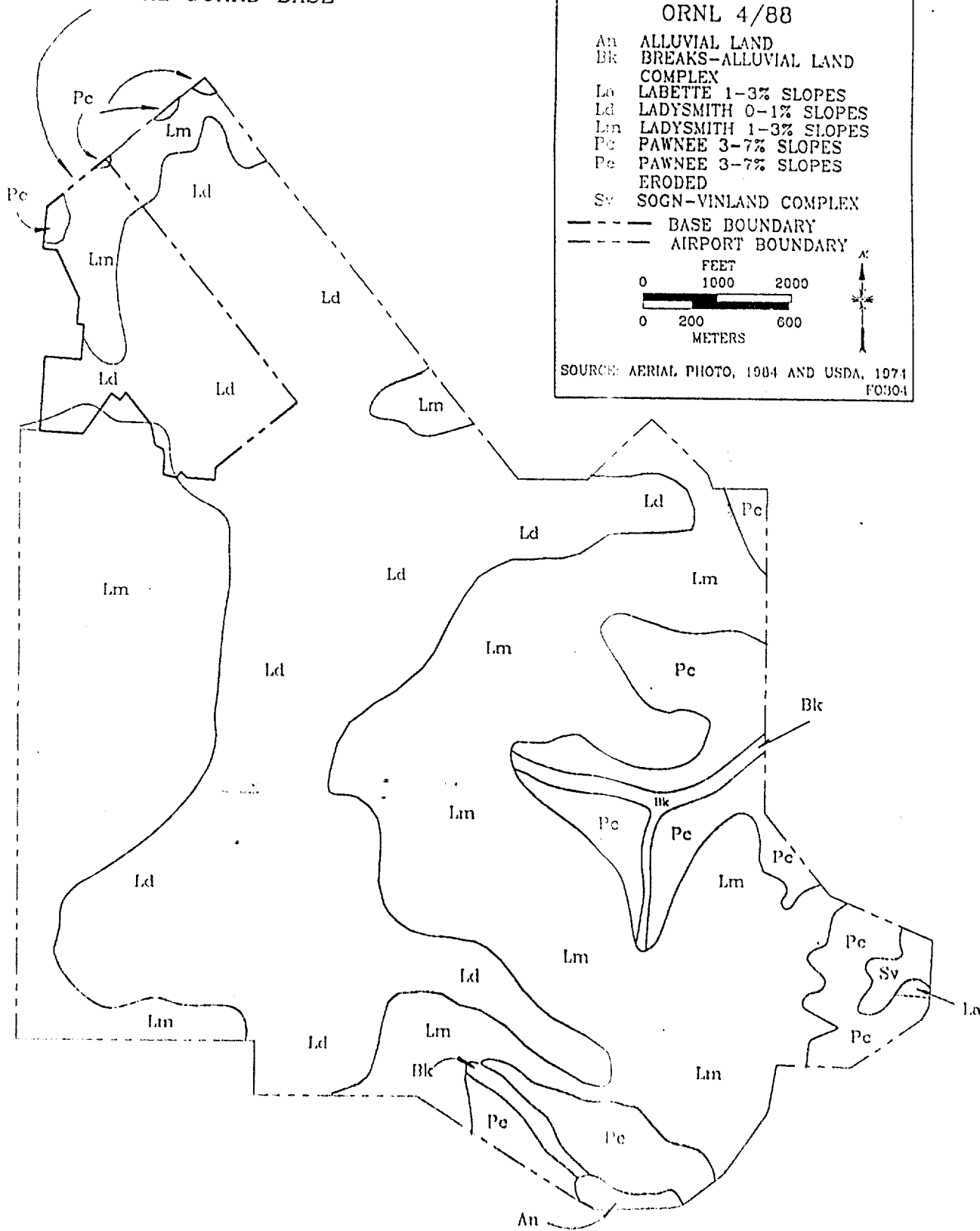


Fig. 2.12. Soils map of Forbes Field ANGB area.

Table 2.7. Forbes Field ANGB soils, and principal characteristics
(Source: USDA Soil Conservation Service, 1970)

Map symbol	Unit description (major fraction)	USDA texture (major fraction)	Thickness (in.)	Unified classification (major fraction)	Permeability (in./hr)
An	Alluvial land	Loam - silty-clay loam	-	-	-
Bk	Breaks-Alluvial	Breaks: silty-clay loam	-	-	-
Ia	Labette 1-3% slopes	Alluvial: loam - silty-clay loam	~42	ML-CL, CL	.2 - .63
Ld	Ladysmith 0-1% slopes	Silty-clay loam	~72	CL [*] , CH [*] , OH ^{**} , SC ^{**} , GC ^{**} , OL ^{**}	.2 - .63
Lm	Ladysmith 1-3% slopes	silty-clay loam	~72	CL, CH [*] , OH ^{**} , GC ^{**}	.2 - .63
Pc	Pawnee 3-7% slopes	Clay loam	~84	ML-CL [*] , OH ^{**}	.2 - .63
Pe	Pawnee 3-7% slopes, eroded	Clay loam	~84	ML-CL	.2 - .63
SV	Sogn-Vinland complex	Sogn: silty-clay loam to limestone Vinland: silty loam shale and clay beds	15 20	CL CL	.05 - .20 .20 - .63

* Classification based on visual field inspection and USDA SCS report, 1970. Approximate classification based on visual field inspections can be made in the field according to the USDA SCS June 1970 report on Shawnee County, Kansas. The USDA SCS classifications are based on laboratory analysis.

** Classification based on visual field inspection.

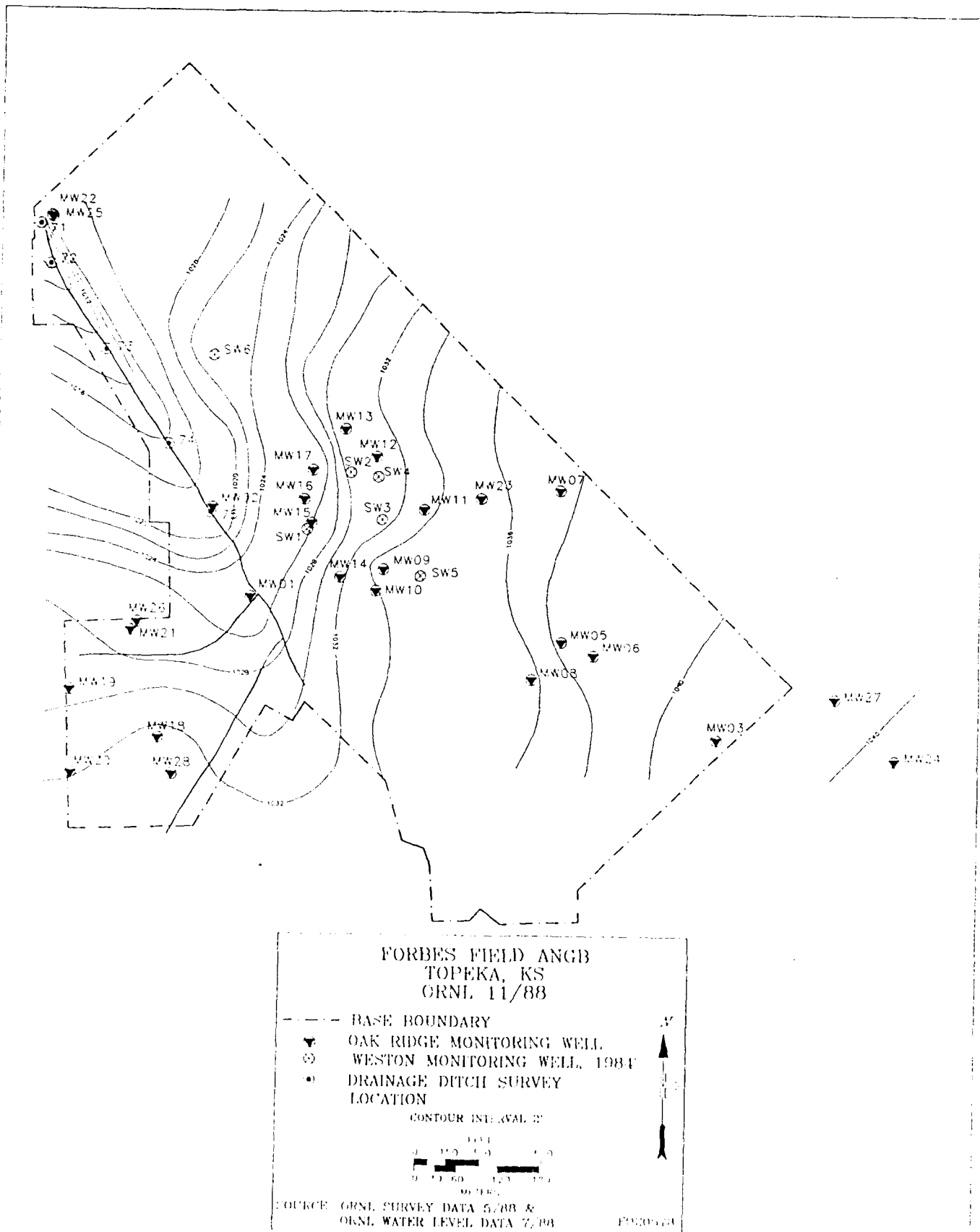


Fig. 2.13a. Potentiometric map of the unconsolidated aquifer water levels measured in July 1988.

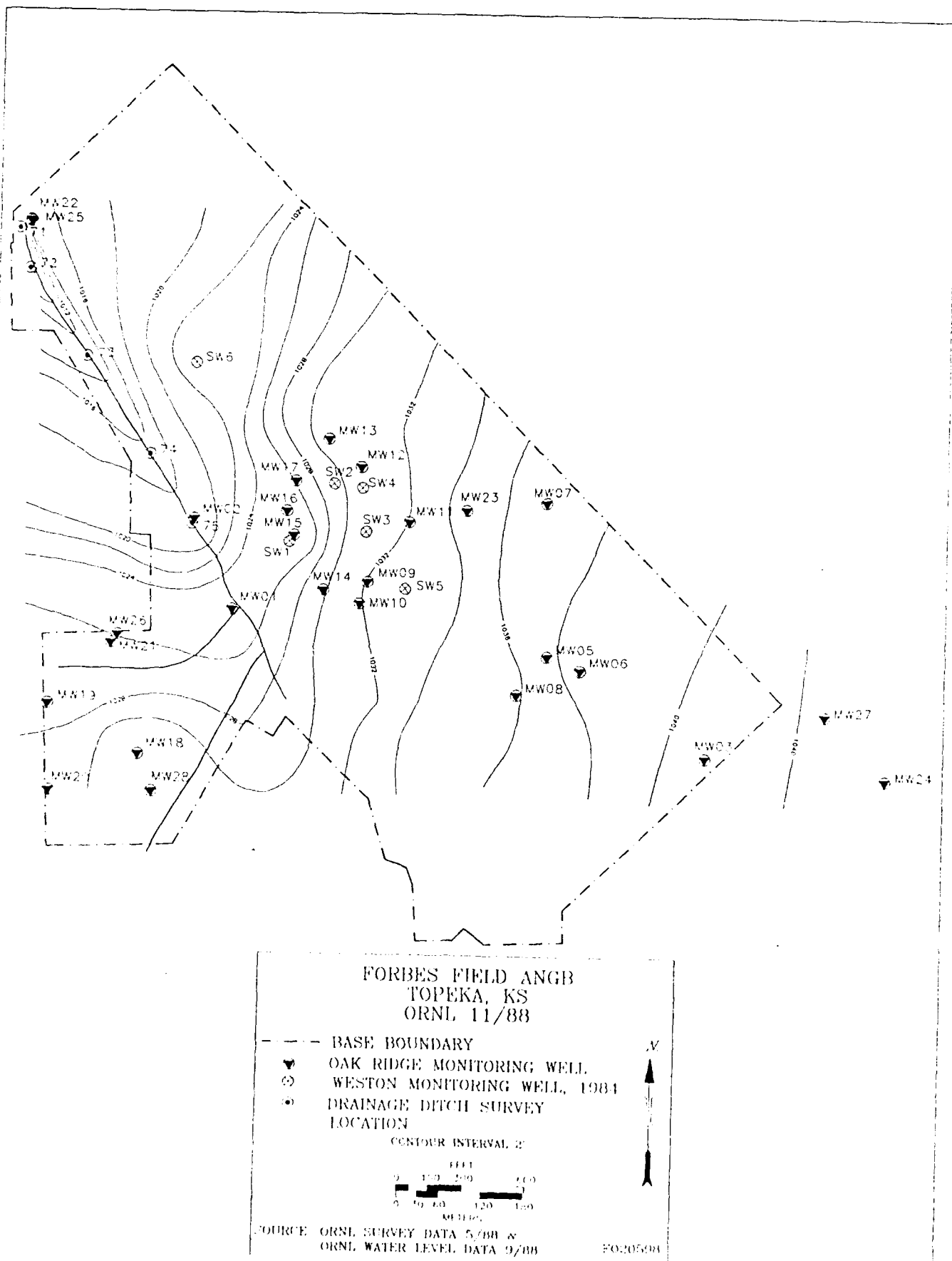


Fig. 2.13b. Potentiometric map of the unconsolidated aquifer water levels measured in September 1983.

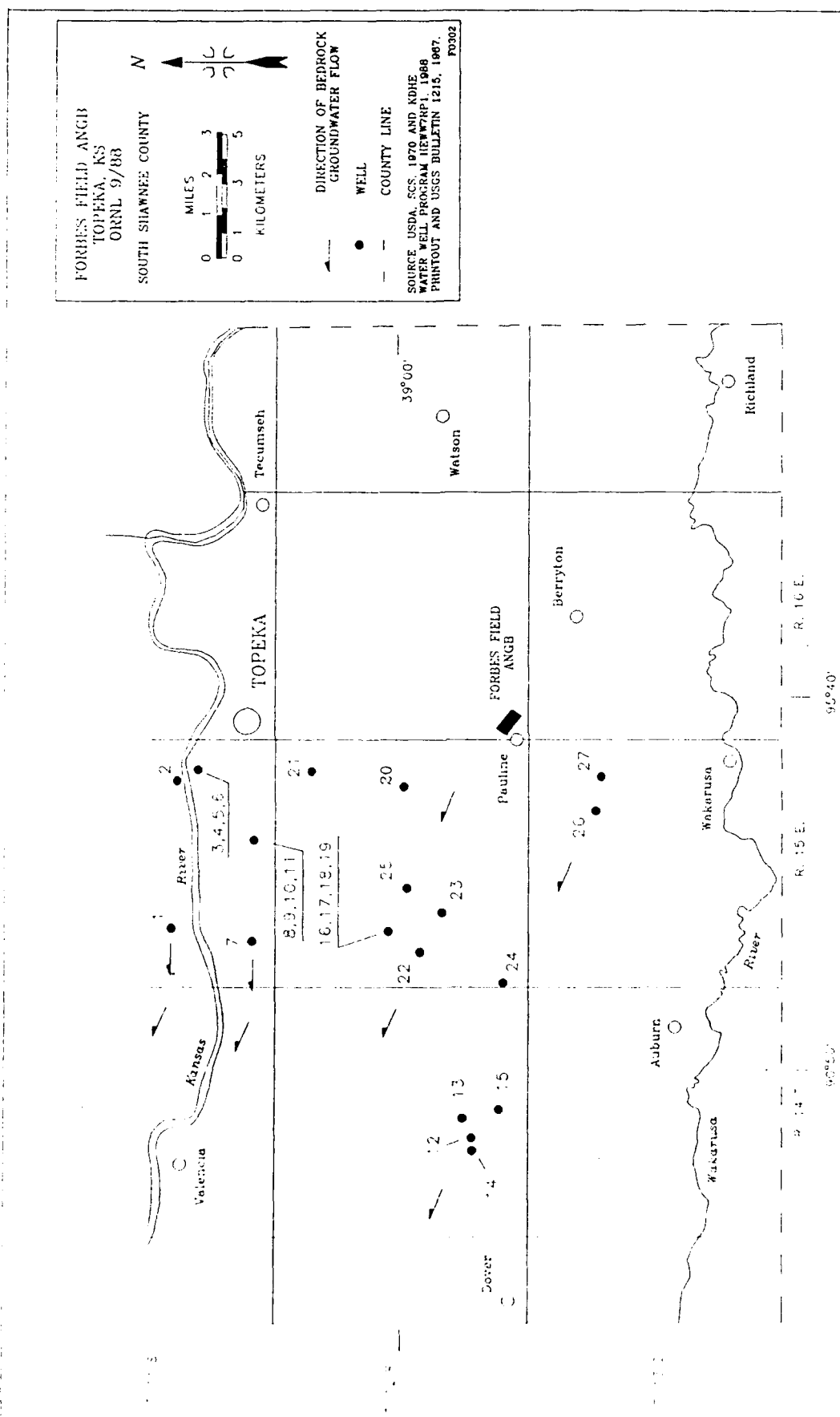


Fig. 2.14. Regional wells west and northwest of Forbes Field ANCB.

Table 2.8. Unconsolidated aquifer relative hydraulic conductivity values
determined from single-well tests

	cm/s ($\times 10^{-4}$)	ft/d
MW001	2.1	.62
002	-----a-----	--a--
003	-----c-----	--c--
004	-----c-----	--c--
005	-----a-----	--a--
006	-----a-----	--a--
007	-----a-----	--a--
008	-----c-----	--c--
009	-----a-----	--a--
010	-----a-----	--a--
011	1.9	0.53
012	2.6	0.72
013	7.1	2.0
014	4.3	1.2
015	-----a-----	--a--
016	-----a-----	--a--
017	3.4	0.97
018	-----b-----	--b--
019	-----b-----	--b--
020	-----b-----	--b--
021	-----a-----	--a--
022	1.2	0.34
023	-----a-----	--a--
024	0.40	0.11
025	-----b-----	--b--
026	-----a-----	--a--
027	-----a-----	--a--
028	-----b-----	--b--

--a-- Magnitude of hydraulic conductivity insufficient to yield reliable
results (lower detection limit $\sim 3.5 \times 10^{-5}$).

--b-- Test not performed on monitoring well.

--c-- Dry hole or insufficient water available for testing.

Curve-matching techniques were used to calculate the permeability and storage of the unconsolidated aquifer. Neuman's type curves (Neuman 1975) for unconfined aquifers were matched with the drawdown versus time graph obtained from the observation well. A transmissivity value of 131.5 g/d/ft and a storage value of 0.002 were calculated. Using a saturated thickness of 4.27m (14 ft), a hydraulic conductivity of 4.2×10^{-4} cm/s (1.2 ft/d) is obtained.

The single-well test on MW022 showed a hydraulic conductivity value of 1.2×10^{-4} cm/s compared to the pumping test value of 4.2×10^{-4} cm/s. The pumping test value is about three times the value obtained from the single-well tests, which is normal agreement between the two methods (Kearl, et al. 1988).

Fuel lateral trenches and aircraft ramp

During the soil-gas survey, water was discovered in the fuel trenches under the aircraft parking ramp. The presence of water in the trenches, and the fact that the water table lies 3 to 9 ft below the bottom of the trenches, indicates that a bath tubing effect is taking place. This shows that water in the trenches is isolated from the water table by the low permeable material comprising the aquifer. This conclusion is supported by field observations of the geology and hydraulic testing of the aquifer.

2.2.6.2 Bedrock Hydrogeology

Numerous water wells are located downgradient from the base according to records maintained by the KDHE. A large percentage of these wells obtain water from the underlying bedrock. Figure 2.14 shows the location of selected wells and Table 2.9 describes the location, well depth, bedrock unit from which water is obtained, and the hydrologic relationship to the base. As pointed out in Table 2.9, there is no threat to the bedrock aquifers downgradient of the base.

On a regional scale, the base lies in a recharge area for bedrock layers which outcrop or subcrop in the area. These bedrock layers are recharged by the overlying unconsolidated aquifer. Because of the topography, however, bedrock which subcrops beneath the base discharges water to the overlying unconsolidated aquifer. This is because the topography slopes at a greater angle than the regional dip and, therefore, truncates the bedrock as

Table 2.9 Regional wells and their hydrologic relationship to
Forbes Field ANGB.

Well number	Location	Depth (ft)	Geologic formation of completion	** Hydrologic relationship
1	SE SE NW SEC 20 T11S, R15E	50	Alluvium	4
*2	SW NW SW SEC 24 T11S, R15E	45	Alluvium	4
*3	SW NE NW SEC 25 T11S, R15E	35	Alluvium	4
*4	SW NE NW SEC 25 T11S, R15E	55	Alluvium	4
*5	SW NE NW SEC 25 T11S, R15E	49	Alluvium	4
*6	SW NE NW SEC 25 T11S, R15E	49	Alluvium	4
7	NW SW SEC 32 T11S, R15E	37	Sandy clay in Scranton Shale	1
8	NE NE NE SEC 33 T11S, R15E	8	Limestone unit of Scranton Shale	1
9	NE NE NE SEC 33 T11S, R15E	10	Limestone unit of Scranton Shale	1
10	NE NE NE SEC 33 T11S, R15E	4	Limestone unit of Scranton Shale	1
11	NE NE NE SEC 33 T11S, R15E	14	Sandstone of Scranton Shale	5

Table 2.9. (continued)

Well Number	Location	Depth (ft)	Geologic formation of completion	** Hydrologic relationship
12	NW NW SW SEC 28 T12S, R14E	95	Stotler Limestone	1, 2
13	NE SE SEC 28 T12S, R14E	102	Wood Siding Root Shale, Stotler Limestone, Pillsbury Shale Zeandale Limestone formations	1, 2
14	NE NE SW SEC 28 T12S, R14E	61	Stotler Limestone	1, 2
15	SW NW NW SEC 34 T12S, R14E	60	Channel Sand in Pillsbury Shale	1, 2
16	N2 NE SW SEC 17 T12S, R15E	26	Alluvial gravel and Limestone unit of Scranton Shale	1, 2, 3
17	N2 NE SW SEC 17 T12S, R15E	26	Limestone unit of Scranton Shale	1, 2
18	N2 NE SW SEC 17 T12S, R15E	26	Limestone unit of Scranton Shale	1, 2
19	N2 NE SW SEC 17 T12S, R15E	25	Limestone unit of Scranton Shale	1, 2
20	NE NE NE SEC 23 T12S, R15E	60	Howard Limestone	3

Table 2.9. (continued)

Well Number	Location	Depth (ft)	Geologic formation of completion	** Hydrologic relationship
21	SE SW SW SEC 2 T12S, R15E	92	Limestone unit of Scranton Shale	1, 2
22	NE NE NE SEC19 T12S, R15E	100	Limestone unit of Scranton Shale	1, 2
23	SE SE SE SEC 20 T12S, R15E	160	Sandstone unit of Scranton Shale	1, 2
24	NW SW NW SEC 31 T12S, R15E	120	Emporia Limestone	1, 2
25	NE NE NW SEC 21 T12S, R15E	180	Channel Sand of Howard Limestone or Severy Shale	3, 5
26	NW NE SW SEC 11 T13S, R15E	30	Scranton Shale	1, 2
27	NW SW SW SEC 12 T13S, R15E	70	Limestone unit of the Severy Shale	3

* Owner: City of Topeka

** Hydrologic relationship

1. Unit eroded away in base area.
2. Recharge area west of base.
3. Unit(s) are hydraulically isolated from aquifers underlying the base.
4. Alluvial well not in hydraulic communication with base.
5. Discontinuous beds not present at the base.

illustrated in Fig. 2.10b. Farther to the west, permeable bedrock units would eventually be recharged before dipping into the Forest City basin. However, these units are not in hydraulic connection with the unconsolidated groundwater system underlying the base.

The lack of hydraulic connection is demonstrated by the three coreholes which were drilled in order to characterize the bedrock hydrogeology. The objective of the bedrock drilling program was to identify the distribution and permeability of the bedrock units that underlie the base. This information permitted an evaluation of the potential for (1) contaminant migration into the bedrock aquifer and (2) subsequent contaminant movement downgradient. For background information on the regional geology and the cyclothem type deposition as it relates to Forbes Field ANGB, refer to Sect. 2.1.4.

Packer Tests

Packer tests were used to determine the permeability of the bedrock units underlying the base. These tests were performed in accordance with procedures described by the U.S. Department of Interior (1974) and the University of Missouri (1981). Emphasis was placed on testing all of the bedrock lithologies; however, difficulty was encountered seating the pneumatic packers in the upper 10 ft of CH001. Therefore, two thin sandstone units at the top of CH001 were not tested for permeability.

The packer test method involves injecting water at a measured rate and pressure into the subsurface formation through an uncased section of the hole. The appropriate parameters are measured and the resulting permeability or hydraulic conductivity (K) values are calculated using the equation:

$$K=Q[\ln(L/r)]/2\pi LH$$

where:

K = permeability or hydraulic conductivity

Q = constant rate of flow into the core hole

L = length of the section of the hole tested

H = differential head of water

r = radius of the hole tested

The three corehole wells were tested at 10-ft intervals; the results are presented in Table 2.10. All of the results, with the exception of the packer tests in the Nodaway Coal, indicated no flow. These no-flow results are interpreted to mean that the permeability of the units tested is below the detection limit of the packer-test method. The practical packer test detection limit with the equipment used is 10^{-6} to 10^{-7} cm/s. These results agree with the field geologic observations which indicate low permeable material with no indication of secondary fractures or faults.

Packer tests for the Nodaway Coal indicate a permeability of 1.1×10^{-3} cm/s (3.20 ft/d). Contrary to the other bedrock units, secondary permeability in the form of cleats in the coal were observed. Therefore, distribution of the Nodaway Coal across the site is important in determining the impact of contaminant transport in the bedrock.

As shown in Fig. 2.10 and 2.11, the Nodaway Coal and bedrock units above the Nodaway Coal subcrop beneath the base. Although the bedrock dips to the northwest and the base is a potential recharge area, the topography slopes at a greater angle truncating the bedrock units. As a result, the permeable Nodaway Coal, which is isolated from the unconsolidated aquifer by impermeable bedrock units in the eastern portion of the base, discharges water to the unconsolidated aquifer in the western portion of the base, as illustrated in Fig. 2.10b. Therefore, even if contamination were to enter the bedrock, it would be confined to the base and eventually discharged to the unconsolidated aquifer.

In summary, because of the low permeability of most of the bedrock units and the fact that even the permeable Nodaway Coal discharges water to the unconsolidated aquifer, there is no threat of groundwater contamination in the bedrock downgradient of the base.

2.2.7 Groundwater Quality

During July 1988, groundwater samples from all of the wells were collected for analyses of metals and major anions/cations. These data provide information which permits correlation with the lithology and a determination of whether the groundwater is suitable for domestic use. Table 2.11 presents a summary of the groundwater quality as well as appropriate regulations for chemical constituents of drinking water.

Table 2.10. Bedrock permeability (K) values determined from core hole packer tests

Test interval (BGL) (feet below ground level)	Bedrock unit	K value	
		ft/d	cm/s
CH001			
36.6 - 48.0	Severy Shale	No flow	No flow
46.6 - 58.0	Severy Shale	No flow	No flow
56.6 - 68.0	Topeka Limestone	No flow	No flow
CH002			
36.0 - 47.0	Severy Shale	No flow	No flow
46.0 - 57.0	Severy Shale and Topeka Limestone	No flow	No flow
56.0 - 67.0	Topeka Limestone	No flow	No flow
CH003			
27.5 - 38.5	Howard Limestone (including Nodaway Coal) and Severy Shale	3.20	1.1×10^{-3}
37.5 - 48.5	Severy Shale	No flow	No flow
47.5 - 58.5	Severy Shale	No flow	No flow
52.5 - 63.5	Severy Shale	No flow	No flow

Table 2.11. Major anions, cations, and metals (mg/L)

Chemical/ parameter	Average	Minimum	Maximum	Comments	SDWA Proposed		Kansas
					MCL	MCLG	
Chloride (Cl)	33.8	3.5	222				250
Fluoride (F)	2.04	0.2	4.7		4.0		4.0
Sulfate (SO ₄)	474	24.0	2700				250
Nitrate (NO ₃)	0.7			found only in MW003	10	10	10
Phosphate (PO ₄)				none detected			
Sodium (Na)	136	5.7	398				100
Magnesium (Mg)	47	0.0	223				
Calcium (Ca)	185	21.0	566				
Arsenic (As)	0.0052	0.002	0.001	found in four samples	0.05	0.05	0.050
Beryllium (Be)				none detected			0.000013
Cadmium (Cd)	0.006			found in one sample	0.01	0.005	0.005
Chromium (Cr)				none detected	0.05	0.12	0.050
Copper (Cu)	0.04	0.03	0.06	found in three samples		1.3	1.0
Lead (Pb)	0.0084	0.002	0.019	found in seven samples	0.05	0.02	0.050
Mercury (Hg)				none detected	0.002	0.003	0.020
Nickel (Ni)				none detected			1.0
Zinc (Zn)	0.022	0.006	0.11		5.0		5.0
TDS	>785	>130	>3846				1000
pH	6.36	6.00	7.16				5.5-9.5

Table 2.11. (continued)

TDS: Total dissolved solids
SDWA: Safe Drinking Water Act
MCL: Maximum contaminant level set by the EPA as required by the SDWA. MCLs are based on health factors and the technological and economic feasibility of removing the contaminant from the water supply.
MCLG: Maximum contaminant level goal set by the EPA as required by the SDWA. MCLGs are entirely health based; thus, they are always less than or equal to MCLs.
Proposed MCLG: A proposed MCLG which may change before being promulgated.
WQC: Water quality criteria - Federal criteria are non-enforceable guidelines, which many states use in the development of enforceable ambient water quality standards.
KAL: Kansas action level--represents the level at which long-term exposure to contaminant concentrations is unacceptable. Applies to all fresh and usable water aquifers.

2-53

* Water quality criterion are for drinking water ingestion only. They were derived from published EPA ambient water quality criteria (45 FR 79318-79379, November 28, 1980) for combined fish and drinking water ingestion and for fish ingestion alone. These adjusted criteria are more appropriate for sites with contamination of potential groundwater drinking water sources because they are based on more realistic exposure assumptions (i.e., exclusion of aquatic organisms as an exposure pathway.)

Source: Superfund Public Health Evaluation Manual, October 1986 (EPA/540/1-86/060)
Groundwater Contaminant Cleanup Target Concentrations, KHE, Division of Environment, Bureau of Water Protection Memorandum December 30, 1986.

2.2.7.1 Chemical Character

The prevalent chemical character (PCC) of the groundwater indicates the relative abundance of major anions and cations. It provides a way of differentiating waters by type and origin. The PCC is determined by converting concentrations to equivalents per million (epm) and listing the major cations and anions in order of abundance. Alkalinity of the groundwater was not measured in the field; therefore, the carbonate and bicarbonate concentrations can only be estimated by difference. Hence, the anion portion of the PCC cannot be calculated. The wells and their associated cation PCC are:

CH001	Ca/Na	MW009	Ca/Mg/Na	MW018	Ca
CH002	Na	MW010	Ca/Mg	MW019	Ca/Na
CH003	Na	MW011	Ca/Mg/Na	MW020	Ca/Mg
MW001	Ca	MW012	Na/Ca	MW021	Ca/Mg
MW002	Ca	MW013	Ca/Mg/Na	MW023	Ca
MW003	Na	MW014	Na/Ca	MW024	Ca/Na
MW005	Na/Ca	MW015	Ca	MW025	Ca
MW006	Na/Ca	MW016	Ca	MW026	Ca
MW007	Na/Ca	MW017	Ca/Mg/Na	MW027	Ca/Na
MW008	Na/Ca				

Calcium and sodium are the dominant cations in the groundwater samples, with several of the samples containing magnesium. The calcium and magnesium indicate that the groundwater passed through sediments or weathered bedrock containing carbonate materials. Several of the lithologic logs (Appendix G) from the monitoring wells show calcareous material in the weathered bedrock and limestone/dolomite clasts in the unconsolidated sediments. The sodium indicates contact with evaporite materials (halite, gypsum, anhydrite, etc.) in the weathered bedrock, which is a good possibility considering the thinly interbedded limestones, claystones, and shales of the Howard Limestone and Scranton Shale (see Section 2.2.4).

The anion side of the PCC, based on the above information, is probably dominated by carbonate, bicarbonate, and sulfate. Carbonate and bicarbonate result from the solution of carbonate minerals such as limestone and dolomite. Sulfate was an analyte in the groundwater samples and was found at levels

ranging from 24 mg/L to 2700 mg/L, averaging 474 mg/L. Sulfate indicates weathering of ferrous iron sulfide minerals, gypsum, and anhydrite, as discussed above.

2.2.7.2 Water Quality, Domestic Use

Groundwater at the base may not be fit for human consumption. As seen in Table 2.11, most of the major anions and metals discovered at the base fall below the Safe Drinking Water Act (SDWA) maximum contaminant levels (MCL) or Kansas action levels (KAL). However, the average level of sulfate in the groundwater (474 mg/L) is almost twice the KAL (250 mg/L) and the average level of sodium in the groundwater (136 mg/L) is above the KAL (100 mg/L). Arsenic was discovered in four wells. The average of these levels (0.0052 mg/L) is well above the Federal Water Quality Criteria guideline (0.000025 mg/L) but below the SDWA and KAL requirement (0.05 mg/L).

Total dissolved solids (TDS) in the groundwater average greater than 785 mg/L, not including carbonate/bicarbonate. The KAL for TDS is 1000 mg/L; the U.S. Public Health Drinking Water standard is 500 mg/L. The average pH of the groundwater is 6.36; the KAL range for pH is 5.5 to 9.5. (A pH of 10.7 was measured on the groundwater sample from CH002, but the next highest pH was 7.16. The 10.7 is probably an invalid measurement since the lithology in CH002 is the same as in other coreholes--essentially limestone and mudstone. Grout in the water could cause this pH but the surface casing was grouted in, then the remaining 50 ft of well was drilled using water--the circulation from drilling would remove any excess grout. No further grout was used in the well. In addition, the calcium level in the groundwater sample was only 21 mg/L. If the high pH was caused by grout the calcium would be higher.)

The SDWA MCLs apply to "public water systems", which is defined as systems for the provision of piped water for human consumption with at least 15 service connections or serving at least 25 persons. Therefore, a single residence well does not have to comply with the requirements.

The KAL (set by the KDHE) represents the level at which long-term human exposure to contaminant concentrations is unacceptable. The KAL is the groundwater contaminant cleanup target concentration and, therefore, is a level of contamination above which an aquifer would have to be remediated. The KALs are suspended in aquifers where the target concentrations are naturally exceeded. Nonetheless, Kansas considers levels above the KAL to be

unacceptable for long-term human exposure and the level of sulfate and sodium in the groundwater at Forbes Field ANGB would make the groundwater unacceptable for domestic use.

2.2.7.3 Water Quality. Irrigation

Classification systems for the suitability of water for agriculture uses generally include several criteria. One of the more common criteria, and one which can be determined based on the analyses performed on groundwater samples at the base, is the salinity hazard (Taylor and Ashcroft 1972).

According to Taylor and Ashcroft (1972), the salinity hazard is directly related to the electrical conductivity (EC) of the irrigation water. Groundwater at the base has an average electrical conductivity of 1900 $\mu\text{mhos/cm}$, which is a high salinity hazard. The water would be marginal for irrigating crops such as cotton, sugar beets, barley, bermuda grass, and tall wheatgrass, which have maximum permissible ECs of 1600 - 1800 $\mu\text{mhos/cm}$. The water would be unproductive for use on most vegetables (max. EC of 800 $\mu\text{mhos/cm}$); potatoes and corn (max. EC of 600 $\mu\text{mhos/cm}$); and most berries, fruits, and beans (max. EC of 200 - 400 $\mu\text{mhos/cm}$). Thus, even if the hydraulic conductivity allowed the production of usable quantities of groundwater, the poor quality would preclude most beneficial uses.

2.2.8 Upgradient Monitoring Wells

Two monitoring wells (MW024 and MW027) were drilled southeast of the base to monitor upgradient groundwater. Section 2.2.4.1 discusses the geology near these monitoring wells.

No fuel constituents were detected in the soil or groundwater samples from the upgradient wells; therefore, no fuel contamination is entering the base in the unconsolidated material. Air monitoring during drilling revealed no detectable volatile contaminants. Groundwater samples from MW024 contained 2.0 $\mu\text{g/L}$ of trichloroethene, an estimated level below the laboratory reporting level. No explanation for the chlorinated solvent can be determined and there is no known source for the compound.

The PCC of the groundwater is similar to groundwater under the base itself (see Section 2.2.7). The dominant cations are calcium and sodium.

The major constituents found in the monitoring wells are:

	MW024	MW027	units
Cl	35.0	17.0	mg/L
F	1.6	1.2	mg/L
SO ₄	190	390	mg/L
Na	95.0	92.8	mg/L
Ca	102	127	mg/L
Mg	19.5	28.2	mg/L
Pb	0.006		mg/L
Zn	0.036		mg/L
TDS	445	656	mg/L
pH	6.41	6.39	
Salinity	1150	1400	
hazard			

These values are all close to average for the groundwater under the base. Indeed, groundwater entering the base is essentially the same quality as the groundwater under the base. Thus, no major lithology changes occur and the groundwater undergoes no major chemical reactions during the groundwater's migration under the base.

2.2.9 Air Quality

Air quality in the Topeka area is good. A review of data for the period from 1970 to 1986 showed that Topeka had attainment status with the Clean Air Act. (James Stewart, Environmental Engineer, Bureau of Air Quality, Kansas Department of Health and Environment, Personal Communication, October, 1988).

The waste areas at Forbes Field ANGB have little potential for hazardous air emissions. Site 1, the tank farm, is covered with roadbase and lawn and Site 5 is covered by gravel and lawn so emissions would be difficult.

Sites 7, 8, 9, and the southeast corner are covered by concrete and asphalt. Site 6, the drainage ditch, is exposed, but portions are under water or covered by heavy vegetation. Volatile organic emissions, measured with a PID, were not detectable except in the headspace of a few monitoring wells. Thus, no air monitoring is necessary unless the sites are excavated.

2.2.10 Subsurface Migration Pathways

Three subsurface pathways for off-base migration exist in the form of domestic water and gas lines crossing the base from north to south along the west side of the base (Fig. 2.15 and Plate 1). Two of the lines are domestic water mains, one of which is abandoned. The new water line and the abandoned water line join together just north of the base and just south of the base. In fact, if contamination were to migrate in either water line trench, that contamination would be confined to one trench shortly after leaving the base in either direction. The third line is a new natural gas main.

These gas and water lines cross the large storm sewer at the north end of the base; however, the gas and water lines lie above the storm sewer. The top of the storm sewer near the intersection is 12 to 18 ft below the surface; the domestic lines are 6 to 8 ft deep. The water table in the area lies 7 to 11 ft below the surface. If contamination were migrating in the storm sewer trench fill, the contamination would not be able to cross to the trenches above the storm sewer. The contamination, therefore, would continue in the storm sewer trench fill to discharge at the pond.

These domestic lines also cross above the jet fuel line which connects the tank farm with the base. This intersection is near the drainage ditch at the south center of the base. The jet fuel line is approximately 8 ft below grade; the new gas and water lines are buried about 4.5 ft below grade. The water table lies 5 to 7 ft below the surface in this area.

Information available at the base indicates that all trenches, except fuel lines, were backfilled with native clay soils. The native clay soil backfill will slow contaminant migration, although not as much as undisturbed clay soils.

2.2.11 Demography and Land Use

According to the 1988 census, Shawnee County has a population of 153,052 and appears stable. Topeka, the state capitol of Kansas, lies near the center of Shawnee County. The city population was 114,898 in 1988. Shawnee County covers 545 square miles; Topeka incorporates 54 square miles. The government is a major employer in this region, employing over 20,000 people in 1986. Other major non-farm employers include trade, services, manufacturing, finance, and transportation/utilities.

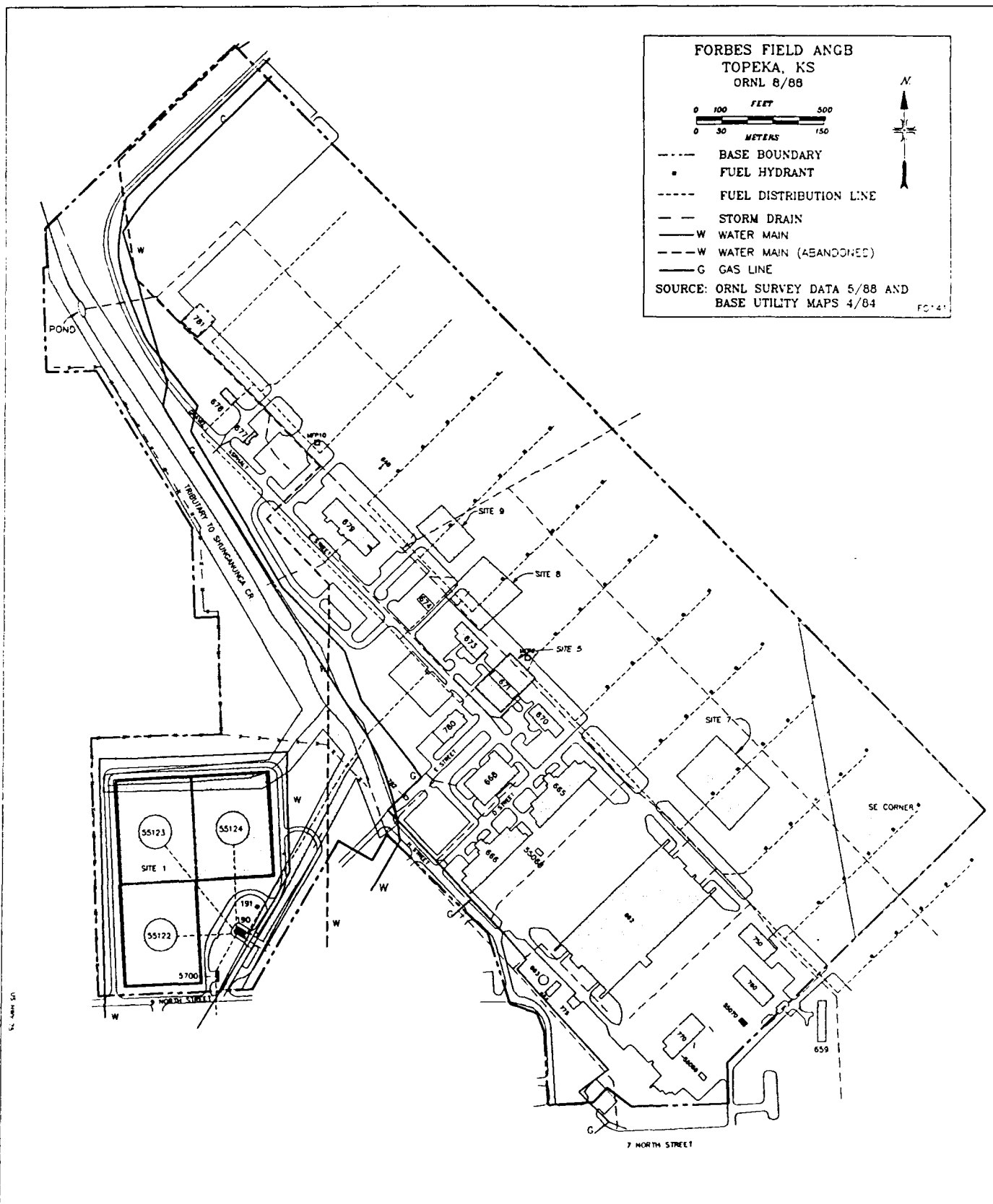


Fig. 2.15. Domestic gas and water mains.

Forbes Field ANGB lies 2.5 miles south of the southern boundary of Topeka, Kansas. The terrain is essentially flat with gentle rolling hills and a small number of streams flowing throughout.

Forbes Field ANGB presently employs over 300 full-time people. In addition, approximately 1100 National Guard personnel are assigned to the base. The National Guard contingent is present one weekend per month and for a single two week period during the year. No people reside on the base.

The former Air Force base extends between 0.5 to 1.5 miles east and 2 miles south of the ANGB. This area is owned by the MTAA and is occupied by several light industries and the airport.

West of the base lies the unincorporated village of Pauline, Kansas. Pauline has a population of approximately 4000 and consists of single family residences; trailer parks; and several small businesses. The Pauline Central Grade School-East and the Shawnee Country Day Care Center adjoin Forbes Field ANGB, sharing boundaries north of the tank farm and west of CH001.

North of the base towards Topeka, several small businesses, residences, and trailer parks adjoin U.S. Highway 75. The remainder of the vicinity is agricultural.

Forbes Field ANGB, Pauline, and the surrounding area obtain domestic water from the Topeka public water system. Topeka obtains public water from the Kansas River alluvium upstream from Shunganunga Creek. Industry and neighboring towns also draw water supplies from wells in the valley alluvium. Irrigation water is drawn from groundwater wells, stock ponds, and reservoirs.

Two recreational areas nearby include Lake Clinton and Sherwood Lake. Lake Clinton is east of the base and is fed by the Wakarusa River. The Wakarusa River valley wells do not produce enough water for irrigation. Lake Clinton provides recreation and serves as a water supply for Lawrence, Kansas, and surrounding agriculture. Sherwood Lake lies west of Topeka on Shunganunga Creek, upstream of the confluence with the South Branch of Shunganunga Creek. It is also a recreational area. Both lakes serve as flood control.

2.2.12 Ecology

As previously noted, the base contains a small stream or drainage ditch which lies in relatively open ground. Downstream from the base, the stream enters an area with heavy undergrowth. The stream continues in intermittently open and overgrown areas to the confluence with the South Branch of

Shunganunga Creek. Approximately two to three miles further downstream, the South Branch of Shunganunga Creek joins Shunganunga Creek. The main creek then flows through downtown Topeka, through a light industrial area, and on to its confluence with the Kansas River. This environment supports a variety of birds, snakes, skunks, frogs, crayfish, and other animals. The remainder of the base is covered with lawns, asphalt, and base facilities.

Shunganunga Creek is not designated for "contact recreation," i.e., swimming; it is designated for "noncontact recreational" use such as wading, boating, fishing, or hunting, and for consumption by aquatic, semi-aquatic, or terrestrial wildlife. Shunganunga Creek bears "expected aquatic life"-- meaning habitat and biota normally found in the area. The creek is designated for domestic water supply use after appropriate treatment to produce potable water. Shunganunga Creek may also be used for irrigation, livestock water, industrial water supply, and groundwater recharge (K.A.R., 1987).

The Kansas Department of Wildlife and Parks lists six threatened and five endangered species occurring in Shawnee County (Table 2.12); however, no critical habitat has been designated. The Kansas River is a critical habitat for the Flathead Chub from the Douglas County line to the confluence with the Missouri River. The Douglas County line is approximately ten miles downriver from Topeka and five miles downriver from the confluence with Shunganunga Creek. Nearby critical habitats include a corridor along the Kansas River from Douglas County to the Missouri River for the Bald Eagle and in Douglas County for the N. Crawfish Frog.

As is typical of the Great Plains, tall grasses are the predominant plant in Shawnee County.

There are no critical habitats, wetlands, or wilderness areas in the vicinity of Forbes Field ANGB.

Table 2.12. Threatened and endangered species occurring in Shawnee County, Kansas

Species	Status	Occurrence in Shawnee County	Critical habitat designated
Bald Eagle	E	Occurs regularly in winter	No
E. Hognose Snake	T	May occur in suitable habitat	No
E. Spotted Skunk	T	May occur in suitable habitat	No
Eskimo Curlew	E	Former spring migrant-no records since pre-1900	No
Least Tern	E	Occurs occasionally in summer	No
Peregrine Falcon	E	Occurs occasionally in winter	No
Piping Plover	T	Occurs occasionally, spring or fall	No
Snowy Plover	T	Occurs occasionally, spring or summer	No
W. Earth Snake	T	May occur in suitable habitat	No
White-faced Ibis	T	May occur occasionally, spring, summer or fall	No
Whooping Crane	E	Occurs occasionally in spring or fall	No

E: Endangered

T: Threatened

(Source: State of Kansas, Department of Wildlife and Parks, Wildlife Operations, 1988, used with permission).

3. SITE 1, AREA ADJACENT TO JP-4 STORAGE FACILITIES 55122, 55123, AND 55124

3.1 SITE BACKGROUND

The area adjacent to the JP-4 storage facilities was included in the IRP study based on a recommendation from the Phase I records search (HMTTC 1986). HMTTC calculated a HARM score of 40 for this site.

3.1.1 Site Description

Site 1, the tank farm, is located on the west edge of the base between U.S. Highway 75 and the main body of the base (Plate 1). It borders the base entrance road on the north. The tank farm area (Fig. 3.1) consists of three large aboveground fuel tanks (bulk storage tank facilities 55122, 55123, and 55124), earth berms to contain spills, a pumphouse, truck unloading hydrants, and a system of underground fuel lines - all enclosed within a security fence.

Two of the storage tanks have a capacity of 45,000 barrels. The remaining tank has a 55,000 barrel capacity. All of the tanks have a floating roof. The three tanks are surrounded by an approximately 4 to 5 ft. earthen dike to impound leaks. The L-shaped area contained by the dirt berm drains into the surface drainage ditch (Site 6) through a system of controlled outlets. These outlets remain closed unless sufficient precipitation occurs to require draining the area.

The pumphouse is the focal point of the tank farm. Fuel is unloaded from trucks at several hydrants along the southeast side of the area. This fuel is pumped to the storage tanks, or, as needed, pumped to the distribution system at the base or returned from the base to the storage tanks. Fuel trucks are unloaded daily and a large volume of fuel is stored.

3.1.2 Site History

Aerial photographs taken in 1954 show the tanks and the pumphouse in their present arrangement. During midsummer of 1981, a leak occurred in tank 55122--the southernmost tank. An estimated 1200 to 1400 gal of jet fuel leaked. The leak occurred on the southeast side of the tank within the diked area. The fire department sprayed foam over the fuel, and no fuel was recovered. Fuel which did not evaporate was adsorbed by the soil.

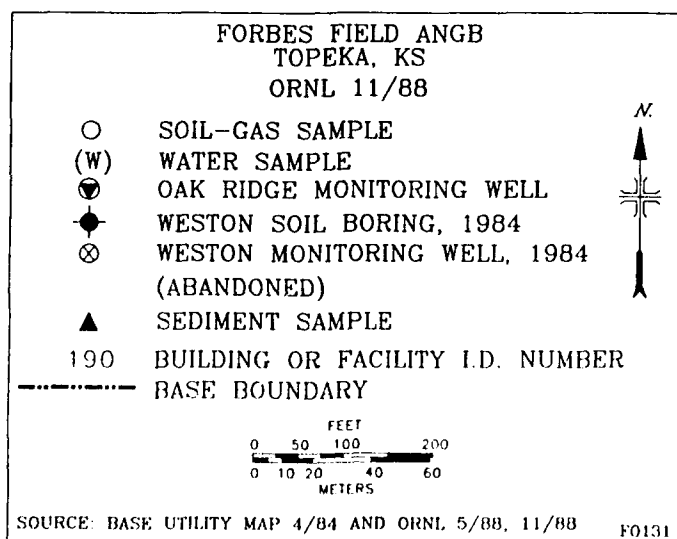
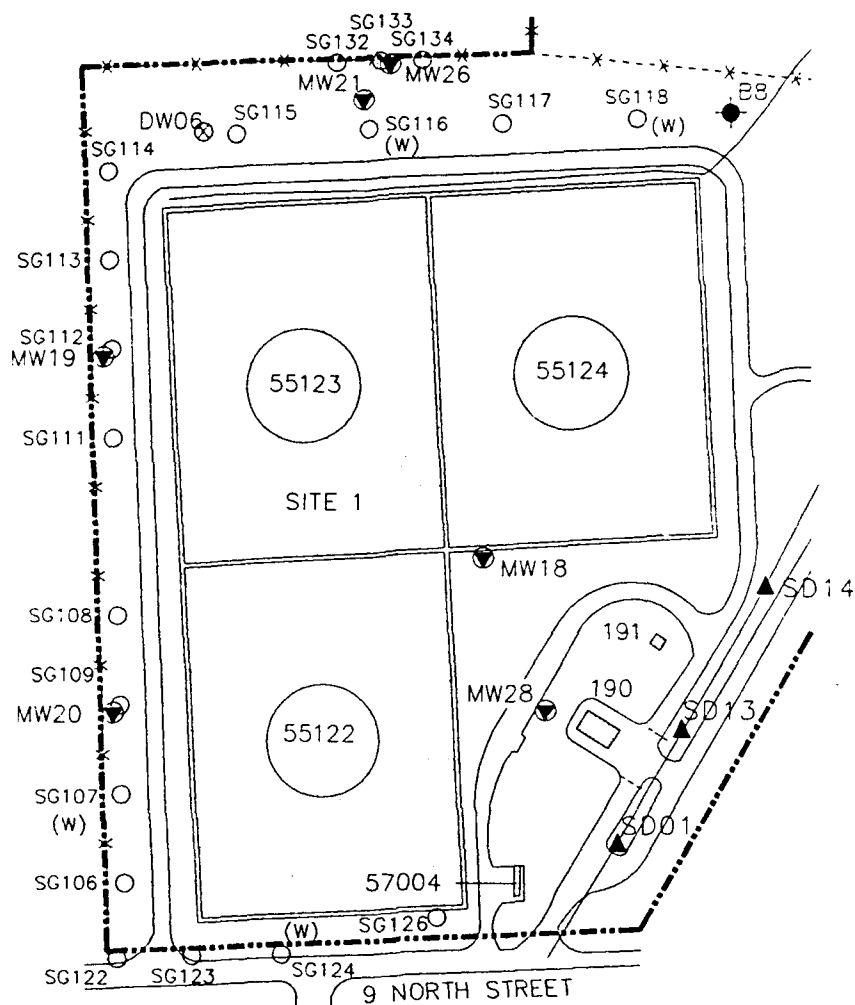


Fig. 3.1. Map of Site 1, tank farm.

Tank cleaning sludges have been buried within the tank farm area. The Phase I records search (HMTc 1986) identified one such area as Site 2 - POL sludge burial area. This burial occurred in 1977 and consisted of 100 gal of JP-4 tank cleaning sludge. The sludge was said to consist of rusty water and soap, and was buried on the west side of the tank storage facility. This activity was not rated with the HARM system because of the small quantity involved and because most of the waste consisted of soap and water.

An additional sludge burial area is located north of the storage tanks. A base employee revealed that this area had been used from sometime in the 1950s to 1978 (Belcher 1988). The sludge resulted from the periodic cleaning and maintenance of the storage tanks, which occurred infrequently, varying from 3 to 10 years between the cleanings. The quantity of sludge and JP-4 buried north of the perimeter dike is unknown, but is thought to be minimal; the tanks were reported to have very little accumulation of sludge at each inspection.

The base employee also discussed the location of an auxiliary wing tank from a B-47 mounted aboveground just west of the pumphouse (Belcher 1988). The estimated capacity of the tank was 600 to 700 gal. The tank held JP-4, av-gas, and the sludge from periodic cleaning of filters. When the tank was full, the mixture was pumped from the tank and used to spray grass and weeds or used in the fire training pit. The base employee did not know how long the tank had been used, but it was removed two to three years after he arrived (1965).

Also within the tank farm area, a spill of about 300 gal of JP-7 occurred at NASA's aboveground fuel storage tank in 1982. The tank (57004) is near the south boundary of the tank farm (Fig. 3.1). Absorption with "Absorbent" (a 3M product designed to absorb fuel products but not water) recovered about 95 percent of this spill, according to estimates (personal communication with Forbes Field ANGB Fire Department). The rest was lost to soil adsorption and evaporation (HMTc 1986). The Phase I records search documented this as Site 3. It was not rated with the HARM system due to the small quantity of fuel not recovered.

The tank farm remains in use as a bulk jet fuel storage area.

3.1.3 Previous Investigations

Weston (1985) drilled one well within this area (Fig. 3.1) to a depth of 50 ft (DW006). Steel casing was set into bedrock (20.4 ft) and cemented in

place; therefore, this well monitors the bedrock aquifer rather than the unconsolidated sediments. Weston's analysis of a water sample from this well indicated 170 $\mu\text{g/L}$ of oil and grease. ORNL/CAT sampled this well in March 1988 and analyzed for VOAs and TPHCs--no fuel components were detected.

Weston also drilled one soil boring (B8) about 80 ft northeast of the northeast corner of the earth dike surrounding tank 55124. Monitoring of this well and soil samples with a HNU PID revealed no elevated measurements. No soil samples were collected for chemical analysis.

The only other investigation was during the Phase I records search. This consisted of interviewing base personnel, reviewing documents, and visiting the site.

3.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

3.2.1 Surface Water Hydrology

Due to the relatively flat topography, surface runoff in the Tank Farm area occurs predominantly as sheet flow. Sheet flow collects into two small drainage ditches on the north and south side of the site which discharge to the surface drainage ditch (Site 6, Sect. 5). Any precipitation occurring in the vicinity of the tanks would be contained by the protective dikes. Consequently, the water in these areas would either infiltrate or evaporate. General surface-water hydrology information for the base is discussed in Sect. 2.2.3.

3.2.2 Geology

The tank farm area rests on unconsolidated sediments deposited during the Kansan Glaciation. Beneath these sediments lies a thin zone of weathered bedrock and then competent bedrock of the Howard Limestone and Severy Shale. A complete description of the geology at the base is presented in Section 2.2.4.

3.2.3 Soils

Site 1 soils are Ladysmith (Ld), 0 to 1% slope, in the northern three-quarters of the area and Ladysmith (Lm), 1 to 3% slope, in the southern

quarter (USDA 1970). General soil information for the base is discussed in Sect. 2.2.5 and Table 2.7.

3.2.4 Hydrogeology

The only water-bearing unit of interest underlying the tank farm is the unconsolidated aquifer in which water is found in the lower portion of the glacial drift or in the underlying weathered bedrock. This unconsolidated aquifer is completely absent in portions of the base. The underlying bedrock consists of impermeable limestones and shales of the Howard Limestone which isolate the lower permeable Nodaway Coal unit.

A complete description of the Forbes Field ANGB hydrogeology is presented in Sect. 2.2.6. Groundwater flow direction and rates for the tank farm area are presented in Sect. 3.3.6.

3.2.5 Demographics and Land Use

The Tank Farm is located at the west edge of the base. Between the west boundary of the tank farm and U.S. Highway 75 is a small (3 to 5 acre) cultivated field. Immediately north of the base boundary fence at the tank farm is the Pauline Central Grade School-East, the Shawnee Country Day School, and the unincorporated village of Pauline, Kansas. The nearest residence is approximately 300 to 400 ft northwest of the tank farm boundary. The tank farm is secured by a fence and access is restricted.

General demographics and land use for the base and Shawnee County are discussed in Sect. 2.2.11.

3.2.6 Ecology

The area outside the earth berms is covered by lawn and roads; no natural vegetation or wildlife is supported. General ecology of the base is discussed in Sect. 2.2.12.

3.3 STUDY AREA INVESTIGATION

3.3.1 Surface Features

Field activities at Site 1 involved surveying in order to accurately map the earth berms, to select soil-gas sample points, and to locate monitoring well locations and elevations. A general description of surface features on the base is presented in Sect. 2.2.1.

3.3.2 Contaminant Source Investigations

The contaminant source investigation at the tank farm area included a review of the Phase I records search, interviews with base personnel, and inspection of aerial photographs.

Jet fuel spills were the main source of contamination, with tank cleaning sludge a secondary source. The leak from storage facility 55122 in 1981 is the most significant. Inspection of aerial photographs from 1976, 1982, and 1984 confirmed this spill. In the 1982 photograph, a dark stain is obvious south of storage tank 55122. This stain does not appear in the 1976 photograph and is considerably fainter in the 1984 photograph. Base personnel provided information on an additional area where tank cleaning sludge was buried (Sect. 3.1.3).

3.3.3 Surface-Water and Sediment Investigation

Surface water in the tank farm area drains into the nearby unnamed tributary (Site 6) to the South Branch of Shunganunga Creek. Consequently, soil and water sampling performed at Site 6 characterizes the surface water and sediment at this site. Information on surface water and sediment investigations for Site 6 are presented in Sect. 5.

3.3.4 Geological Investigation

Surface lithology information for the tank farm area was obtained from borings of MW018, MW019, MW020, MW021, MW026, and MW028. With the use of a continuous sampler, a complete lithologic record was kept for each hole. The

six boreholes were subsequently completed as monitoring wells. The well summary forms with well construction and lithologic descriptions are attached in Appendix G.

The surface lithology consists of unstratified silty-clays deposited by melt water from the receding glaciers. Locally, these are mostly varying shades of gray and brown. The clays are predominantly very plastic with varying amounts of silt; mottled with limonite streaks and nodules; fairly high in organic matter; and peppered with red, yellow, and gray shaley partings. The thickness ranges from 8 ft in MW026 to 9.5 ft in MW019. The upper portions (0 to 5 ft) of the sediments are dark brown grading to olive-brown. Some evidence of carbonaceous material was detected as very dark gray to black laminations between 0 and 4 ft in all boreholes except MW018. The sediments were moist within 1 to 3 ft above the weathered bedrock, and in MW021 and MW028, a strong fuel odor was associated with the moisture zone.

A weathered yellow-brown claystone with locally scattered argillaceous limestone stringers of the same color comprises the upper part of the bedrock. Fossil evidence, including crinoid stems, gastropod shells, and bryozoan casts and molds, was found in the fissile and thin bedded claystone underlying the weathered zone.

Moisture in the weathered bedrock is limited to the zone near the contact with the overlying glacial deposits. In MW018 a strong fuel odor was also associated with the wet zone of the weathered bedrock. The weathered bedrock is part of the lower Howard Limestone. As a note of interest, evidence of diagenesis was found in the form of vertical and horizontal gypsum veins scattered throughout the weathered zone in MW020.

3.3.5 Vadose Zone and Soil Investigation

3.3.5.1 Vadose Zone

Twenty-one soil-gas and water samples were collected around the tank farm area. Sampling locations are shown on Plate 1 and Fig. 3.1. Samples SG106 through SG118, and SG122 through SG126 bracket the tank farm perimeter on the north, south, and east. These samples were collected by driving the drivepoint to bedrock, then withdrawing the probe about 3 ft. If water entered the hole immediately, a 40-mL water sample was taken. Otherwise, the

probe was capped and left overnight. If there was still insufficient water to sample on the following day, a soil-gas sample was collected. Soil-gas samples SG101 and SG127 were collected at a depth of 5 ft and are situated directly over the main fuel line which supplies the base with JP-4. Water sample SG116 was collected in a former disposal site for sludge and JP-4. Soil-gas samples SG132 through SG134 are located 80 ft downgradient from SG116. Results are discussed in Sect. 3.4.2 and analytical values are presented in Appendix D.

Section 2.1.2.2 provides a detailed discussion on soil-gas collection methods.

3.3.5.2 Soils

Soil samples were collected with a 5-ft continuous sampler during the drilling of MW018, MW019, MW020, MW021, MW026, and MW028 (Fig. 3.1). Samples were inspected visually for contamination and monitored along their length with an HNU PID. If elevated readings were noted, a grab sample was taken. Otherwise, samples for chemical analysis were collected every 3 ft until the water table was reached. Soil samples from Site 1 were analyzed for VOAs and TPHCs. Two samples were analyzed for VOAs following extraction by the Toxicity Characteristic Leaching Procedure (TCLP). Analytical results are discussed in Sect. 3.4.2.

3.3.6 Groundwater Investigation

Six monitoring wells were installed in the area to determine the lithology, hydraulic conductivity, depth to water, groundwater flow direction, and the presence of contamination in the groundwater. Potentiometric maps, based on water-level measurements taken in July and September 1988, are shown in Fig. 2.13. These maps indicate a general groundwater flow direction to the northwest; however, locally, under the tank farm, groundwater flow is to the northeast--towards the drainage ditch.

Based on the groundwater flow directions, MW019, MW020, and MW026 are located downgradient of potential sources of contamination while MW018, MW021, and MW028 are within source areas. In addition, MW001 is located downgradient of the tank farm.

Bail tests were performed on MW021 and MW026 to measure the permeability of the unconsolidated aquifer in the area. For both tests, the magnitude of the permeability was insufficient to yield reliable test results. Therefore, it is estimated that the hydraulic conductivity of the unconsolidated aquifer in the vicinity of the tank farm is less than 3.5×10^{-5} cm/s (0.1 ft/d).

A discussion of the base hydrogeology and results of the aquifer tests are presented in Sect. 2.2.6.

3.4 NATURE AND EXTENT OF CONTAMINATION

3.4.1 Sources

The source of the organic compounds found in the groundwater and soil at the tank farm is the fuel tanks. These organics result from fuel which leaked from the tanks and sludge left from tank cleaning. Spilled fuel was absorbed into the surrounding soils and the sludge was buried west and north of the dikes surrounding the tanks.

3.4.2. Vadose Zone and Soils

3.4.2.1 Vadose Zone

The soil-gas survey revealed from 4.5 $\mu\text{g/L}$ to 747 $\mu\text{g/L}$ of TPHCs in the vadose zone. No "average" background value was evident. Elevated TPHC concentrations were found at seven locations (Fig. 3.1) as follows:

<u>Sample Location</u>	<u>TPHC ($\mu\text{g/L}$)</u>
SG107W *	86,800
SG109	97
SG113	747
SG115W	92.5
SG116W	30,700
SG118W	395
SG124W	1,290

* W denotes a water sample

Obviously, the range of values is wide and the elevated data points are scattered around the area. Samples SG107 and SG109 were collected from the area which was identified as Site 3 in the Phase I records search; SG116 was collected from the sludge burial area north of the tank farm.

No historical or anecdotal information explains the other elevated soil-gas samples. These elevated soil-gas points are scattered and are probably the result of undocumented disposals (e.g., one-time disposals of tank cleaning material or other hydrocarbon containing waste). The elevated soil-gas samples show no pattern and, therefore, do not indicate a plume or other expression of a larger source.

The absence of elevated TPHC (see discussion in Appendix D) concentrations in the sample at SG127 (50.8 $\mu\text{g/L}$ TPHC) and SG101 (25.2 $\mu\text{g/L}$ TPHC) suggests that contamination is not leaving the site via less consolidated fill material along the distribution line (Plate 1).

3.4.2.2 Soils

A soil sample taken at a depth of 12 ft in MW018 (Fig. 3.1) contained TPHCs (140,000 $\mu\text{g/kg}$), xylene (3700 $\mu\text{g/kg}$), and toluene (900 $\mu\text{g/kg}$). The remaining samples from MW018 contained no contaminants above the laboratory reporting levels. Soil samples collected from depths of 6 and 9 ft in MW021 contained 490,000 $\mu\text{g/kg}$ and 34,000 $\mu\text{g/kg}$ of TPHCs, respectively. In addition, MW021 contained significant quantities of other fuel components in the 6 and 9-ft samples. A soil sample taken from a depth of 7 ft in MW028 contained 145,000 $\mu\text{g/kg}$ of TPHCs, 1800 $\mu\text{g/kg}$ of toluene, and 5900 $\mu\text{g/kg}$ of xylene.

A soil sample from 6 ft in MW021 was submitted for the TCLP; this procedure resulted in only 39 $\mu\text{g/L}$ of total xylenes. The procedure is designed to determine the capability of contaminants to leach from the soil into the groundwater. Since the soil sample collected at 6 ft in MW021 contained 31,000 $\mu\text{g/kg}$ of xylenes, the TCLP procedure indicates that the contaminants are not readily leachable from this soil.

Significant analytical results are presented in Appendix E.

3.4.3 Groundwater

During July and September/October 1988, groundwater samples were collected from MW018, MW019, MW020, MW021, and MW026 (Fig. 3.1). Samples collected in July were analyzed for VOAs, TPHCs, HSL metals, and major

cations/anions. In addition, groundwater samples from MW021 were analyzed for HSL pesticides, PCBs, and semi-volatiles. Samples collected in September/October were analyzed for VOAs and TPHCs. Chemical constituents of jet fuel were detected in the groundwater in three of the six monitoring wells in the tank farm area.

During September/October, two groundwater samples were collected from both MW018 and MW026. In MW018, the two samples were collected because the soil at 12 ft in the monitoring well contained 140,000 $\mu\text{g/kg}$ TPHCs; however, the groundwater sample collected in July contained no detectable contamination. The stagnant water in the well might contain low levels of contamination leached from the soil; therefore, collecting a sample prior to purging the well would identify that contamination. Both samples, one collected before purging and one after purging, contained no detectable fuel contamination, indicating that the contamination in the soil at 12 ft is not leaching into the groundwater. Two samples were collected from MW026 because of contamination discovered in MW021, only 50-ft upgradient. No contamination was discovered in MW026 during drilling in June or subsequent groundwater sampling in July. To be certain that no contamination was being missed in the groundwater at MW026, a sample was collected before and after purging. The groundwater contained no detectable contamination.

No detectable contamination was discovered in MW020.

MW019 contained 83 $\mu\text{g/L}$ TPHCs, 1.4 $\mu\text{g/L}$ benzene, 1.0 $\mu\text{g/L}$ toluene, and 5.0 $\mu\text{g/L}$ 1,1,2-trichloroethane. The jet fuel constituents were found in both July and September/October samples, the 1,1,2-trichloroethane is a solvent for chlorinated rubber and various organic materials (Verschueren 1983). Since no source exists for this compound and it was found only in the July sample, its presence probably results from laboratory contamination.

MW021 contained 760 $\mu\text{g/L}$ TPHCs, 11 $\mu\text{g/L}$ benzene, and 110 $\mu\text{g/L}$ xylenes. Both July and September/October samples showed the jet fuel constituents, but only the October sample showed the TPHCs. No explanation can be provided for the lack of TPHCs in the July sample.

Groundwater samples were collected in November and December from MW028 and were analyzed for VOAs and TPHCs. In November 1988, a floating film was detected in MW028; therefore, a sample of the stagnant water was collected. The stagnant sample contained 2000 $\mu\text{g/L}$ TPHCs, and 30 $\mu\text{g/L}$ toluene; a sample collected after purging the well contained 200 $\mu\text{g/L}$ TPHCs, 0.9 $\mu\text{g/L}$ benzene, 20 $\mu\text{g/L}$ toluene, and 7 $\mu\text{g/L}$ total xylenes. No floating film was detected in

December 1988. The sample collected in December after purging the well contained 270 µg/L TPHCs, 4.4 µg/L benzene, 10 µg/L toluene, and 4 µg/L total xylenes.

Significant analytical results are provided in Appendix E.

3.4.4 Surface Water and Sediments

No surface water samples were collected at Site 1. Sediment samples were collected in the drainage ditch east of the tanks; these samples are part of the characterization of Site 6 and results are discussed in Sect. 5.4.4.

3.4.5 Air

Routine air monitoring during drilling was performed with an HNU model PI-101 PID. No anomalous readings were obtained while monitoring ambient air, indicating that even though organic compounds are present in the subsurface, volatilization to the atmosphere is insignificant.

3.5 CONTAMINANT FATE AND TRANSPORT

The contamination found in the soil and groundwater at this site is due to leaks of JP-4 jet fuel and to burial of tank cleaning remnants. The absence of chlorinated solvents and other non-fuel related compounds has been established by both soil and groundwater analyses.

3.5.1 Contaminant Persistence

The fate and persistence of TPHCs cannot be discussed in a simple fashion because JP-4 is composed of many individual compounds with widely varying properties. JP-4 is made by blending naphtha, gasoline, and kerosene -- themselves mixtures of widely varying composition. Thus, the distillation range of JP-4 reportedly varies from 140 to 270°C, with component hydrocarbons ranging from C-4 to C-14 compounds. One typical analysis of JP-4 showed 61% alkanes, 29% cycloalkanes, 8% alkylbenzenes, 1% indans and tetralins, <1% naphthalenes, and up to 5% olefins. Another reference stated that JP-4's major components could be characterized as 63% alkanes, 16% cycloalkanes, 18% alkylbenzenes and benzene, and 3% naphthalene. This wide range in composition

and classes of compounds means that the concentration of individual compounds will also vary widely. For example, Roberts and Thomas (1986) have shown that the concentration of normal-decane varied from 0.81% to as much as 2.16% in different samples of JP-4. Obviously, the environmental behavior of the individual compounds varies significantly.

3.5.1.1 Chemical Reactions of Fuel Hydrocarbons

Fuel hydrocarbons are composed of a host of individual compounds--most of which can be broadly classed as alkanes (e.g., n-octane) or aromatics (e.g., benzene). These compounds may undergo substantial biodegradation but they are not subject to any chemical (non-biological) reactions of environmental significance. That is not to say, however, that there are no examples of naturally occurring chemical reactions of organic compounds. For example, Haag and Mill (1988) have shown that haloalkanes (e.g., trichloroethane) undergo natural chemical reactions, but the rate constants are so small that the reactions are not an important factor in assessing the persistence of haloalkanes in the environment. The overall reactivity of alkanes and aromatics is less than haloalkanes, demonstrating that natural chemical reactions of fuel hydrocarbons must also be insignificant. The following sections provide an overview of the chemical reactivity of alkanes and aromatics.

Alkanes

Alkanes undergo very few reactions even under laboratory conditions. Reactions involving alkanes take place only under vigorous circumstances, usually involving free-radical chain reactions. What this means is that only an extremely reactive particle--typically an atom or free-radical--can attack an alkane molecule. Hence, alkanes would not be expected to undergo any significant chemical reactions under environmental conditions.

The non-reactivity of alkanes is shown by examples of two typical laboratory reactions. The first is halogenation. Halogenation of an alkane can only occur if the halogen has been disassociated into individual atoms. This reaction requires ultraviolet light or temperatures of 200 to 400°C. Another reaction undergone by alkanes is pyrolysis, which is the disassociation of the alkane itself. Pyrolysis occurs at 400 to 600°C.

Aromatics

Benzene, toluene, ethylbenzene, and xylenes are examples of very stable ring structures known as resonance hybrids. The ring structure is the result of the sharing of two less stable structures where each of the six carbon-carbon bonds have the same bond energy even though the chemical formula would lead one to expect a compound with three double bonds and three single bonds. Typically, a compound that has multiple bonds (e.g., an alkene such as trichloroethene) is very reactive and made more stable by an addition reaction that would remove the multiple bond. Resonance hybrids, on the other hand, because the single and double bonds are shared, have exceptionally stable structures. Thus, reactions that break the ring structure require more energy than is typically available under environmental conditions.

Compounds such as xylene, ethylbenzene, and toluene consist of an alkyl (derived from an alkane) group attached to the ring portion of the structure. Thus, the alkane discussion would apply to the reactivity of these substituent groups.

3.5.1.2 Biodegradation

Many of the components of JP-4 are easily biodegraded in the environment (API 1975 and Atlas 1981). The actual amount of biodegradation is site-specific since the microbes need both moisture and nutrients to thrive. Microbes are generally less active in groundwater than in soil; however, biodegradation in groundwater usually progresses indefinitely because there is a continuous supply of nutrients and moisture.

Recent work by numerous authors (e.g., Ward 1984) has demonstrated that there are indigenous microflora everywhere in the subsurface. The subsurface microorganisms have lower activities than do those in surface soils; however, the subsurface microflora can effectively mineralize organic contaminants under aerobic conditions. Indeed, Wilson et al. (1985) have shown that biodegradation at the margin of the plume is often rapid.

Rifai et al. (1988) have modeled the biodegradation at an aviation fuel spill site. Their paper contains a thorough description of the factors governing the biodegradation of benzene, toluene, and xylene in the subsurface. In general, the mass loss due to biodegradation was most

sensitive to the coefficient of reaeration from the water table, the coefficient of anaerobic decay within the contaminant plume, and the hydraulic conductivity.

This means that the low hydraulic conductivity at Forbes Field ANGB limits the amount of biodegradation, while it also limits the amount of contaminant migration. The possible rate at which biodegradation does occur is regulated by the transport of oxygen to the system. Since the transport of oxygen is likely to be either as rapid or more rapid than the transport of the contaminants, it is reasonable to assume that any contaminants that do move are rapidly biodegraded by the indigenous microflora.

The above explanation is supported by the work of Wilson et al. (1987). These authors studied an aviation fuel spill in Michigan and found that the heart of the plume contained high concentrations of methane and alkylbenzenes with no detectable oxygen. The heart of the plume was surrounded by an anaerobic zone of biological activity with greatly reduced concentrations of alkylbenzenes and no oxygen. This anaerobic zone was surrounded by an aerobic region with detectable oxygen and even greater reductions in alkylbenzene concentrations. A renovated or pristine zone surrounded the aerobic zone of treatment with high concentrations of oxygen and no detectable contaminants. Hence, the low hydraulic conductivity at the base results in very thin zones such that the appearance is one of a highly concentrated area surrounded by an adjacent pristine area.

3.5.2 Potential Routes of Migration

The potential route of exposure to a receptor from contamination at Site 1 is by migration in the surface drainage system adjacent to the base. Contamination from Site 1 could reach the ditch as surface runoff or by the leaching of contaminated groundwater.

Groundwater under Site 1 discharges north and northeast to the drainage ditch as shown by the potentiometric map from September 1988 water level measurements (Fig. 2.13b). This map also shows a slight westward component of flow in the southwest corner of the tank farm, indicating that groundwater might be flowing away from the drainage ditch. Further west, however, this westward component of flow will probably curve back to the northeast and discharge to the drainage ditch. Evidence of this can be seen where the potentiometric lines north of MW019 show flow toward the ditch from points west of the base.

The soil borings demonstrated that the contamination within the site is found at depths of 6 ft and greater; the overlying soil is clean. For example, soil samples collected at MW021, located on the north side of this site, contained 490,000 $\mu\text{g}/\text{kg}$ of TPHCs at a depth of 6 ft. Fortunately, the clay soil inhibits migration of the contaminants as shown by results for water samples and for the TCLP. Water in MW021 contained 11 $\mu\text{g}/\text{L}$ benzene, 110 $\mu\text{g}/\text{L}$ xylenes, and 760 $\mu\text{g}/\text{L}$ TPHCs. The TCLP procedure, performed on the soil sample that contained 490,000 $\mu\text{g}/\text{kg}$ TPHCs, showed only xylenes detectable in the leachate (39 $\mu\text{g}/\text{L}$).

MW018, located in the middle of the site, had 140,000 $\mu\text{g}/\text{kg}$ of TPHCs in the soil but none were detected in the water. MW019, on the west side, had 83 $\mu\text{g}/\text{L}$ of TPHCs in the groundwater. MW020, also on the west, contained no detectable contamination in the groundwater. MW021 showed 760 $\mu\text{g}/\text{L}$ of TPHCs while MW026, located less than 50 ft downgradient, was clean. Again, the tight clay soils inhibit the migration of contaminants off-site.

Field measurements with hand-held survey meters were unable to detect any volatilization of contaminants from the site. Furthermore, it is certain that such measurements were taken in the areas likely to be most contaminated, since the location of the borings and wells was determined by soil-gas anomalies. Unless the area were excavated, there is no significant air exposure and no potential for contamination in surface runoff.

There is contamination in the adjacent drainage ditch that may have originated from spills at Site 1. This contamination is discussed in Sect. 5.5.

3.5.3 Contaminant Migration

Table 3.1 compares the mobility of some components of JP-4 (a discussion of the varied composition of JP-4 is presented in Sect. 3.5.1). Because there are so many types of compounds, migration rates are not easily predicted. Some of the components, for example, are very volatile and will rapidly disperse in the atmosphere. Others, such as xylene, are not as volatile and will rapidly migrate through the soil to the water table. For example, Aurelius and Brown (1987) have shown that even if volatilization is significant, some spilled xylene will migrate rapidly to the water table. Moreover, if the soil is moist, a greater percentage of the spilled components will flow to the water table. The increased leaching with higher soil

Table 3.1. Comparison of mobility in the environment for contaminants found

Compound	Solubility* mg/L	Log K _{oc}	Mobility** in groundwater classification	Boiling point*
Benzene	.1780	1.93	high mobility	80.1
Ethylbenzene	150	2.6	low mobility	136.2
Hexane	13		low mobility	68.7
Cyclohexane	55		low mobility	81.0
Methyl Cyclohexane	14		low mobility	101
Naphthalene	30		low mobility	217.9
Nonane	.07		very low mobility	151
Octane	.7		very low mobility	125.7
Toluene	500	2.28	medium mobility	110.8
Xylenes	158	2.59	low mobility	138-144

* Verschuere, Karel. Handbook of Environmental Data on Organic Chemicals. Second Edition, VanNostrand Reinhold Company, 1983, New York, New York.

** Roy, W. R., and Griffin, R. A. "Mobility of Organic Solvents in Water-Saturated Soil Materials" Environmental Geol. Water Sci. Vol 7, No. 4, 1985, 241-247.

moisture is due to water filling the smaller soil pores and then repelling the spilled hydrocarbons. The repulsion effect and the hydrocarbon's lower kinematic viscosity results in rapid flow in the larger pores. It has been reported that these phenomena result in migration to the water table ten to 1000 times faster than water.

Once fuel hydrocarbons come in contact with the water table, most will remain in the capillary fringe because they are either lighter than water or immiscible. These compounds are considered to be highly mobile in the environment but because they are so easily biodegraded and volatilized, their cumulative effect is generally quite small. Xylenes and other aromatics are most likely to dissolve in the groundwater and be conducted from the spill area. However, the high clay content of the soil at Forbes Field ANGB limits the amount of leaching.

To determine the likelihood of leaching, a highly contaminated soil sample from Site 1 (490,000 $\mu\text{g/kg}$ TPHCs and 31,000 $\mu\text{g/kg}$ xylenes in soil from MW021) was subjected to the TCLP test. Xylenes were detected at 39 $\mu\text{g/L}$, indicating only slight leachability in the sample. This result is borne out by results from all of the contaminated areas at Forbes Field ANGB, which generally show that the fuel spills have not migrated with the groundwater.

3.6 BASELINE RISK ASSESSMENT

This section describes the public health and environmental concerns resulting from Site 1. Contaminants identified at this site are TPHCs--which were found in concentrations as high as 490,000 $\mu\text{g/kg}$ in soil and 760 $\mu\text{g/L}$ in groundwater.

The risk assessment for the base, including details of exposure pathways, exposure scenarios, toxicity of chemicals, and risk characterization is presented in Appendix J.

3.6.1 Exposure Assessment

The following evaluation of potentially contaminated media demonstrates that contamination from Site 1 does not result in significant exposure to the environment or the public.

3.6.1.1 Air

Air emissions were evaluated with a hand-held survey meter at ground level. The data showed that there were no emissions from the site; however, soil-gas measurements did demonstrate that anomolous concentrations of TPHCs were present in the subsurface. The concentrations were so low that any transport to the surface would be minute and quickly diluted such that exposure to the public or even military personnel using the site would be insignificant.

3.6.1.2 Groundwater

The groundwater associated with this site contains traces of TPHCs (up to 760 $\mu\text{g/L}$). Priority pollutant volatile compounds detected were benzene (up to 11 $\mu\text{g/L}$), toluene (up to 30 $\mu\text{g/L}$), and xylene (up to 110 $\mu\text{g/L}$). There are, however, no residences or groundwater wells between the contaminated location and the likely discharge points to the storm drainage system. The tight clay soil, discontinuities in the alluvial aquifer, and the controlled access to this site make eventual use of the groundwater unlikely.

3.6.1.3 Surface Water

Spills at Site 1 may have resulted in some contamination of sediments in the runoff ditch. This contamination is discussed separately as Site 6 (Sect. 5.5).

3.6.1.4 Soil

Soil samples at the tank farm contained high levels of TPHCs (490,000 $\mu\text{g/kg}$) at depths of 6 ft or greater. The data indicate that exposures to fuel-derived hydrocarbons could result if the area were excavated. Crops are grown adjacent to this location but there is no grazing of livestock.

3.6.2 Risk Evaluation

Risks presented by contamination at Site 1 were evaluated using the construction worker scenario (Appendix J). Under this scenario, workers could be exposed to four of the contaminants of concern (benzene, ethylbenzene, toluene, and xylene) via inhalation or dermal absorption of contaminants in either groundwater or subsurface soils. Estimation of possible exposures via volatilization from groundwater assumes that 100% of the concentrations found in groundwater will volatilize and be inhaled by the receptors. Estimation of dermal absorption exposures assumes a 100% absorption across the skin barrier.

Evaluation of construction worker exposures to contaminated groundwater and subsurface soil indicates a negligible probability of carcinogenic effects resulting from either inhalation or dermal absorption of benzene. In addition, the hazard indices for these exposure routes are well below levels of concern.

Analysis of the resident scenario also shows no probability of developing carcinogenic or noncarcinogenic effects from off-base exposure to site groundwater. This scenario assumes that resident exposure in groundwater equals the concentrations currently measured on-site; actual exposures and, thus, actual risks (should off-base wells be identified) would be even lower.

Considering the conservative assumptions used, concentrations of contaminants of concern at Site 1 are not expected to adversely impact either workers or off-base residents under the simulated conditions.

3.7 SUMMARY AND CONCLUSION

3.7.1 Summary

The contamination found at Site 1, the tank farm area, is from jet fuel and associated tank cleaning sludge. The highest levels of contamination are from 6 to 12 ft in the first moist zone in the soils.

The fuel appears to be tightly held by the soil, as shown by the relative lack of contamination in the groundwater and by the TCLP analysis. Further verification of this conclusion comes from MW026 which was drilled 50 ft downgradient of a well containing contaminated groundwater (MW021). The groundwater in MW026 was clean.

Soil-gas data shows inconsistent levels of contamination and indicates a series of individual spills rather than a contaminant plume.

3.7.2 Conclusions

No risk to the public or environment exists from Site 1, but excavations at certain areas in the tank farm area could result in exposure to workers.

The preferred alternative is no action with continued restricted access to the site.

4. SITE 5, PUMPHOUSE E, BUILDING 671

4.1 SITE BACKGROUND

The area surrounding pumphouse E, building 671 was included in the IRP study based on a recommendation from the Phase I records search (HMTc 1986). HMTc calculated a HARM score of 59 for this site.

4.1.1 Site Description

Site 5 surrounds pumphouse E, building 671 (Plate 1). This pumphouse is southwest of the aircraft parking ramp and near the center of the base (Fig. 4.1). The pumphouse is a single story concrete block building surrounded by a gravel strip 30 to 50 ft wide surrounded by grass. The arteries for several of the base utilities are buried northeast of this facility, between the pumphouse and the aircraft parking ramp, at depths of 2 to 7 ft. In addition to numerous buried utility lines around the pumphouse, there are also fourteen 50,000 gal underground fuel storage tanks situated on the north and south sides of the building.

The pumphouse pumps fuel to or from the fuel distribution lines and fuel laterals under the aircraft parking ramp. In addition, the pumps bring fuel from, or return it to, the large aboveground storage facilities in the tank farm (Site 1). Pumphouse E serves laterals 1 through 6.

4.1.2 Site History

Pumphouse E was constructed between 1954 and 1959. In 1967, a spill of JP-4 flowed out beyond the confines of the facility and onto the ground along the north side of the building. Estimated volumes of the spill range from 2000 to 10,000 gal. No fuel was recovered. In 1979 or 1980, construction activities involving excavation in the area uncovered soil visibly contaminated with fuel. The Phase I investigators observed vegetative stress within this area (HMTc 1986).

Pumphouse E is still an active pumping facility for base operations.

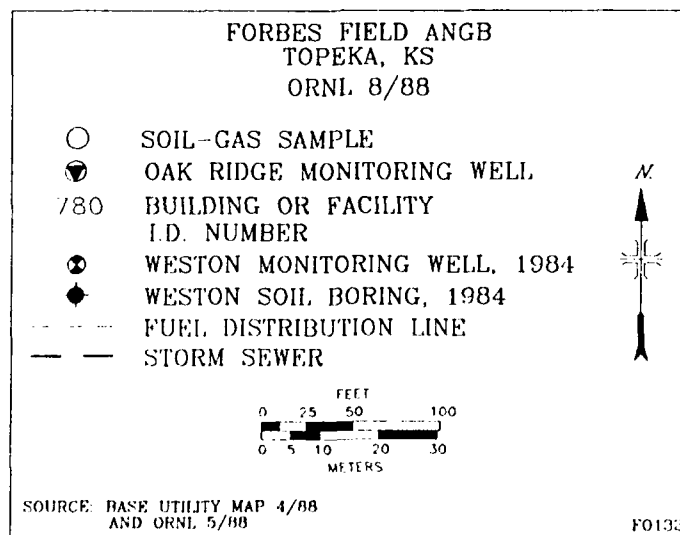
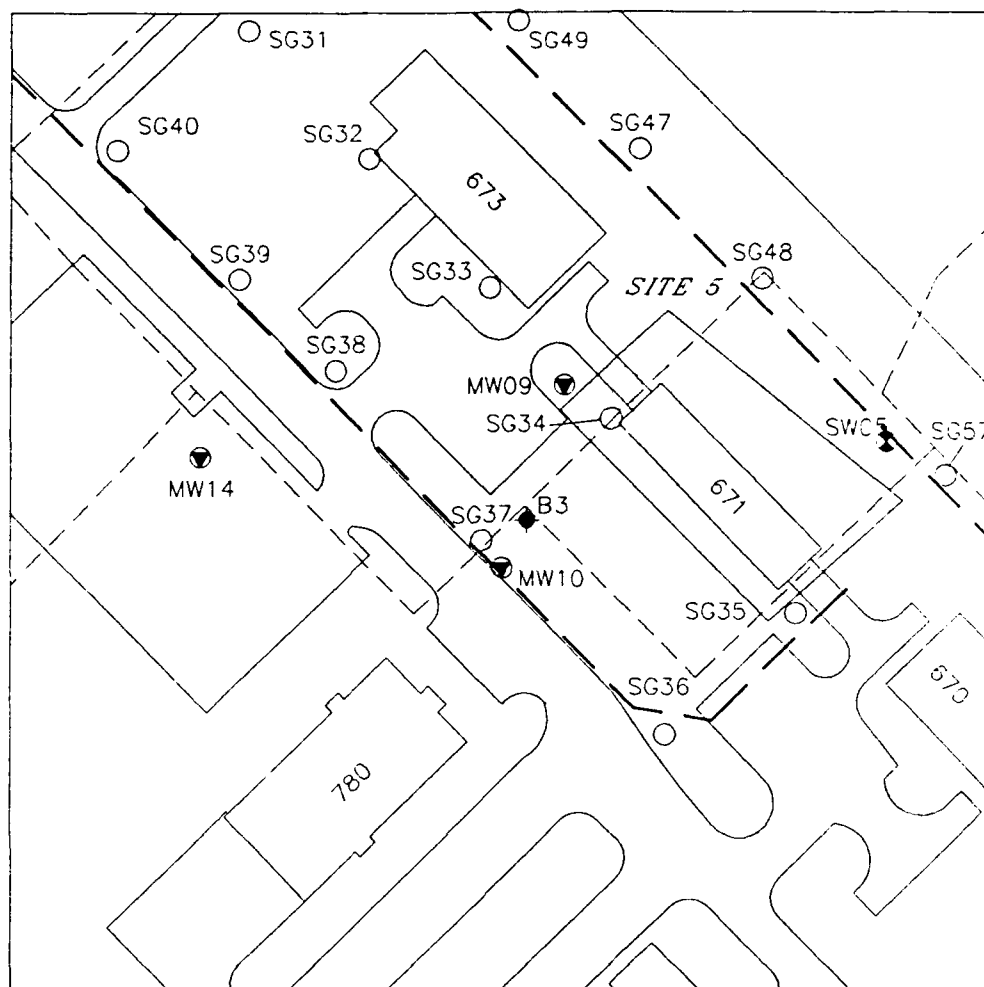


Fig. 4.1. Map of Site 5, pumphouse E.

4.1.3 Previous Investigations

Weston inspected and surveyed storm sewer manholes on and adjacent to the refueling ramp. This consisted of visual observations and measurements with an OVA and an HNU PID. No organic vapors were detected.

Weston (1985) drilled one well about 70 ft upgradient (southeast) of the pumphouse. SW005 was installed in the trench fill near the intersection of fuel distribution lines from pumphouse E and the storm sewer system (Fig. 4.1). Oil and grease analysis of a soil sample taken from 3 to 7.7 ft revealed a concentration of 829 mg/kg. Weston also measured a floating layer of fuel (0.20 ft) in the well. Analysis of one water sample collected from the well revealed 3970 mg/L of oil and grease.

Weston drilled one soil boring (B3) downgradient of the pumphouse and northeast of MW010 (Fig. 4.1). Boring B3 was near the intersection of two fuel distribution lines and was drilled into the trench. The log shows clay from 0 to 2 ft and sand with little silt from 2 to 8 ft. One soil sample was collected from 5 to 8 ft in this boring; analysis revealed 50,000 $\mu\text{g/kg}$ of oil and grease.

In March 1988, ORNL/CAT detected a very thin floating layer on the water in SW005. This layer was barely detectable with an oil/water interface probe and no measurement of the thickness of the layer was possible. Prior to purging the well, a sample was collected for TPHCs analysis. It revealed 8900 $\mu\text{g/L}$ of TPHCs. Replicate samples, collected after purging the well to dryness and allowing it to recover, showed 12,000 and 13,000 $\mu\text{g/L}$ of TPHCs.

The only other investigation was during the Phase I records search. This consisted of interviewing base personnel, reviewing documents, and visiting the site.

4.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

4.2.1 Surface Water Hydrology

Due to the pavement and relatively flat topography, surface runoff at Site 5 occurs predominantly as sheet flow. The runoff either discharges to the drainage ditch (Site 6, Sect. 5) or is routed through the storm sewer before entering the ditch. General surface water hydrology information for Forbes Field ANGB is discussed in Sect. 2.2.3.

4.2.2 Geology

Site 5 rests on unconsolidated sediments deposited during the Kansan Glaciation. Beneath these sediments lies a thin zone of weathered bedrock and then competent bedrock of the Howard Limestone and Severy Shale. A complete description of the geology at the base is presented in Section 2.2.4.

4.2.3 Soils

Site 5 soils are Ladysmith (Ld), 0 to 1% slope (USDA 1970). General soil information for the base is discussed in Sect. 2.2.5 and Table 2.7.

4.2.4 Hydrogeology

The only water bearing unit of interest underlying Site 5 is the unconsolidated aquifer in which water is found in the lower portion of the glacial drift or the underlying weathered bedrock. This unconsolidated aquifer is completely absent in portions of the base. The underlying bedrock consists of impermeable limestones and shales of the Howard Limestone, which isolate the lower permeable Nodaway Coal unit.

A complete description of the Forbes Field ANGB hydrogeology is presented in Sect. 2.2.6. Groundwater flow direction and rates for the site are discussed in Sect. 4.3.6.

4.2.5 Demographics and Land Use

Pumphouse E, building 671 - the center of Site 5 - is where the original spill occurred. Building 670, support services, and building 673, headquarters, lie about 100 ft southeast and northwest, respectively; both buildings contain offices. No people reside within approximately 1200 ft of Site 5. The site is within the secured and patrolled portion of the base.

General demographics and land use for the base and Shawnee County are discussed in Sect. 2.2.11.

4.2.6 Ecology

This site is covered by building 670, gravel, and lawn; no natural vegetation or wildlife is supported. General ecology of the base is discussed in Sect. 2.2.12.

4.3 STUDY AREA INVESTIGATION

4.3.1 Surface Features

Field activities at Site 5 involved surveying to accurately map the building locations, soil-gas sample points, and monitoring well locations and elevations. A general description of base surface features is presented in Sect. 2.2.1.

4.3.2 Contaminant Source Investigations

The contaminant source investigation at pumphouse E consisted of a Phase I records search review. A spill of 2000 to 10,000 gal of jet fuel from the facility in 1967 is the source of contamination for the site.

4.3.3 Surface Water and Sediment Investigation

Surface water at Site 5 drains to the northeast or southwest into the storm sewer system, which then drains into the nearby unnamed tributary (Site 6) to the South Branch of Shunganunga Creek. Surface water and sediment investigations for Site 6 are discussed in Sect. 5.

4.3.4 Geological Investigation

Surface lithology information for the pumphouse E area was obtained from borings of MW009, MW010, and MW014. With the use of a continuous sampler, a complete lithologic record was kept for each hole. The three boreholes were subsequently completed as monitoring wells. The well summary forms, with well construction and lithologic descriptions, are attached in Appendix G.

The surface lithology consists of unstratified silty clays deposited by melt water from the receding glaciers. These are predominantly gray and brown clays, but are locally quite stained with red-brown limonite oxide, are non-calcareous, and moderately organic. The clays are predominantly very plastic with minor amounts of silt. These clays also exhibit scattered dark red and dark gray to black shale partings. The sediments range in thickness from 7.5 to 8 ft. The sediments were wet in MW009 and MW010 at depths greater than 3 to 5 ft; MW014 was dry down to the weathered bedrock. Associated with the moisture is a fuel odor that varies in concentration. In MW009, this odor was observed throughout the surficial deposits.

The sediments overlie a weathered yellow-brown claystone interbedded with gray and black carbonaceous shales. Visible contorted relict bedding was noted in all boreholes. In MW014, where the sampler penetrated to a depth of 12.5 ft, an argillaceous siltstone was encountered at 12 ft. It is an olive-yellow, slightly carbonaceous, and well-cemented calcareous siltstone. No fossil evidence was observed locally. The weathered bedrock in MW009 and MW010 was wet near the top; in MW014 it was wet near the bottom.

The weathered bedrock in the area of Site 5 is the lower part of the Howard Limestone. The underlying bedrock consists of the impermeable limestones and shales of the lower Howard Limestone.

4.3.5 Vadose Zone and Soil Investigations

4.3.5.1 Vadose Zone

Six soil-gas samples were collected surrounding pumphouse E (Fig. 4.1.). In addition, several other soil-gas samples were collected using a 100 ft grid northwest from pumphouse E. Samples SG48 and SG57 were collected northeast of the pumphouse in the backfill of storm sewer and fuel line trenches. Sample SG34 and SG35 were collected near the west and southwest corners of the pumphouse, respectively; and SG36 and SG37 were collected downgradient.

Samples were taken by pushing the drive point to a depth of 5.5 ft, then raising the probe 6 in. Results are discussed in Sect. 4.4.2.

Section 2.1.2.2 provides details on soil-gas collection methods.

4.3.5.2 Soils

Soil samples were taken with a 5-ft continuous sampler during the drilling of MW009, MW010, and MW014. Samples were inspected visually for contamination and monitored along their length with an HNU PID. If elevated readings were noted, a grab sample was taken. Otherwise, samples for chemical analysis were collected every 3 ft until the water table was reached. Soil samples from Site 5 were analyzed for VOAs and TPHCs. Sample 5054, taken from MW009, was analyzed for VOAs following extraction by the TCLP. Analytical results are discussed in Sect. 4.4.2.

4.3.6 Groundwater Investigation

Three monitoring wells were installed in the area to determine the lithology, hydraulic conductivity, depth to water, groundwater flow directions, and the presence of contamination in the groundwater. Potentiometric maps, based on water-level measurements taken in July and September 1988, are shown in Fig. 2.13. These maps indicate a general groundwater flow direction to the northwest, towards the tributary to Shunganunga Creek (Site 6).

Based on the groundwater flow direction, MW009, MW010, and MW014 are located downgradient from potential sources of contamination. SW005 is used to provide source area water quality. In addition, well MW002 provides information on downgradient water quality.

Bail tests were performed on MW009, MW010, and MW014 to measure the permeability of the unconsolidated aquifer in the area. For tests performed on MW009 and MW010, the permeability was insufficient to yield reliable test results. Therefore, it is estimated that the hydraulic conductivity of the unconsolidated aquifer at these wells is less than 3.5×10^{-5} cm/s (0.1 ft/d). The permeability for well MW014 is 4.3×10^{-4} cm/s (1.2 ft/d), indicating some discontinuity in the aquifer permeability.

A discussion of the base hydrogeology and results of the aquifer tests are presented in Sect. 2.2.6.

4.4 NATURE AND EXTENT OF CONTAMINATION

4.4.1 Sources

The source of organic compounds found in the groundwater and soil in the ORNL/CAT monitoring well at Site 5 is fuel which has leaked from the pumphouse. The fuel in Weston's SW005 may be from the spill at pumphouse E or from fuel migrating in trenches from another leak. The oil and grease discovered in Weston's soil boring B3 is from contamination in the trench backfill.

4.4.2 Vadose Zone and Soils

4.4.2.1 Vadose Zone

Five of the six soil-gas samples taken around pumphouse E showed elevated concentrations of TPHCs (Fig. 4.1). The data from these five samples is as follows:

<u>Sample Location</u>	<u>TPHC ($\mu\text{g/L}$)</u>
SG34	174
SG35	201
SG37	277
SG48	151
SG57	147

These soil-gas samples were all collected near the spill area, either from fuel line trench backfill or adjacent to a fuel line trench. Soil-gas sample SG36, collected about 10 ft from the fuel line trench, contained background levels ($9.0 \mu\text{g/L}$) of TPHCs. Complete results from the soil-gas survey are provided in Appendix D.

4.4.2.2 Soils

A soil sample taken at a depth of 6 ft during the drilling of MW009 contained TPHCs ($26,000 \mu\text{g/kg}$) and xylenes ($2600 \mu\text{g/kg}$). TPHCs and VOAs were less than reporting levels in MW010, located 120 ft downgradient from MW009.

Soil samples from MW014 contained 2.0 and 3.0 $\mu\text{g}/\text{kg}$ toluene at depths of 3 and 6 ft, respectively, but no other fuel compounds. These levels of toluene are estimated values below the laboratory reporting levels. The Weston soil boring B3 contained 50,000 $\mu\text{g}/\text{kg}$ of oil and grease in a soil sample collected between 5 and 8 ft. Boring B3 was located about 80 ft downgradient of pumphouse E and was drilled into the trench backfill of a buried fuel distribution line. Significant analytical results are provided in Appendix E.

The pervasive presence of backfill material, the presence of floating product in SW005, and the oil and grease found in boring B3 suggest that past spills have remained in the less consolidated fill, with very limited migration into the surrounding, undisturbed silty clay. Soil-gas data suggest that fuel has migrated through the fuel line backfill to the boring B3 location.

During drilling, ORNL/CAT personnel noted a distinct odor of fuel at a depth of about 6 ft in MW009 and MW010, decreasing to a "faint fuel odor" in MW014 (Appendix G).

4.4.3 Groundwater

Weston's SW005, located in the backfill of a trench between the pumphouse and the flightline, showed 0.20 ft of floating product in 1984. ORNL/CAT sampling in March 1988 revealed 13,000 $\mu\text{g}/\text{L}$ of TPHCs plus other fuel components. The well contained 0.16 ft of floating product in September 1988. A sample collected prior to purging the well in September revealed 9500 $\mu\text{g}/\text{L}$ TPHCs; a sample collected after purging the well revealed 8700 $\mu\text{g}/\text{L}$ TPHCs.

Groundwater samples were collected from MW009, MW010, and MW014 (Fig. 4.1). Samples collected in July were analyzed for VOAs, TPHCs, HSL metals, and major cations/anions. Samples collected in September/October were analyzed for VOAs and TPHCs. TPHCs were found (1100 $\mu\text{g}/\text{L}$) in MW009 as well as benzene (26 $\mu\text{g}/\text{L}$), ethylbenzene (20 $\mu\text{g}/\text{L}$), toluene (10 $\mu\text{g}/\text{L}$), and xylene (39 $\mu\text{g}/\text{L}$).

During drilling in both MW010 and MW014, a fuel odor was noticed at about 6 ft. The soil sample collected at 6 ft in MW014 contained 3.0 $\mu\text{g}/\text{kg}$ toluene (estimated value below the reporting level), but soil in MW010 contained no detectable contamination. Groundwater samples from both wells (July) contained no detectable contamination. The groundwater level in both wells in July was about 4 ft below ground--2 ft above the jet fuel odor; therefore, the groundwater would have leached any contaminants held at 6 ft.

To be certain that no slight groundwater contamination was being missed, two groundwater samples were collected from MW010 and MW014 during September/October -- one sample prior to purging the well and one sample after purging the well. Neither of the samples from the two monitoring wells contained detectable contamination. Therefore, if the soil at 6 ft is contaminated in these two monitoring wells, it must be at levels below the detection limits for soil samples and the contamination is not leaching into the groundwater.

No significant levels of metals or major cations/anions were discovered. Significant analytical results are provided in Appendix E.

4.4.4 Surface Water and Sediments

No surface water or sediment samples were collected at Site 5.

4.4.5 Air

Routine air monitoring during drilling was performed with an HNU model PI-101 PID. No anomalous readings were obtained while monitoring ambient air, indicating that even though organic compounds are present in the subsurface, volatilization to the atmosphere is insignificant.

4.5 CONTAMINANT FATE AND TRANSPORT

The contamination found in the soil and groundwater at Site 5 results from spills or leaks of JP-4. The absence of chlorinated solvents and other non-fuel related compounds has been established by analyses of both soil and groundwater.

4.5.1 Contaminant Persistence

A discussion on the persistence of JP-4 derived contaminants is presented in Sect. 3.5.1.

4.5.2 Potential Routes of Migration

The potential route of exposure to a receptor from contamination at Site 5 is leaching to the nearby drainage ditch and creek. MW009, MW010, and MW014 were installed at this site. MW010 and MW014 are downgradient of the area; MW010 is uncontaminated and MW014 contains estimated levels of toluene below laboratory reporting levels. MW009 is located in the source area and is contaminated. SW005, installed in a previous program (Weston 1985), may have been installed in the trench at the intersection of the storm sewer and the fuel distribution line. This would explain why SW005 has contained floating product while the ORNL wells do not. In addition, the Weston soil boring B3 was drilled into a trench near the intersection of two fuel distribution lines. Thus, the possibility that significant quantities of fuel have collected in the backfill cannot be discounted.

Field measurements demonstrated that there are no detectable hydrocarbon emissions from the site. Soil sampling from the monitoring wells demonstrated that the contamination is covered by several feet of soil. Thus, unless the area were excavated, there is no significant air exposure.

4.5.3 Contaminant Migration

The clay soils at this site severely inhibit the migration of the spilled fuel. The spilled fuel is present in the subsurface and in trench backfill; there is no evidence that a contaminant plume is migrating from the area.

See Sect. 3.5.3 for additional details.

4.6 BASELINE RISK ASSESSMENT

This section describes the public health and environmental concerns resulting from Site 5. Contaminants identified at this site are TPHCs--which were found in the soil (26,000 ug/kg) and in the water (0.2 ft of floating product, 13,000 ug/L).

The risk assessment for the base, including details of exposure pathways, exposure scenarios, toxicity of chemicals, and risk characterization is presented in Appendix J.

The following evaluation of potentially contaminated media demonstrates that there is presently no exposure to the public from contamination at Site 5.

4.6.1 Exposure Assessment

4.6.1.1 Air

Air emissions were evaluated with a hand-held survey meter at ground level. The data showed that there were no emissions from the site; however, soil-gas measurements did demonstrate that anomalous concentrations of TPHCs were present in the subsurface. The concentrations were so low that any transport to the surface would be minute and quickly diluted such that exposure to the public or even military personnel using the site would be insignificant.

4.6.1.2 Groundwater

The groundwater associated with this site contains traces of TPHCs (up to 1100 $\mu\text{g/L}$). Priority pollutant volatile compounds detected were benzene (26 $\mu\text{g/L}$), ethylbenzene (20 $\mu\text{g/L}$), toluene (10 $\mu\text{g/L}$), and xylene (39 $\mu\text{g/L}$). There are, however, no residences or groundwater wells between the contaminated location and likely discharge points to the storm drainage system. The tight clay soil, discontinuities in the alluvial aquifer, and the controlled access to this site make eventual use of the groundwater unlikely.

The levels of TPHCs (floating product) found in the Weston well SW005 would make the groundwater unfit for use. This fuel appears to be confined to the backfill within the trench since other wells within the site do not produce the floating product.

4.6.1.3 Surface Water

Contaminants leaching from Site 5 presumably could migrate in the trench backfill to the storm drainage system. The storm sewers were backfilled with native clay soil which will inhibit contaminant migration, although not as much as undisturbed soil would inhibit migration.

4.6.1.4 Soil

Soil samples at Site 5 contained moderate levels of TPHCs (26,000 $\mu\text{g/kg}$) at a depth of 6 ft. The presence of floating product in a nearby well indicates that fuel is contained within the backfill of trenches. This indicates that exposure to fuel derived hydrocarbons would result if the area were excavated. No exposure to humans or the environment would occur with present usage of the site.

4.6.2 Risk Evaluation

Risks presented by contamination in the unconsolidated sediments and groundwater at Site 5, pumphouse E, were evaluated using the construction worker and resident scenarios (Appendix J). Construction workers could be exposed to four of the contaminants of concern (benzene, ethylbenzene, toluene, and xylene) via inhalation or dermal absorption of contaminants in either groundwater or subsurface soils. Estimation of possible exposures via volatilization from groundwater assumes that 100% of the concentrations found in groundwater will volatilize and be inhaled by the receptors. Estimation of dermal absorption exposures assumes a 100% absorption across the skin barrier.

Evaluation of construction worker exposures to contaminated groundwater and subsurface soil indicates a negligible probability of carcinogenic effects resulting from either inhalation or dermal absorption of benzene. In addition, the hazard indices for these exposure routes are well below levels of concern.

Calculation of the hazard index for the resident scenario is well below the acceptable level and indicates no potential for noncarcinogenic effects. However, estimation of carcinogenic risks to off-base residents from exposure to contaminated groundwater does indicate an excess cancer risk (2.6×10^{-4}). This risk is only slightly outside the range of acceptability. This scenario assumes that resident exposure in groundwater equals the concentrations currently measured on the site; actual exposures and, thus, actual risks (should off-base wells be identified) would be even lower. The combined influence of regional hydrogeology, the low hydraulic conductivity, the discontinuous nature of the water table aquifer, the significant effect of dilution on the concentration, and the distance to receptors makes the actual probability of exposure minimal.

The conservative assumptions used (in conjunction with the effects expected from distance, dilution, and dispersion) make it most likely that any actual risks would be significantly lower, and, consequently, well within acceptable levels.

The only potential risk is exposure of workers to air contaminants or possible explosion hazards if the trench backfill were excavated. The explosion hazard results from the possibility of relatively high concentrations of fuel vapors or possible free product in a confined space (trench).

4.7 SUMMARY AND CONCLUSION

4.7.1 Summary

The contamination discovered at Site 5, pumphouse E, is from jet fuel. The highest levels of contamination are in the soils at a depth of 6 ft. The fuel appears to be tightly held by the soil as shown by the relative lack of contamination in the groundwater. Further indication of this containment comes from MW010, which was drilled only 30 ft downgradient of the Weston boring B3. Soil at 5 to 8 ft in B3 contained 50,000 $\mu\text{g}/\text{kg}$ of oil and grease; groundwater in MW010 was clean.

Fuel in the trench backfill at SW005 is obviously a concern; however, the tight clay soils appear to confine the contamination to the trench. Exposure hazard from the contamination is limited to excavation activities in the area.

4.7.2 Conclusions

Jet fuel is present in the soil and groundwater near pumphouse E; however, the potential for migration is slight. Even if the contamination migrated to its likely discharge point, the drainage ditch, there are no receptors within the pathway to the ditch. Any excavation near the trenches could result in exposure to workers or possible explosion hazards.

The preferred alternative is no action with continued restricted access to the site.

5. SITE 6, SURFACE DRAINAGE DITCH AND STORM SEWER OUTFLOW

5.1 SITE BACKGROUND

The surface drainage ditch and storm sewer outflow was included in the IRP study based on a recommendation from the Phase I records search (HMTc 1986). HMTc calculated a HARM score of 57 for this site.

5.1.1 Site Description

Site 6 consists of the unnamed tributary of the South Branch of Shunganunga Creek, which flows through the northwest side of the base, and all of its tributaries, including the base storm sewer system (Plate 1, Fig. 5.1). This unnamed tributary is also referred to as the "drainage ditch." One tributary drains the fuel tank farm (Site 1); another drains the area southwest of the hangars and the Shawnee County Waste Repair Facility. (The Shawnee County Waste Repair Facility repairs large trucks - primarily garbage trucks. It occupies a building southwest of hangar 666, approximately 50 ft from the base boundary. Prior to closure of the Air Force Base, the building was a jet engine repair shop.)

The open drainage ditch is lined by vegetation and lies approximately 6 ft below the bank level at MW001 (Fig. 5.1). It cuts to approximately 15 ft below the east bank horizon at the north base boundary near MW022 and MW025. The ground there has been recently disturbed by heavy equipment dozing the dirt and banks.

Storm runoff enters the ditch through a system of storm sewers and by direct surface runoff. Most of the base, including all of the aircraft parking ramps, hangars, and roads, drains through the storm sewers. The storm sewers drain into the ditch at three major locations. The largest of these is the outflow at the northwest corner of the base; this storm sewer drains all of the aircraft parking ramp and most of the parking lots and roads near the ramp. The outflow is a 6 ft square concrete culvert which empties into a

small basin at the northwest corner of the base. This basin is a depression in the ditch with an average depth of 1 ft and a total surface area of about 3000 ft². The basin is created by a small dam which increases the stream gradient approximately two feet. This basin is called "the pond."

A small portion of undeveloped land on the north side of the base drains off-base to the north and eventually contributes to the drainage ditch several hundred yards downstream of the base.

The tributary draining the tank farm includes a borrow ditch adjacent to the truck unloading hydrants and drainage ditches from the road leading into the base. Along the west base boundary, the ditch also drains runoff from an elementary school and several houses in Pauline. Near the small pond at the northwest corner of the base, the ditch approaches within about 200 ft of U.S. Highway 75; therefore, the ditch collects some runoff from the highway.

5.1.2 Site History

The drainage ditch exists in the 1954 aerial photograph which dates it prior to the build-up of the present ANGB. There was, however, a large man-made pond between the tank farm and the present day pond. This old pond was about 600 ft long and 50 to 100 ft wide, and was probably used for livestock and/or irrigation. In the 1959 aerial photograph, the dam and pond are gone and the ditch appears to follow its present course through the base.

According to personnel interviews in the Phase I records search, an oily sheen has been observed in the ditch and on the pond on several occasions. This is to be expected since the ditch drains the area adjacent to the truck unloading hydrants, several roads, and the aircraft parking ramp. Minor spills of any POL would likely show up as an oily sheen in the ditch.

On at least one occasion, however, fuel flowed into the storm sewer system and into the ditch. During pressurization of the fuel lateral at Site 9 to locate a leak (Sect. 8), an unknown quantity of fuel was observed flowing into a storm sewer catch basin at the northwest corner of the base (probably north of building 679).

Aerial photographs from 1954 to 1982 show that the ditch has occasionally been cleared of heavy vegetation. Clearing the brush and trees tends to increase the velocity of the surface water flow and erosion for a period of time, thus deepening the ditch and its contact with the alluvial aquifer and lowering the water table in close proximity to the ditch.

5.1.3 Previous Investigations

Weston (1985) inspected and surveyed 24 storm sewer manholes on and adjacent to the refueling ramp. The survey consisted of visual observations and measurements with an OVA and an HNU PID. No organic vapors were detected but a slight oily sheen was seen floating on the surface in a manhole located northeast of building 665 (Fig. 1.3).

In addition, Weston collected four water samples from manholes at the southwest end of fuel laterals 4, 6, 7, and 8. They allowed the samples to come to room temperature, then analyzed the headspace gases with an OVA and HNU. The sample collected at lateral 8 revealed 15 ppm of volatile organic vapors in air on the HNU. The remaining samples showed no detectable organic vapors.

In 1985, the base bio-environmental engineering technician sampled the surface water in the pond. Small amounts of oil and grease (300 $\mu\text{g/L}$) and an elevated level of manganese (406 $\mu\text{g/L}$) were detected.

ORNL/CAT personnel inspecting the drainage ditch on the east side of the tank farm noticed one discolored spot in the bottom of the ditch. The spot was about 20 ft long and was characterized by vegetative stress. The soil had a distinct fuel odor when crushed. Other much smaller spots were also noticed in and around the ditch.

ORNL/CAT personnel inspected the covered concrete pits where the fuel distribution lines tie into the fuel laterals under the ramp. Several of the pits contained standing water which appeared to have a floating film of JP-4. All pits, including the dry ones, smelled strongly of JP-4. These investigations took place in May 1988. During subsequent field investigations in June and July, the pits were again inspected. No standing water or JP-4 was discovered; however, the JP-4 odor remained.

The only other investigation was during the Phase I Records Search. This consisted of interviewing base personnel, reviewing documents, and visiting the site.

5.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

5.2.1 Surface Water Hydrology

The drainage ditch receives the bulk of the surface runoff occurring on the base. The ditch eventually drains into the South Branch of Shunganunga Creek. Surface runoff occurs predominantly as sheet flow, due to the relatively flat topography, and discharges directly to the ditch or through the storm sewer to the ditch.

Any large spill on the base would be drained by the storm sewer and/or the ditch; no mechanism exists to prevent the flow of water and contaminants off-base. As a result, any on-site contamination transported by the surface water will be discharged to the drainage ditch and eventually to the creek.

General surface water hydrology information for Forbes Field ANGB is discussed in Sect. 2.2.3.

5.2.2 Geology

Site 6 rests on unconsolidated sediments deposited during the Kansan Glaciation. Beneath these sediments lies a thin zone of weathered bedrock and then competent bedrock of the Howard Limestone and Severy Shale. A complete description of the base geology is presented in Section 2.2.4.

5.2.3 Soils

Ladysmith (Ld), 0 to 1% slope, soils represent the southern, upstream areas of the Site 6 drainage ditch including most of the tank farm. Ladysmith (Lm), 1 to 3% slope, soils include the center length of the ditch and the southern most portion of the tank farm. Where the ditch exits the base, including the pond area, Pawnee (Pc), 3 to 7% slope, soils occur. (USDA 1970). General soil information for the base is discussed in Sect. 2.2.5 and Table 2.7.

5.2.4 Hydrogeology

The unnamed tributary to the South Branch of Shunganunga Creek is the discharge area for the unconsolidated aquifer underlying the base. Water levels along the ditch generally range only a few feet beneath the land surface. In other words, the majority of the unconsolidated aquifer in the drainage ditch area is saturated. This is due in part to the discharge of water from the Nodaway Coal directly upgradient from the area and the fact that the drainage ditch is located in a topographic low. The relict structure of the Nodaway Coal in the weathered bedrock portion of the unconsolidated aquifer is prevalent in this area.

A complete description of the Forbes Field ANGB hydrogeology is presented in Sect. 2.2.6. Groundwater flow direction and rates for the area are discussed in Sect. 5.3.6.

5.2.5 Demographics and Land Use

The drainage ditch lies at the west side of the base and includes the stream and its banks. After exiting the base, the stream enters an area of heavy growth and travels through several areas of agricultural, industrial, and commercial lands as it joins with major streams and eventually the Kansas River.

The stream travels within 100 ft of several private residences and within about 200 ft of U.S. Highway 75 on the west base boundary prior to exiting the base. Runoff from these residences and the highway also contribute to the ditch.

The drainage ditch, except for about 600 ft of the downstream portion, is within the secured and patrolled area of the base.

General demographics and land use for the base and Shawnee County are discussed in Sect. 2.2.11.

5.2.6 Ecology

The site is covered with indigenous grasses, brush, cattails, and other plants. Within about 20 ft of the ditch, natural grasses, shrubs, and other plants are allowed to grow. Small native animals, such as frogs, turtles, snakes, birds, and crayfish, live in and near the site. General ecology of the base is discussed in Sect. 2.2.12.

5.3 STUDY AREA INVESTIGATION

5.3.1 Surface Features

Field activities at Site 6 involved surveying to accurately map the course of the ditch through the base and to locate soil-gas sample points, monitoring well locations, and elevations. A general description of the surface features is presented in Sect. 2.2.1.

5.3.2 Contaminant Source Investigations

The contaminant source investigation at Site 6 included a review of the Phase I records search, interviews with base personnel, and inspection of aerial photographs.

The sources of contamination are spills or leaks which flowed into the storm sewers or directly into the ditch, and, potentially, infiltration of contaminated groundwater from the alluvial aquifer.

5.3.3 Surface Water and Sediment Investigations

5.3.3.1 Surface Water

Six surface water samples were collected during low-flow or natural conditions. These samples were presumed to be representative of the groundwater discharge. Three surface water samples were planned for collection during high-flow or storm event conditions; unfortunately, the severe drought in northeastern Kansas during 1988 precluded collection.

Three low-flow samples were collected in September 1988 at points WS001, WS002, and WS003 (Fig. 5.1). Analyses revealed a small amount of chlorinated solvent (15 $\mu\text{g/L}$ 1,2-DCE) at WS001; therefore, three additional low-flow surface water samples were collected in November 1988. These samples, collected at points WS001, WS004, and WS005 (Fig. 5.1), were taken to verify the results of the original WS001 sample. The three check samples also contained chlorinated solvents (up to 46 $\mu\text{g/L}$ 1,2-DCE). Sample WS004 was collected at the first location where water was visible, i.e., where the storm sewers from the south end of the base and other off-base industrial areas

empty into the ditch. Low-flow condition was estimated to be 0.25 to 0.5 gal/min and is the result of groundwater infiltrating the storm sewer. Sample WS005 was collected about midway between WS001 and WS002. The September samples were analyzed for VOAs, TPHCs, semi-volatiles, and PCBs/pesticides. The November samples were analyzed for VOAs and TPHCs. Results of these samples are discussed in Sect. 5.4.4.

5.3.3.2 Sediment

Sixteen sediment samples were collected from the ditch and pond. Sampling locations are shown on Fig. 5.1. Two samples, SD002 and SD003, were taken at the "headwaters" of the two main tributaries in order to assess background levels of chemicals in the soil. Eight samples were collected near junctions with feeder ditches or storm sewers to identify contaminated tributaries. Samples SD011 and SD012 were taken downstream from the base property before the tributary's confluence with the South Branch of Shunganunga Creek. Sampling locations SD011 and SD012 are shown on Fig. 5.2. The remaining samples were collected along the tank farm drainage inside the base property. Samples SD001 through SD012 were collected in June 1988. Samples SD013 through SD016 were collected in October 1988 following discovery of fuel compounds in sample SD001. The sediments were analyzed for VOAs, TPHCs, semi-volatiles, PCBs/pesticides, and metals.

5.3.4 Geological Investigation

Surface lithology information for the drainage ditch area was obtained from drilling MW001, MW002, MW022, and MW025 and by drilling CH002 to 75 ft. The well summary forms with well construction and lithologic descriptions are attached in Appendix G. Findings from the corehole drilling are described in Sect. 2.2.4, bedrock geology.

The surface lithology is unstratified glacial sediments consisting of silty clays in varying shades of gray and brown, with some black soils near the surface. The clays are generally very plastic, fat, and homogenous, with some limonite-stained zones attributed to leaching processes. The sediments range from 10 ft in the area of MW001 and MW002 to 5.5 ft in wells MW022 and MW025. Occasional sand and silt stringers are more common with depth. In MW001, a clayey gravel was encountered consisting of a fossiliferous angular limestone in a yellowish-brown clay matrix overlying a 2 in. layer of coarse

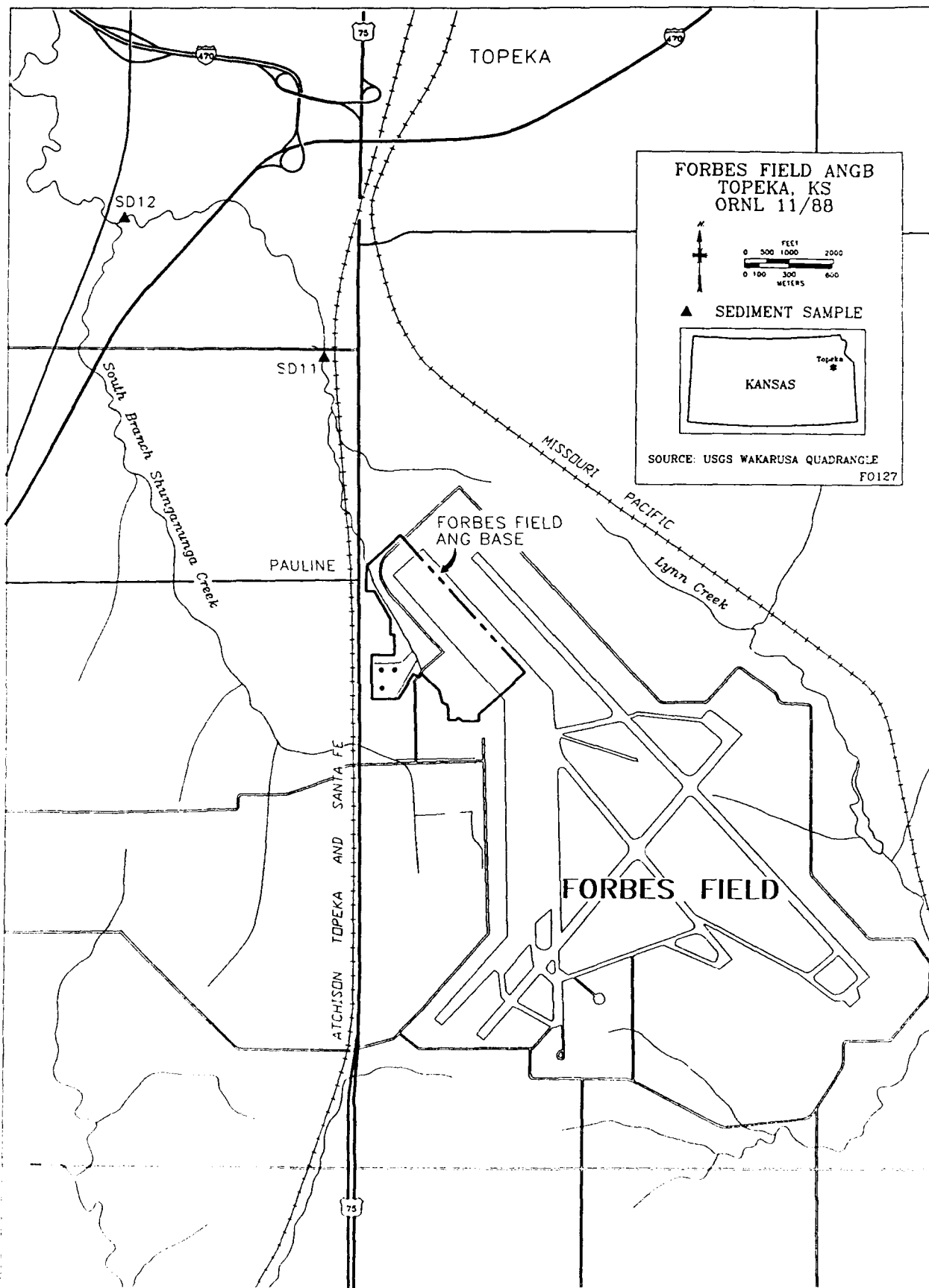


Fig. 5.2. Location of downstream sediment samples.

sand. These erratics were likely deposited by a glaciofluvial stream following the drainage pattern still evident today. Moisture was encountered in the sediments at a depth of 8 ft in MW001 and MW002; the sediments were dry in MW022 and MW025.

The bedrock lithology encountered in these boreholes consists of an upper 2 ft of very weathered yellow-brown claystone with abundant soft gray clay and carbonaceous laminations. Underneath is a continuous, very soft, greasy (sub-bituminous) coal seam, interbedded with numerous gray and yellow-brown claystones up to 1.5 ft thick. This is followed by 2 ft of yellow-brown claystone, laminated with coal streaks and dark red shale partings. In MW002, a thin lens of poorly sorted, angular sand was observed resting on a basal gray micaceous and fossiliferous mudstone. However, in MW025, another thin coal seam was found lying on the same basal gray mudstone. In all of the monitoring wells, the weathered bedrock was wet. The weathered bedrock is the lower portion of the Howard Limestone.

5.3.5 Vadose Zone and Soil Investigations

5.3.5.1 Vadose Zone

Seven soil-gas and water samples were collected to help characterize the drainage ditch and storm sewer system (Fig. 5.1). All of the samples were collected in the backfill surrounding the storm sewers. Samples were taken by pushing the drive point to a depth consistent with the storm sewer, then raising the probe 6 in. At sample location SG11, the backfill was moist and a water sample was collected and analyzed using the soil-gas system. Sample SG11 was collected by allowing water to seep into the soil-gas probe hole and collecting the water with a stainless steel bailer.

Samples SG11 and SG12 were collected under the aircraft parking ramp between fuel laterals 7 and 8, just upstream of the confluence of two storm sewers under the ramp. Samples SG8, SG9, SG27, SG121, and SG25 were collected continuously downstream in the storm sewer backfill, terminating above the storm sewer outflow. Results are discussed in Sect. 5.4.2.

Section 2.1.2.2 provides details on soil-gas collection methods.

5.3.5.2 Soils

Soil samples were taken with a 5-ft continuous sampler during the drilling of MW001, MW002, and MW022. Samples were inspected visually for contamination and monitored along their length with an HNU PID. If elevated readings were noted, a grab sample was taken. Otherwise, samples for chemical analysis were collected every 3 ft until the water table was reached. Soil samples were not collected from CH001 and CH002. Soil samples from Site 6 were analyzed for VOAs and TPHCs. Analytical results are discussed in Sect. 5.4.2.

5.3.6 Groundwater Investigation

Four monitoring wells were installed in the area to determine the lithology, hydraulic conductivity, depth to water, groundwater flow directions, and the presence of contamination in the groundwater. Potentiometric maps, based on water-level measurements taken in July and September 1988, are shown in Fig. 2.13. These maps indicate a general groundwater flow direction to the northwest, toward the tributary to Shunganunga Creek (Site 6). In other words, this tributary to Shunganunga Creek is a discharge point for most of the groundwater underlying the base.

Based on the groundwater flow direction, MW001, MW002, MW022, and MW025, are located downgradient from potential sources of contamination. To intercept contamination from Site 1, the tank farm, MW001 was installed downstream of the confluence of the tributary from the tank farm and the ditch. MW002 was installed east of the ditch, downgradient from the sites near the aircraft parking ramp. MW022 and MW025, located at the northwest corner of the base, intercept contamination in the alluvial groundwater associated with the ditch. Therefore, any widespread contamination which has traveled a significant distance and poses a threat for off-site exposure should be detected in these wells.

Bail tests were performed on MW001, MW002, and MW022 to measure the permeability of the unconsolidated aquifer in the area. For tests performed on MW002, the permeability was insufficient to yield reliable results. MW001 and MW022 show permeability values of 2.1×10^{-4} cm/s (0.62 ft/d) and 1.2×10^{-4} cm/s (0.34 ft/d), respectively. The values indicate some discontinuity in the aquifer permeability.

A pumping test was performed on MW025 using MW022 as an observation well.

A discussion of the base hydrogeology and results of the aquifer tests are presented in Sect. 2.2.6.

5.4 NATURE AND EXTENT OF CONTAMINATION

5.4.1 Sources

The source of contamination in the ditch is a combination of the spills in the tank farm area; the fuel-line leaks which contaminated the storm sewer system, road dust, and other combustion source deposits washed in from the base and U.S. Highway 75; and pesticides washed into the ditch from local spraying. Groundwater from the base discharges to the drainage ditch; however, no contamination has been found in groundwater near the ditch.

No source has been identified for the chlorinated hydrocarbons in the upstream surface water samples (Sect. 5.4.4). A possible source includes the spillage of a solvent in a storm drain, either on the base or in the industrial area off-base.

5.4.2 Vadose Zone and Soils

5.4.2.1 Vadose Zone

A water sample collected from the storm sewer backfill between laterals 7 and 8 (SG11) contained 516 $\mu\text{g/L}$ TPHCs. This sample was collected and analyzed using the soil-gas equipment (Sect. 5.3.5.1). A possible explanation for the presence of JP-4 at this location is the high concentrations of TPHCs found in fuel laterals 1 through 7: up to 169,000 $\mu\text{g/L}$ of TPHCs were found in lateral 3. Past fuel leaks in the lateral lines have probably migrated through the backfill material beside the storm drain. The storm drain runs perpendicular to the laterals from southeast to northwest (Plate 1). A soil-gas sample taken downstream from the next storm drain confluence had only background levels of TPHCs. None of the remaining soil-gas samples collected in the study of the drainage system contained elevated levels of TPHCs.

Analytical results of the soil-gas survey are presented in Appendix D.

5.4.2.2 Soils

Soil samples from MW001, MW002, and MW022 were analyzed for VOAs and TPHCs. No contamination was detected in any of the samples.

A thin layer (about 1 ft) of sub-bituminous coal (the Nodaway Coal) was encountered at 7.5 ft in MW022. A grab sample of this coal layer was submitted for oil and grease analysis; it revealed 360,000 $\mu\text{g}/\text{kg}$. This coal seam possibly contributed to the oil and grease findings in the Weston study (1985). Analytical results of the soil samples showed no detectable TPHCs or VOAs. Significant analytical results are provided in Appendix E.

5.4.3 Groundwater

Groundwater samples were collected from MW001, MW002, and MW025 (Fig. 5.1). Samples collected in July were analyzed for VOAs, TPHCs, HSL metals, and major cations/anions. In addition, groundwater samples from MW001 and MW025 were analyzed for HSL pesticides, PCBs, and semi-volatiles. Samples collected in September/October were analyzed for VOAs and TPHCs. None of the samples contained detectable quantities of contamination. Significant analytical results are provided in Appendix E.

5.4.4 Surface Water and Sediments

5.4.4.1 Surface Water

In September 1988, the low-flow surface water sample collected at WS001 (Fig. 5.1) contained a total of 15 $\mu\text{g}/\text{L}$ of 1,2-dichloroethene; no other compounds were detected in WS001. No contamination was detected in WS002 and WS003.

Samples collected in November 1988 revealed chlorinated hydrocarbons in the samples from WS001 [31 $\mu\text{g}/\text{L}$ of 1,2-dichloroethene (total), 9 $\mu\text{g}/\text{L}$ of chlorobenzene, and 4 $\mu\text{g}/\text{L}$ vinyl chloride] and WS004 [46 $\mu\text{g}/\text{L}$ of 1,2-dichloroethene (total), 5 $\mu\text{g}/\text{L}$ of trichloroethene, and 7 $\mu\text{g}/\text{L}$ vinyl chloride]. The vinyl chloride levels in samples WS001 and WS004 were estimated values below the laboratory reporting levels. The sample collected at WS005 contained no detectable contamination. Significant analytical results are provided in Appendix E.

5.4.4.2 Sediments

Sediments were collected from sixteen places in the drainage ditch system (Fig. 5.1 and 5.2). Significant findings in the sediment samples are provided in Table 5.1. Samples SD002 and SD003 are background samples. The 9 $\mu\text{g/kg}$ of toluene detected in SD002 and 26 $\mu\text{g/kg}$ of toluene in SD003 is from an unknown source. Samples SD005, SD006, SD007, SD011, SD012, SD014, and SD015 contained no detectable contamination. Sample SD013 contained 184 mg/kg of lead; all other levels of metals were normal. Sample SD004 contained 2.0 $\mu\text{g/kg}$ of vinyl chloride and 6.0 $\mu\text{g/L}$ of 1,1-dichloroethane, both were estimated values below the laboratory reporting level; neither contaminant was detected in any other sediment sample.

Only samples SD001, SD002, SD003, SD004, and SD010 contained fuel related compounds (Table 5.1); SD008, SD009, SD010, and SD016 contained polynuclear aromatic compounds; SD009 contained detectable pesticides.

Significant analytical results are provided in Appendix E.

5.4.5 Air

Routine air monitoring during drilling was performed with an HNU model PI-101 PID. No anomalous readings were obtained while monitoring ambient air, indicating that even though organic compounds are present in the subsurface, volatilization to the atmosphere is insignificant.

5.5 CONTAMINANT FATE AND TRANSPORT

Contamination found at this site results from spills or leaks of jet fuel and roadwash from the base and the surrounding residences and highways.

5.5.1 Contaminant Persistence

The biodegradation of JP-4 has been discussed in a previous section (Sect. 3.5.1). A review of pertinent literature indicates that biodegradation in surface streams would be more rapid than in groundwater. For example, studies by Ward (1985) showed that the indigenous microflora in the subsurface have lower activities than those in the surface, although both can effectively mineralize organic contaminants. As an example, Vaishnav and Babeu (1987)

Table 5.1. Significant findings from sediment samples

Sample number	Analyte	Concentration ($\mu\text{g/kg}$)
SD001	Xylene (total)	14,000
	TPHCs	120,000
SD002	Toluene	9.0
SD003	Toluene	26.0
SD004	TPHCs	11,000
	Vinyl chloride	2.0
	1,1-dichloroethane	6.0
SD008	Phenanthrene	23,000
	Anthracene	2,600
	Flouranthene	47,000
	Pyrene	41,000
	Benzo(a)anthracene	23,000
	Chrysene	20,000
	Benzo(b)fluoranthene	23,000
	Benzo(k)fluoranthene	17,000
	Benzo(a)pyrene	12,000
	Indeno(1,2,3-cd)pyrene	12,000
	Benzo(g,h,i)perylene	19,000
SD009	Phenanthrene	2,300
	Fluoranthene	3,400
	Pyrene	3,100
	Dieldrin	47
	4,4'-DDE	30
	4,4'-DDT	65
SD010	Pyrene	3,000
	Fluoranthene	3,400
	TPHCs	6,000
SD013	Lead	184,000
SD016	Fluoranthene	1,300
	Pyrene	1,100

showed that the rate constant for biodegradation of benzene in river water is nearly double that in groundwater systems. Similar results were found for all of the compounds studied by these authors.

Pesticides and polynuclear aromatics are not as biodegradable as JP-4 components. Again, this generalization must be viewed with caution because the polynuclear aromatics, at least, are biotransformed. For example, Giesy et al. (1983) studied the uptake of benzo (a) pyrene and anthracene by biota and found that under certain conditions uptake was significant. Likewise, Tabak et al. (1981) studied the biodegradation of benzene, toluene, ethylbenzene, and several polynuclear aromatics. They found that all of the compounds degraded. These authors also studied a host of pesticides and found no biodegradation under their laboratory conditions. On the other hand, Richards and Shieh (1986), in a review of literature, concluded that polynuclear aromatic compounds were as persistent as pesticides, but agreed that benzene and its derivatives were much more easily transformed.

In the absence of additional site-specific data, more generalizations are not possible. Indeed, if the contaminated sediments are from rather old spills, the literature would lead one to expect that biodegradation would already be complete. Thus, the continued presence of contaminants in the ditch may indicate that either physical transfer of nutrients and microorganisms to the substrate is inhibited by clay particles or there may be fresh sources for the contaminants.

5.5.2 Potential Routes of Migration

The potential route of exposure to a receptor from contamination at Site 6 is transport of contaminated sediment. Hence, a series of sediment samples was collected to determine if transport was occurring (Fig. 5.1). Sediment sample SD001, collected in the ditch adjacent to the truck unloading hydrants, contained 120,000 ug/kg of TPHCs and 14,000 ug/kg of xylenes. Sample SD004, which was collected in the main ditch upstream of the tributary that contains SD001, contained 11,000 ug/kg of TPHCs, but no xylenes. Two more sediment samples were collected in the main ditch between the contaminated samples and the small pond (SD006 and SD007). Both of these samples contained no detectable contamination--apparently indicating that contaminated sediment has not been transported recently.

Sample SD008, taken from the pond, contained phenanthrene and other polynuclear aromatics. These compounds are typically associated with combustion engines (either internal combustion or jet engines) and are a frequent component of road dust (Verschuieren 1983). Sample SD009, collected downstream of the pond, shows lower quantities of the same contaminants with traces of the pesticides 4,4'-DDE, 4,4'-DDT, and dieldrin. SD010 was collected as a replicate to SD009. Sample SD010 also contained the polynuclear aromatics. Pesticides were not detected, but 6000 ug/kg of TPHCs were found. The replicate samples were collected next to each other, but were not homogenized and subsampled to avoid degassing the volatiles.

Samples SD008, SD009, and SD010 (Fig. 5.1) were collected from the pond and the ditch approximately 100 to 200 ft from U.S. Highway 75. Similarly, the fact that only low amounts of TPHCs were found in one of two replicates suggests that the base is not presently causing off-site contamination. The low concentration of pesticides may be due to local agricultural activities.

Samples SD011 and SD012 (Fig. 5.2) were taken approximately 5500 ft and 11,000 ft downstream of the base, respectively. Neither sample contained detectable contaminants.

The TPHCs found at SD001 prompted the collection of four additional sediment samples from the tributary ditch (SD013 through SD016, Fig. 5.1). SD013 was collected about 30 ft downstream from the discolored spot discussed in Sect. 5.1.3. All of the extra samples contained no detectable contaminants except SD016, which contained fluoranthene (1300 $\mu\text{g/kg}$) and pyrene (1100 $\mu\text{g/kg}$), both of which are polynuclear aromatics. No JP-4 compounds were discovered.

The measurements taken at this site have demonstrated that there are no detectable volatile contaminants over most of the area. Indeed, only xylene, found at SD001, is classed as a volatile. The main streambed is underwater except on very dry occasions, further minimizing the possibility of air emissions. Any volatilization from the stream water itself would also be slight. The xylene in SD001 is apparently tightly held by other organic matter in the sediment or is of recent origin. Otherwise, it would already have been transported from the area.

Three surface water samples collected near the head of the ditch, below the storm sewer outflow, contained chlorinated hydrocarbons. One of these samples was collected in September 1988 and the presence of 15 $\mu\text{g/L}$ of 1,2-dichloroethene in the sample prompted collection of three additional samples. The three additional samples were collected in November 1988 and two

of these samples contained 31 $\mu\text{g/L}$ and 46 $\mu\text{g/L}$ of 1,2-dichloroethene. Chlorobenzene (9 $\mu\text{g/L}$) and trichloroethene (5 $\mu\text{g/L}$) were each detected in one surface water sample. No source has been identified for these compounds and further sampling will be required to determine the location and extent of the source. These chlorinated hydrocarbons are not being transported off-base in detectable quantities, as shown by the samples collected further downstream.

5.5.3 Contaminant Migration

Table 5.2 compares the mobility of the compounds found at this site. The data demonstrate that, except for xylene, the compounds are insoluble in water, very immobile, and very persistent in the environment.

See Sect. 3.5.3 for additional details.

5.6 BASELINE RISK ASSESSMENT

This section describes the public health and environmental concerns resulting from Site 6 -- the surface drainage ditch and storm sewer outflow. Contaminants found at this site are TPHCs (120,000 $\mu\text{g/kg}$), polynuclear aromatic compounds (2600 to 47,000 $\mu\text{g/kg}$, Table 5.1), and pesticides (30 to 65 $\mu\text{g/kg}$, Table 5.1), which were found in the ditch sediments. In addition, chlorinated solvents (up to 46 $\mu\text{g/L}$) were found in the surface water at the site.

The risk assessment for the base, including details of exposure pathways, exposure scenarios, toxicity of chemicals, and risk characterization is presented in Appendix J.

The following evaluation of potentially contaminated media demonstrates that there is little exposure to the public from contamination at Site 6.

5.6.1 Exposure Assessment

5.6.1.1 Air

Air emissions were evaluated with a hand-held survey meter at ground level. The data showed that there were no air emissions associated with the site.

Table 5.2 Comparison of mobility in the environment for contaminants found

Chemical	Water solubility (mg/L)	Vapor pressure (mmHg)	Henry's law constant (atm-m ³ /mol)	Koc (mL/g)	Log Kow	Mobility
Napthalene	3.17E+01	2.30E-01	1.15E-03	1,300	3.44	Low
Flouranthene	2.06E-01	5.00E-06	6.46E-06	38,000	4.90	Very low
Phenanthrene	1.00E+00	6.80E-04	1.59E-04	14,000	4.46	Very low
Pyrene	1.32E-01	2.50E-06	5.04E-6	38,000	4.88	Very low
Benzo(a)anthracene	5.70E-03	2.20E-08	1.16E-06	138,000	5.60	Very low
Benzo(a)pyrene	1.20E-03	5.60E-09	1.55E-06	550,000	6.06	Very low
Benzo(b)flouranthene	1.40E-02	5.00E-07	1.19E-05	55,000	6.06	Very low
Benzo(g,h,i)perylene	7.00E-04	1.03E-10	5.34E-08	1,600,000	6.51	Very low
Benzo(k)flouranthene	4.30E-03	5.10E-07	3.94E-05	550,000	6.60	Very low
Bis (2-ethylhexyl) phthalate	2.85E-01	2.00E-07	3.61E-07	5,900	3.98	
Chrysene	1.80E-03	6.30E-09	1.05E-06	200,000	5.61	Very low
Diabenz(a,h)anthracene	5.00E-04	1.00E-10	7.33E-08	3,300,000	6.80	Very low
Indeno(1,2,3-cd)pyrene	5.30E-04	1.00E-10	6.86E-08	1,600,000	6.50	Very low
cis-1,2-dichloroethene	3.50E+03	2.08E+02	7.58E-03	49	0.70	
trans-1,2-dichloroethene	6.30E+03	3.24E+02	6.56E-03	59	0.48	
Dieldrin	1.95E-01	1.78E-07	4.58E-07	1,700	3.50	
4,4'-DDE	4.00E-02	6.50E-06	6.80E-05	4,400,000	7.00	Very low
4,4'-DDT	5.00E-03	5.50E-06	5.13E-04	243,000	6.19	

Table 5.2. (continued)
EXPLANATION OF DATA PRESENTED IN TABLE

Water Solubility is the maximum concentration of a chemical that dissolves in pure water at a specific temperature and pH. It is a critical property affecting environmental fate and transport. Values for water solubility, in mg/L, are given for a neutral pH and a temperature range of 20 to 30 degrees Celsius

Vapor Pressure is a relative measure of the volatility of a chemical in its pure state and is an important determinant of the rate of vaporization from waste sites.

Henry's Law Constant is another parameter important in evaluating air exposure pathways. Values for Henry's Law Constant (H) were calculated using the following equation:

$$H(\text{atm}\cdot\text{m}^3/\text{mole}) = \frac{\text{vapor pressure (atm)} \times \text{molecular weight (g/mole)}}{\text{water solubility (g/m}^3\text{)}}$$

It has been found that chemicals with Henry's Law Constants $>10^{-3} \text{ atm}\cdot\text{mol}\cdot\text{m}^{-3}$ are amenable to stripping, with removals estimated to be >25%.

Organic Carbon Partition Coefficient (Koc) is a measure of the tendency for organics to be adsorbed by soil and sediment and is expressed as:

$$Koc = \frac{\text{mg chemical adsorbed/kg organic carbon}}{\text{mg chemical dissolved/liter of solution}}$$

The Koc is chemical specific and is largely independent of soil properties.

Octanol-Water Partition Coefficient (Kow) is a measure of how a chemical is distributed at equilibrium between octanol and water. This is an important parameter and is often used in assessment of environmental fate and transport of organic chemicals. Kow values greater than 3 indicate low mobility and values greater than 4 indicate very low mobility. Comparing the Kow values of the chemicals in the tank farm area (3.03-6.80) to trichloroethane (2.47-2.5) shows these compounds are very persistent and relatively immobile.

Source: U.S. Environmental Protection Agency (EPA), October, 1986. Superfund Public Health

Evaluation Manual, Office of Emergency and Remedial Response, EPA/540/1-86/060, U.S. EPA, Washington, D.C.

5.6.1.2 Groundwater

Monitoring wells surrounding Site 6 indicated that groundwater at this site is not contaminated.

5.6.1.3 Surface Water

Surface water samples collected from the ditch during low-flow conditions revealed no TPHCs. Sample WS001, however, contained 15 $\mu\text{g/L}$ of 1,2-dichloroethene (total); this sample was collected in September 1988 near the head of the ditch. Three additional surface water samples were collected in November 1988 to verify these results. The sample WS001 contained 31 $\mu\text{g/L}$ of 1,2-dichloroethene (total), 9 $\mu\text{g/L}$ of chlorobenzene, and 4 $\mu\text{g/L}$ of vinyl chloride. The sample WS004 contained 46 $\mu\text{g/L}$ of 1,2-dichloroethene (total), 5 $\mu\text{g/L}$ of chlorobenzene, and 7 $\mu\text{g/L}$ of vinyl chloride. Sample WS005, however, contained no detectable contaminants. Thus, although contamination is found in the ditch water, it is not detectable once it leaves the base.

A high-energy flood event does have the potential of transporting contaminated sediments from the base, but dilution would quickly render the concentration insignificant.

5.6.1.4 Soil

None of the soil samples collected from the monitoring wells at this site were contaminated.

The TPHCs in the ditch sediments can be transported in the environment. Dilution, however, would quickly render the concentrations insignificant. The low levels of polynuclear aromatics and pesticides found in the small pond are apparently due to road dust or runoff from the aircraft ramp. The pesticides may come from road dust or local agricultural activities. The presence of these compounds would be a concern if they were indicative of a larger or unknown problem. In this case, however, they are probably only indicative of a heavily traveled road in an agricultural and industrial area.

5.6.2 Risk Evaluation

Risks presented by contamination at Site 6 were evaluated using the maintenance worker and off-site child scenarios (Appendix J). Because

conditions at Site 6, the drainage ditch, make current or future exposure most probable during routine maintenance and groundskeeping, only the maintenance worker scenario was used to evaluate risks to on-base workers. Risks to off-base receptors from this site were evaluated using the child scenario since children playing in the creek off-base are the most likely potential receptors. Contaminants of concern are found only in ditch surface water and sediments. No indicator chemicals are found in the groundwater at Site 6, eliminating the need to evaluate exposures to this medium.

Trichloroethene and vinyl chloride are of concern in surface waters. On-base, sediments are contaminated with vinyl chloride and 1,1-dichloroethane.

Maintenance worker contact with ditch surface water involves exposure to two carcinogens: trichloroethene and vinyl chloride. Levels of trichloroethene contained in the surface water are associated with a low excess cancer risk (10^{-6}), which is not regarded as a health concern. Risk estimates associated with dermal absorption of vinyl chloride indicate an increased potential for excess cancer risk (2.3×10^{-3}). However, this scenario assumes 100% absorption, while in actuality vinyl chloride is poorly absorbed by the skin. Also, the very high volatility of vinyl chloride would reduce the actual exposure concentrations. The combined effect of the high volatility and low dermal absorption of vinyl chloride would reduce actual concentrations well below those used in risk calculations. However, the influence of dermal absorption and volatility on vinyl chloride exposure concentration has not been quantitatively determined for humans and thus cannot be included in the calculation of risk.

In addition, vinyl chloride levels decrease in concentration in downstream surface water, based on samples WS001, WS004, and WS005 (vinyl chloride was not detected in WS005). Exposure to the levels of vinyl chloride assumed in the risk calculations is limited to the headwater area of the drainage ditch. Thus, exposure to vinyl chloride may not be occurring at a frequency or intensity that would produce carcinogenic effects in workers who might come in contact with surface water.

The actual risk associated with dermal absorption of vinyl chloride in surface water at Site 6 is less than the estimate for excess cancer risk (2.3×10^{-3}). The exposure scenario applied is mitigated by several factors which greatly reduce the actual risk from exposure to vinyl chloride: the low dermal absorption and high volatility of vinyl chloride, the limited area of contamination, and the excessive exposure duration used in risk calculations.

Evaluation of the maintenance worker scenario for contact with ditch sediments also indicates a low possibility of adverse health effects via inhalation; contact via dermal absorption is not associated with any adverse effects. Inhalation of suspended sediment particles is associated with a slight increase in excess cancer risk (2.1×10^{-4}) from exposure to vinyl chloride. However, these findings must be considered in light of mitigating site conditions. Vinyl chloride (the carcinogenic agent) was detected in only one sediment sample. The absence of vinyl chloride in other sediment samples and its appearance in decreasing concentrations in the surface water reduce the likelihood that workers could contact it at a level and a frequency which would induce adverse effects.

Evaluation of off-base risks posed by Site 6 is limited to the child scenario. This scenario evaluates risks posed by dermal contact with either ditch surface water or sediment. Regardless of the exposure route considered, no adverse carcinogenic or noncarcinogenic effects are associated with children playing in the ditch/creek after it's exit from the base.

5.7 SUMMARY AND CONCLUSION

5.7.1 Summary

Soil-gas samples, collected from the storm sewer trench backfill, indicate that contamination from the other sites has not migrated to the drainage ditch through the trench backfill. Soil and groundwater samples from the monitoring wells also reveal no contamination.

Sediment samples collected from the ditch show fuel compounds; however, these appear to be tightly held in the soil. For example, sample SD001 contained 120,000 $\mu\text{g}/\text{kg}$ of TPHCs, but samples SD013 through SD016, all collected downstream in the same tributary, contained no detectable fuel contamination. Thus, the contamination appears to be the result of small spills and leaks -- not a surface expression of a larger source.

Surface water during normal, low-flow conditions is not transporting fuel contaminants. Chlorinated hydrocarbons were found in surface water samples from locations WS001 and WS004. No source for the chlorinated hydrocarbons has been determined; however, it is unlikely that any of the sites studied in this investigation are the source. Further investigation would be required to determine the source.

5.7.2 Conclusions

Jet fuel, polynuclear aromatics, and pesticides are contained in the drainage ditch sediments. Transport of the contaminated sediments would only occur during a high energy flood event and dilution under those circumstances would render the concentrations insignificant. Groundwater recharging the ditch from under the base is not contaminated.

The preferred alternative is to continue periodic monitoring in accordance with Air National Guard Regulation 19-7, as part of the base's environmental monitoring program. Samples should be collected at least quarterly with analyses to include VOAs, TPHCs, pesticides, and semi-volatiles. After one year, results of these samples should be evaluated and the sampling regime reassessed (i.e., if no pesticides are discovered, there is no need to continue pesticide analysis). All sample collection should be in accordance with applicable EPA guidelines for QA/QC.

6. SITE 7, AREA ADJACENT TO REFUELING HYDRANT, LATERAL 3

6.1 SITE BACKGROUND

The area adjacent to the refueling hydrant, located on lateral 3, was included in the IRP study based on a recommendation from the Phase I records search (HMTc 1986). HMTc calculated a HARM score of 65 for this site. Sites 7, 8, and 9 were grouped together for the HARM rating due to similarities of substances spilled, probable quantities, and relative location.

6.1.1 Site Description

Site 7 consists of the area surrounding the southwestern fuel hydrant on fuel lateral 3 northeast of building 662 (Plate 1, Fig. 6.1). Site 7, as well as 8 and 9, is located on the aircraft parking apron east of the buildings. Here, the flat ramp is drained by grated catchment basins flush with the surface. These are attached to a storm sewer system which drains into the small pond mentioned in Site 6.

The fuel hydrants are located in the aircraft parking ramp; a flush-mounted lid covers the connections. The hydrants allow a direct connection to aircraft for fueling and defueling. The ramp is made up of a 18 to 22 in. concrete pad with a 3.5 in. asphalt overlay; the fuel laterals are buried approximately 3.5 ft under the concrete with a tee connection to each fuel hydrant. Lateral 3 receives fuel from pumphouse E.

6.1.2 Site History

The aircraft parking ramp was constructed between 1954 and 1959, as shown by aerial photographs taken in those years.

An undetermined amount of jet fuel leaked from the fuel hydrant at Site 7 in December 1981. Fuel lateral 3 is still in use.

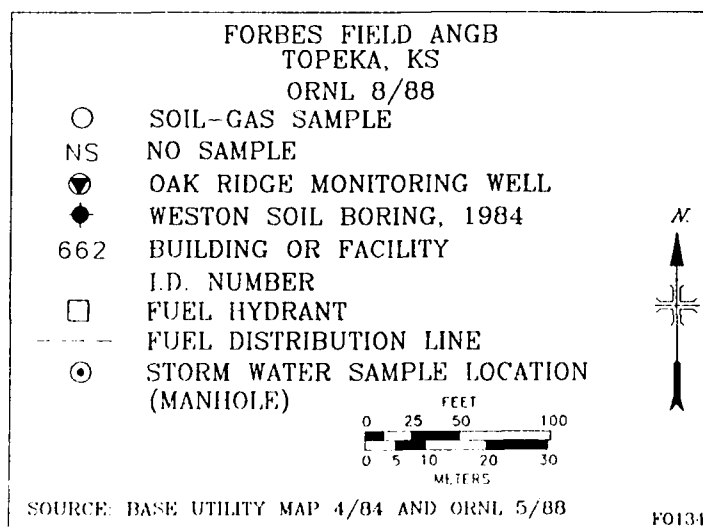
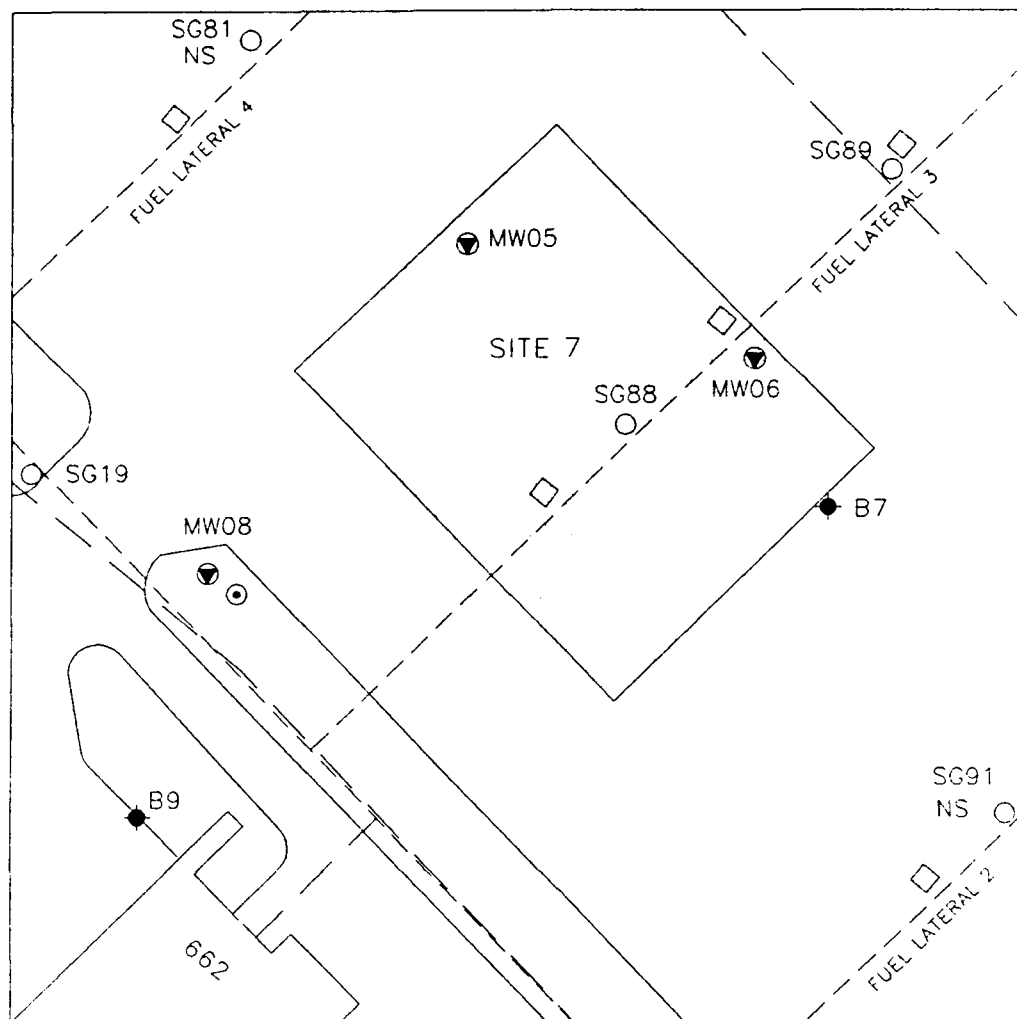


Fig. 6.1. Map of Site 7.

6.1.3 Previous Investigations

Weston (1985) inspected and surveyed storm sewer manholes on and adjacent to the refueling ramp. This consisted of visual observations and measurements with an OVA and an HNU PID. No detectable organic vapors were discovered, but a slight oily sheen was seen floating on the surface in a manhole located northeast of building 665. This is downgradient of Site 7. (Fig. 1.3).

Weston also collected a water sample from the storm sewer manhole at the southwest end of fuel lateral 4 (Fig. 6.1), the next fuel lateral north of Site 7. They allowed the sample to come to room temperature then analyzed the headspace gases with an OVA and HNU. No organic vapors were detected.

Weston drilled two soil borings in the vicinity of Site 7 (Fig. 6.1): one midway between laterals 2 and 3 (B7), and one downgradient and west of MW008 (B9). Weston screened soil samples from the wells with field instruments prior to sending samples for analysis. Boring B7 samples contained no detectable organic vapors; therefore, the sample was not analyzed. The sample from 8 to 12.7 ft in boring B9 contained 25,000 $\mu\text{g/kg}$ of oil and grease; the oil and grease analysis is a screening technique.

The only other investigation was during the Phase I records search. This consisted of interviewing base personnel, reviewing documents, and visiting the site.

6.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

6.2.1 Surface Water Hydrology

Since the area surrounding Site 7 is part of the parking ramp and is paved, all of the precipitation occurring in the area becomes surface runoff. Due to the relatively flat topography, the runoff occurs as sheet flow and is routed through the storm sewer and eventually into the unnamed tributary to the South Branch of Shunganunga Creek (Site 6, Sect. 5).

General surface water hydrology information for the base is discussed in Sect. 2.2.3.

6.2.2 Geology

Site 7 rests on unconsolidated sediments deposited during the Kansan Glaciation. Beneath these sediments lies a thin zone of weathered bedrock and then competent bedrock of the Howard Limestone and Severy Shale. A complete description of the base geology is presented in Section 2.2.4.

6.2.3 Soils

Site 7 soils are Ladysmith (Ld), 0 to 1% slope (USDA 1970). General soil information for the base is discussed in Sect. 2.2.5 and Table 2.7.

6.2.4 Hydrogeology

The only water bearing unit of interest underlying Site 7 is the unconsolidated aquifer in which water is found in the lower portion of the glacial drift or the underlying weathered bedrock. The underlying bedrock consists of impermeable limestones and shales of the Howard Limestone which isolate the lower permeable Nodaway Coal unit.

Water is found only in the lower few feet of the unconsolidated aquifer and is completely absent under portions of the site.

A complete description of the Forbes Field ANGB hydrogeology is presented in Sect. 2.2.6. Groundwater flow directions and rates for the area are discussed in Sect. 6.3.6.

6.2.5 Demographics and Land Use

The large hangar, building 662, is 200 ft southwest of this site; several base personnel work in the hangar. Site 7 is covered with a concrete and asphalt pad used for aircraft parking and fueling. No people reside within about 2500 ft. The site is within the secured and patrolled portion of the base.

General demographics and land use for the base and Shawnee County are discussed in Sect. 2.2.11.

6.2.6 Ecology

No vegetation or wildlife is supported, as this site is covered with a concrete and asphalt pad. General ecology of the base is discussed in Sect. 2.2.12.

6.3 STUDY AREA INVESTIGATION

6.3.1 Surface Features

Field activities at Site 7 involved surveying to accurately map the fuel laterals, hydrants, soil-gas sample points, and monitoring well locations and elevations. A general description of the surface features on the base is presented in Sect. 2.2.1.

6.3.2 Contaminant Source Investigations

The contaminant source investigation at Site 7 included a review of the Phase I records search, interviews with base personnel, and inspection of aerial photographs. The Phase I records search identifies the source of contamination as jet fuel which had leaked from the first fuel hydrant.

6.3.3 Surface Water and Sediment Investigations

Surface water at Site 7 drains into the storm sewer system which then drains into the nearby unnamed tributary (Site 6) to the south branch of Shunganunga Creek. Surface water and sediment investigations for Site 6 are discussed in Sect. 5.

6.3.4 Geological Investigation

The surface lithology information for the fuel lateral 3 area was obtained from borings of MW005, MW006, and MW008. By using a continuous sampler, a complete lithologic record was maintained for each of the boreholes. The well summary form with well construction and lithology descriptions are attached in Appendix G.

The surface lithology is composed of unstratified silty clays ranging from 11 to 13.5 ft, deposited by meltwaters from a receding glacier. These are predominantly gray to very dark gray homogeneous plastic clays with some silt content, mottled with yellow and red-brown limonite stains; slightly organic; and noncalcareous. Moisture content in these clays is very slight and limited to the zone overlying the weathered bedrock.

The upper bedrock in the area consists of a weathered and fissile yellow-brown claystone, which is interbedded with gray shales and carbonaceous stringers. These soft relict beds are cohered by a noncalcareous agent. Moisture content is very slight in MW005 and MW008 and somewhat higher in MW006, where a wet zone at 14.2 ft was encountered.

The weathered bedrock in the area of Site 7 is part of the lower Howard Limestone. The underlying bedrock consists of the impermeable limestones and shales of the lower Howard Limestone.

6.3.5 Vadose Zone and Soil Investigations

6.3.5.1 Vadose Zone

Soil-gas and water samples were collected from beneath the refueling apron along laterals 1 through 12 and lateral 20 (Plate 1). The samples were collected by drilling a 1.5 in. hole through the concrete, then driving the probe to a depth of about 3.5 ft. The fuel lateral distribution lines branch from the main trunkline every 300 ft, running about 3.5 ft beneath the surface of the apron. The lateral lines are bedded in a coarse sand which fills the trench to the undersurface of the apron. All the trenches contained water; some had water standing to the undersurface of the concrete.

Three samples were collected from the trench backfill of fuel lateral 3, as shown on Fig. 6.1 and Plate 1. Samples SG88, SG89, and SG90 were collected from the southwest, center, and northeast end of the lateral, respectively. Results are discussed in Sect. 6.4.2.

Section 2.1.2.2 provides details on soil-gas collection methods.

6.3.5.2 Soils

Soil samples were collected with a 5-ft continuous sampler during the drilling of MW005, MW006, and MW008. Samples were inspected visually for contamination and monitored along their length with an HNU PID. If elevated

readings were noted, a grab sample was taken. Otherwise, samples for chemical analysis were collected every 3 ft until the water table was reached. Soil samples from Site 7 were analyzed for VOAs and TPHCs. Analytical results are discussed in Sect. 6.4.2.

6.3.6 Groundwater Investigation

Three monitoring wells were installed in the area to determine the lithology, hydraulic conductivity, depth to water, groundwater flow directions, and the presence of contamination in the groundwater. Potentiometric maps, based on water-level measurements taken in July and September 1988, are shown in Fig. 2.13. These maps indicate a general groundwater flow direction to the northwest, towards the tributary to Shunganunga Creek (Site 6).

Based on the groundwater flow direction, MW005 and MW008 are located downgradient from potential sources of contamination while MW006 is within the contaminated area or slightly upgradient. Other wells which measure the upgradient water quality include MW003, MW024, and MW027.

Bail tests were performed on MW005 and MW006 to measure the permeability of the unconsolidated aquifer in the area. For both tests, the permeability was insufficient to yield reliable test results. Therefore, it is estimated that the hydraulic conductivity of the unconsolidated aquifer is less than 3.5×10^{-5} cm/s (0.1 ft/d). Further evidence of the low-permeability of the unconsolidated aquifer in the area is the relative absence of water in MW008.

A discussion of the base hydrogeology and results of the aquifer tests are presented in Sect. 2.2.6.

6.4 NATURE AND EXTENT OF CONTAMINATION

6.4.1 Sources

The source of contamination at Site 7 is jet fuel which leaked from the southwest fuel hydrant on fuel lateral 3.

6.4.2 Vadose Zone and Soils

6.4.2.1 Vadose Zone

A soil-gas sample taken from the fuel lateral trench within the area of Site 7 (SG88) contained only 21 $\mu\text{g/L}$ of TPHCs. Further northeast in the fuel lateral 3 trench, however, concentrations of 79,000 $\mu\text{g/L}$ (SG89) and 169,000 $\mu\text{g/L}$ (SG90) were discovered. Soil-gas samples collected near the trunklines between the fuel laterals contained background levels of TPHCs (SG19 = 58 $\mu\text{g/L}$; SG20 = 31 $\mu\text{g/L}$; and SG22 = 53 $\mu\text{g/L}$).

The soil-gas data suggests that the fuel is confined to the sandy backfill in the fuel lateral trenches. In addition, the data indicates that the trench slopes toward the northeast, and that the fuel has migrated toward the northeast and pooled in that portion of the trench. Complete results from the soil-gas survey are provided in Appendix D.

6.4.2.2 Soils

Soil samples from MW005, MW006, and MW008 were analyzed for VOAs and TPHCs. No contamination was detected in any of the samples. Significant analytical results are provided in Appendix E.

6.4.3 Groundwater

Groundwater samples were collected from MW005, MW006, and MW008 (Fig. 6.1). Samples collected in July were analyzed for VOAs, TPHCs, HSL metals, and major cations/anions. Samples collected in September/October were analyzed for VOAs and TPHCs. None of the samples contained detectable quantities of contamination. Significant analytical results are provided in Appendix E.

6.4.4 Surface Water and Sediments

No surface water or sediment samples were collected at Site 7.

6.4.5 Air

Routine air monitoring during drilling was performed with an HNU model PI-101 PID. No anomalous readings were obtained while monitoring ambient air, indicating that even though organic compounds are present in the subsurface, volatilization to the atmosphere is insignificant.

6.5 CONTAMINANT FATE AND TRANSPORT

No contamination was found in the ORNL/CAT monitoring wells at Site 7. The absence of VOAs and TPHCs indicates that all fuel spilled at the site is confined to the fuel trenches.

The oil and grease reported by Weston in nearby boring B9 was the lowest level detected by their analysis of soil samples. Considering the lack of reliability of oil and grease analyses to quantify fuel contamination, the soil may or may not be contaminated.

6.5.1 Contaminant Persistence

A discussion on the persistence of JP-4 derived contaminants is presented in Sect. 3.5.1.

6.5.2 Potential Routes of Migration

The potential route of exposure to a receptor from contamination at Site 7 includes air, leaching of contaminated groundwater, and flow in the backfill around the buried fuel lines and pipes. MW005, MW006, and MW008 were drilled to monitor Site 7; soil samples collected during drilling were analyzed for VOAs and TPHCs. Groundwater samples were analyzed for HSL metals, VOAs, TPHCs, and major anions/cations. None of the samples were contaminated, indicating that all fuel spilled at the site is confined to the fuel trenches. MW005 is downgradient of the northeast portion of the fuel lateral; if contaminants were leaching into groundwater from the pool at the northeast, MW005 would detect that contamination.

The fuel lateral passes over the top of the storm sewer near soil-gas sample location SG89, but the two lines are separated by 3 to 6 ft of native soil backfill. If fuel crossed this native soil backfill to the storm sewer trench, it would permit the contamination to migrate in the storm sewer trench backfill and leak into the storm sewer. However, soil-gas sample SG80, collected in fuel lateral 4 near the intersection of the fuel lateral trench and the storm sewer trench, contained no elevated TPHCs. Also, surface water samples collected to characterize the drainage ditch (Site 6) showed no fuel downstream of the storm sewer outflow. Therefore, if fuel is crossing from the fuel lateral trench to the storm sewer trench, it is not migrating along the storm sewer trench.

Air monitoring during drilling detected no contamination at the surface. Because of the impermeability of the clay soils, fuel has apparently not leached into the groundwater from Site 7; this conclusion is consistent with findings at other sites on the base. Since drilling was always performed to avoid puncturing fuel lines, migration in the backfill is a possibility that cannot be discounted.

6.5.3 Contaminant Migration

The clay soils at this site apparently confine spilled fuel to the backfill within the fuel-line trenches. Soil-gas data indicates that fuel in the trench backfill has migrated to the northeast end of the lateral, which is a dead-end. The soil-gas sample from the trench within the outlined Site 7 (SG88, Fig. 6.1) showed background levels, indicating that most of the fuel has apparently migrated away from the original source.

See Sect. 3.5.3 for additional details.

6.6 BASELINE RISK ASSESSMENT

This section describes the public health and environmental concerns resulting from Site 7. Contaminants identified at this site are TPHCs (169,000 $\mu\text{g/L}$) -- found in the fuel lateral trench backfill using soil-gas samples.

The risk assessment for the base, including details of exposure pathways, exposure scenarios, toxicity of chemicals, and risk characterization is presented in Appendix J.

The following evaluation of potentially contaminated media demonstrates that there is no present exposure from contamination at Site 7.

6.6.1 Exposure Assessment

6.6.1.1 Air

Air emissions were evaluated with a hand-held survey meter at ground level. The data demonstrated no emissions from the site. Soil-gas measurements did demonstrate that anomalous concentrations of TPHCs were present in the subsurface.

6.6.1.2 Groundwater

Monitoring wells surrounding Site 7 and downgradient of the northeast end of fuel lateral 3 indicate that groundwater at this site is not contaminated.

6.6.1.3 Surface Water

Contaminants leaching from Site 7 presumably could migrate in the trench backfill to the storm drainage system. The storm sewers were backfilled with native clay soil which will inhibit contaminant migration, although not as much as undisturbed soil would inhibit migration.

6.6.1.4 Soil

None of the soil samples collected at this site were contaminated.

6.6.2 Risk Evaluation

Risks presented by contamination in the unconsolidated sediments and groundwater at Site 7, refueling hydrant on lateral 3, were evaluated using the construction worker scenario only (Appendix J). Analysis of construction worker exposure to both groundwater and subsurface soil for both inhalation and dermal absorption pathways indicates no potential for either noncarcinogenic or carcinogenic effects.

The only potential risk is exposure of workers to air contaminants or possible explosion hazards if the trench backfill were excavated. The explosion hazard results from the possibility of relatively high concentrations of fuel vapors or possible free product in a confined space (trench).

6.7 SUMMARY AND CONCLUSIONS

6.7.1 Summary

Groundwater and soil at Site 7 is not contaminated; however, fuel is present in the backfill of the buried fuel lateral. Fuel in the trench backfill is contained by tight clay soils.

6.7.2 Conclusions

No risk to the public or environment exists from Site 7, but any excavation near the trenches could result in exposure to workers and possible explosion hazards. The preferred alternative is no action with continued restricted access to the site.

7. SITE 8, AREA ADJACENT TO REFUELING HYDRANT, LATERAL 7

7.1 SITE BACKGROUND

The area adjacent to the refueling hydrant located on lateral 7 was included in the IRP study based on a recommendation from the Phase I records search (HMTc 1986). The HMTc calculated a HARM score of 65 for this site. Sites 7, 8, and 9 were grouped together for the HARM rating due to similarities of substances spilled, probable quantities, and relative location.

7.1.1 Site Description

Site 8 consists of the area surrounding the first fuel hydrant (southwest end) on fuel lateral 7 northeast of building 673 (Plate 1, Fig. 7.1). Here, the flat ramp is drained by grated catchment basins flush with the surface. These are attached to a storm sewer system which drains into the small pond noted in Site 6 (Sect. 5).

The fuel hydrants are located in the aircraft parking ramp. The hydrants allow a direct connection to aircraft for fueling and defueling. A flush-mounted lid covers the connections. Ramp construction consists of an 18 to 22 in. reinforced concrete pad with a 2 to 4 in. asphalt overlay. The fuel lines are buried approximately 3.5 ft under the concrete with a tee connection to each fuel hydrant. Lateral 7 receives fuel from pumphouse G (building 674).

7.1.2 Site History

The aircraft parking ramp was constructed between 1954 and 1959, as shown by aerial photographs taken in those years.

An undetermined amount of jet fuel leaked from the fuel hydrant at Site 8 in July 1982. Fuel lateral 7 is still in use.

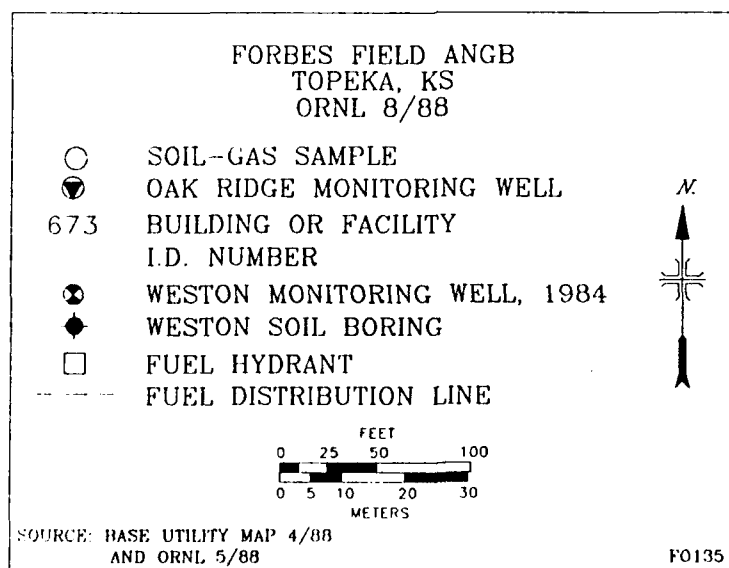
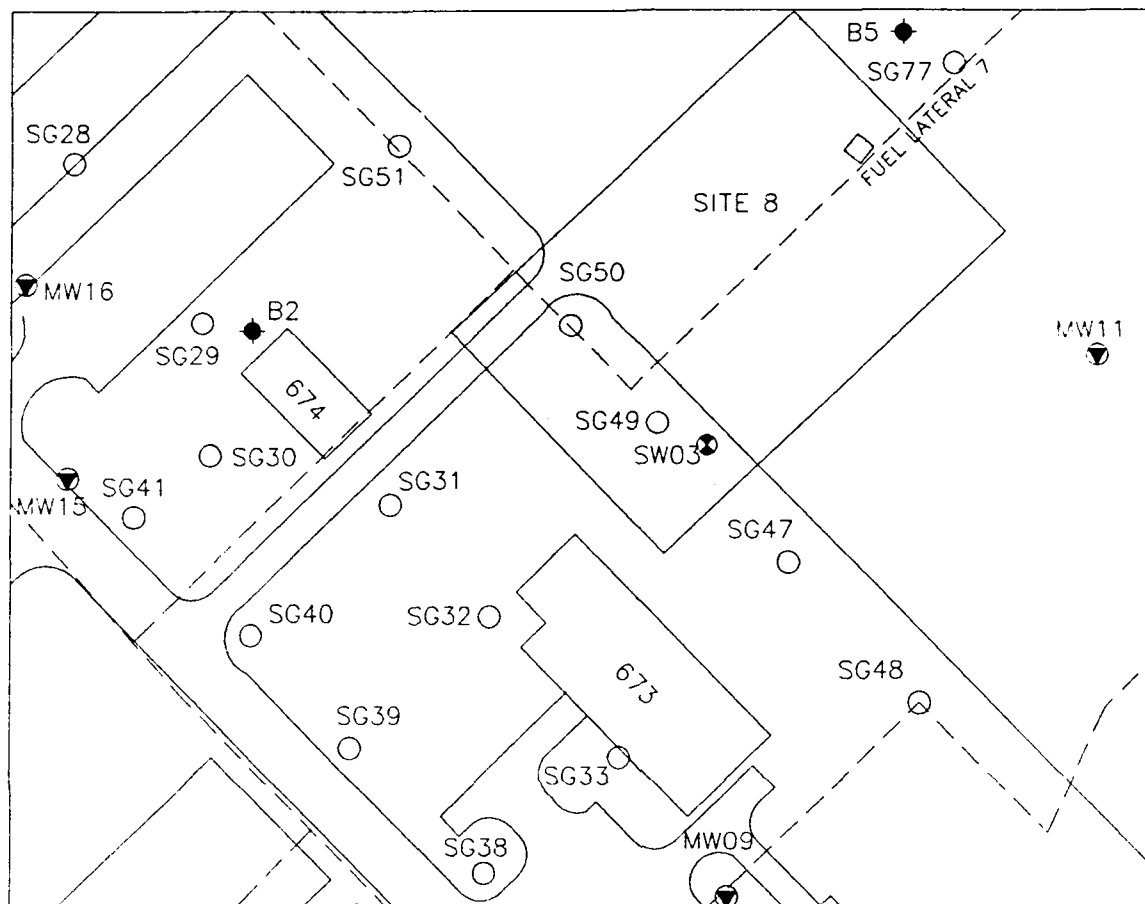


Fig. 7.1. Map of Site 8.

7.1.3 Previous Investigations

Weston (1985) inspected and surveyed storm sewer manholes on and adjacent to the aircraft parking ramp (Fig. 1.3). This consisted of visual observations and measurements with an OVA and an HNU PID. No organic vapors were detected near Site 8.

Weston also collected a water sample from the storm sewer manhole near pumphouse G, about 350 ft downgradient of the fuel hydrant. The sample was allowed to come to room temperature and the headspace gases were analyzed with an OVA and HNU. The sample showed 15 ppm of volatile organic vapors in air using the HNU.

Weston drilled two monitoring wells near Site 8. SW003 is near the southeast end of fuel lateral 7, and downgradient of the hydrant. SW004 lies between Site 8 and Site 9 on the aircraft parking ramp. The Weston groundwater samples, using oil and grease analysis, showed 230 and 450 $\mu\text{g/L}$ in SW003 and SW004, respectively. The ORNL groundwater samples collected in March 1988 revealed no detectable TPHCs in SW003 and 190 $\mu\text{g/L}$ of TPHCs in SW004.

Weston also drilled two soil borings in the vicinity of Site 8 (Fig. 7.1). One is located about 30 ft west of the second fuel hydrant on lateral 7 (B5) upgradient of Site 8 and the other is located north of pumphouse G (building 674) downgradient of Site 8 (B2). Weston screened soil samples from the wells with field instruments prior to sending samples for analysis. Samples from boring B5 contained no detectable organic vapors; therefore, no samples were analyzed. The sample collected from 8 to 13 ft in boring B2 contained 51,000 $\mu\text{g/kg}$ of oil and grease.

The only other investigation was during the Phase I records search. This consisted of interviewing base personnel, reviewing documents, and visiting the site.

7.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

7.2.1 Surface Water Hydrology

Since the area surrounding Site 8 is part of the parking ramp and is paved, all of the precipitation occurring in the area becomes surface runoff. Due to the relatively flat topography, the runoff occurs as sheet flow and is

routed through the storm sewer and eventually into the unnamed tributary to the South Branch of Shunganunga Creek (Site 6, Sect. 5). General surface water hydrology information for Forbes Field ANGB is discussed in Sect. 2.2.3.

7.2.2 Geology

Site 8 rests on unconsolidated sediments deposited during the Kansan Glaciation. Beneath these sediments lies a thin zone of weathered bedrock and then competent bedrock of the Howard Limestone and Severy Shale. A complete description of the base geology is presented in Section 2.2.4.

7.2.3 Soils

Site 8 soils are Ladysmith (Ld), 0 to 1% slope (USDA 1970). General soil information for the base is discussed in Sect. 2.2.5 and Table 2.7.

7.2.4 Hydrogeology

The only water bearing unit of interest underlying Site 8 is the unconsolidated aquifer in which water is found in the lower portion of the glacial drift or the underlying weathered bedrock. This unconsolidated aquifer is completely absent in portions of the base. The underlying bedrock consists of impermeable limestones and shales of the Howard Limestone which isolate the lower permeable Nodaway Coal unit.

A complete description of the Forbes Field ANGB hydrogeology is presented in Sect. 2.2.6. Groundwater flow direction and rates for the site are discussed in Sect. 7.3.6.

7.2.5 Demographics and Land Use

Building 674, pumphouse G, is 400 ft downgradient of Site 8. This building contains no offices or permanent work stations. Site 8 is covered with a concrete and asphalt pad used for aircraft parking and fueling. No people reside within about 1200 ft of the site. The site is within the secured and patrolled portion of the base.

General demographics and land use for the base and Shawnee County are discussed in Sect. 2.2.11.

7.2.6 Ecology

No vegetation or wildlife is supported, as this site is covered with a concrete and asphalt pad. General ecology is discussed in Sect. 2.2.12.

7.3 STUDY AREA INVESTIGATION

7.3.1 Surface Features

Field activities at Site 8 involved surveying to accurately map the fuel laterals, hydrants, soil-gas sample points, and monitoring well locations and elevations. A general description of surface features on the base is presented in Sect. 2.2.1.

7.3.2 Contaminant Source Investigations

The contaminant source investigation at Site 8 included a review of the Phase I records search. Phase I identified the source of contamination as jet fuel that leaked from the first fuel hydrant.

7.3.3 Surface Water and Sediment Investigations

Surface water at Site 8 drains into the storm sewer system which then drains in the nearby unnamed tributary (Site 6) to the south branch of Shunganunga Creek. Surface water and sediment investigations for Site 6 are discussed in Sect. 5.

7.3.4 Geological Investigation

Surface lithology information for the fuel lateral 7 area was obtained during the drilling of MW011, MW015, and MW016. With the use of a continuous sampler, a complete lithologic record was kept for each hole. The well summary forms with well construction and lithologic descriptions are attached in Appendix G.

The surface lithology consists of unstratified silty clays deposited by melt waters from the receding glaciers. These clays are predominantly dark gray, very plastic and sticky, have a moderate silt content, and are highly oxidized with limonite stains. Of local interest is a thin sand and gravel layer found at 4 to 5 ft in all three boreholes. It could be the remains of a small diversion channel common to the receding glacial ice. The sediments range between 10 and 14.5 ft, becoming higher in organic matter with depth. MW015 and MW016 were damp between about 5 ft and the top of the weathered bedrock; MW011 revealed only one wet zone in the sediments, which was about 3 in. above the weathered bedrock.

The sediments overlie a weathered yellow-brown claystone interbedded with gray and black carbonaceous shales. Visible relict bedding and abundant fossils (crinoid stems) were encountered in the claystone. The relict bedding planes are contorted and occasionally truncated. The weathered bedrock was wet within a few inches of bedrock in MW011 and MW015. MW016 was slightly damp in the weathered bedrock. The weathered bedrock in the area of Site 8 is part of the lower Howard Limestone. The underlying bedrock consists of the impermeable limestones and shales of the lower Howard Limestone.

7.3.5 Vadose Zone and Soil Investigation

7.3.5.1 Vadose Zone

Soil-gas and water samples were collected from beneath the refueling apron along laterals 1 through 12 and lateral 20 (Plate 1). The samples were collected by drilling a 1.5 in. hole through the concrete, then driving the probe to approximately 3.5 ft. The fuel lateral distribution lines branch from the main trunkline every 300 ft, running about 3.5 ft beneath the surface of the apron. The lateral lines are bedded in a coarse sand which fills the trench to the undersurface of the apron. All the trenches contained water; some had water standing to the undersurface of the concrete.

Three samples were collected from the trench backfill of fuel lateral 7, as shown on Fig. 7.1 and Plate 1. Samples SG75, SG76, and SG77 were collected from the northeast, center, and southwest portion of the lateral, respectively. Results are discussed in Sect. 7.4.2.

Section 2.1.2.2 provides details on soil-gas collection methods.

7.3.5.2 Soils

Soil samples were collected with a 5-ft continuous sampler during the drilling of MW011, MW015, and MW016. Samples were inspected visually for contamination and monitored along their length with an HNU PID. If elevated readings were noted, a grab sample was taken. Otherwise, samples for chemical analysis were collected every 3 ft until the water table was reached. Soil samples from Site 8 were analyzed for VOAs and TPHCs. Analytical results are discussed in Sect. 7.4.2.

7.3.6 Groundwater Investigation

Three monitoring wells were installed in the area to determine the lithology, hydraulic conductivity, depth to water, groundwater flow direction, and the presence of contamination in the groundwater. Potentiometric maps, based on water-level measurements taken in July and September 1988, are shown in Fig. 2.13. These maps indicate a general groundwater flow direction to the northwest, toward the tributary to Shunganunga Creek (Site 6).

Based on groundwater flow direction, MW015 and MW016 are located downgradient of potential sources of contamination, while MW011 is upgradient of the source area. MW015 and MW016 were also placed downgradient of the Weston soil boring B2 to intercept possible contamination migrating from the area of building 674 (pumphouse G). In addition, MW002 and MW017 are also located downgradient of Site 8 and MW007 and MW023 are located upgradient.

Bail tests were performed on MW011, MW015, and MW016 to measure the permeability of the unconsolidated aquifer in the area. For MW015 and MW016, the permeability was insufficient to yield reliable test results. MW011 showed a permeability value of 1.9×10^{-4} cm/s (0.53 ft/d). The values indicate some discontinuity in the aquifer permeability.

A discussion of the base hydrogeology and results of the aquifer tests are presented in Sect. 2.2.6.

7.4 NATURE AND EXTENT OF CONTAMINATION

7.4.1 Sources

The contamination source at Site 8 is jet fuel which leaked from the southwest fuel hydrant on fuel lateral 7.

7.4.2 Vadose Zone and Soils

7.4.2.1 Vadose Zone

A soil-gas sample taken from the fuel lateral trench just northeast of Site 8 (SG77) contained 163 $\mu\text{g/L}$ of TPHCs. Further northeast in fuel lateral 7, two samples (SG75 and SG76) revealed 22 and 28 $\mu\text{g/L}$, respectively, suggesting that fuel has not migrated to the northeast in the trench.

Samples SG50 and SG51 were collected near the fuel distribution line trench. Unfortunately, they were not collected from the trench backfill as planned. These plans failed either because the trench was not where it was expected to be or because it was backfilled with compacted native soil and was not distinguishable from the surrounding material. Since the samples were not collected from the trench backfill, no conclusions regarding the trench can be drawn from these results.

Complete results from the soil-gas survey are provided in Appendix D.

7.4.2.2 Soils

Soil samples from MW011, MW015, and MW016 were analyzed for VOAs and TPHCs. No contamination was detected in any of the samples. Significant analytical results are provided in Appendix E.

7.4.3 Groundwater

Groundwater samples were collected from MW011, MW015, and MW016 (Fig. 7.1). Samples collected in July were analyzed for VOAs, TPHCs, HSL metals, and major cations/anions. Samples collected in September/October were analyzed for VOAs and TPHCs. None of the samples contained detectable quantities of contamination. Significant analytical results are provided in Appendix E.

7.4.4 Surface Water and Sediments

No surface water or sediment samples were collected at Site 8.

7.4.5 Air

Routine air monitoring during drilling was performed with an HNU model PI-101 PID. No anomalous readings were obtained while monitoring ambient air, indicating that even though organic compounds are present in the subsurface, volatilization to the atmosphere is insignificant.

7.5 CONTAMINANT FATE AND TRANSPORT

No contamination was found in the ORNL/CAT monitoring wells at Site 8. The absence of VOAs and TPHCs indicates that all fuel spilled at the site is confined to the fuel trenches.

7.5.1 Contaminant Persistence

A discussion on the persistence of JP-4 derived contaminants is presented in Sect. 3.5.1.

7.5.2 Potential Routes of Migration

The potential route of exposure to a receptor from contamination at Site 8 is leaching to the nearby drainage ditch. MW015 and MW016 are downgradient of the area and both are uncontaminated. MW011 is upgradient and is also uncontaminated.

Additional potential routes of migration include air emission and flow in the backfill around the buried fuel lines and pipes. Field measurements demonstrated that there are no detectable hydrocarbon emissions from the site. Thus, unless the area were excavated, there is no significant air exposure. Since drilling was performed to avoid hitting fuel lines, migration in the backfill is a possibility that cannot be discounted.

7.5.3 Contaminant Migration

The clay soils encountered at this site apparently confine the spilled fuel to the backfill within the fuel line trenches. There is no evidence that a contaminant plume is migrating from the area. The low soil-gas concentrations in the trench northeast of Site 8 suggests that the spilled fuel has not migrated toward the northeast.

Contamination in the groundwater from the Weston well SW004 is probably due to fuel that migrated under the concrete ramp when the leak at Site 9 occurred. The contaminated soil Weston discovered in soil boring B2 is probably due to fuel in the trench backfill or buried tanks near pumphouse G. The ORNL/CAT MW015 and MW016 are downgradient of B2; neither of these wells are contaminated.

See Sect. 3.5.3 for additional details.

7.6 BASELINE RISK ASSESSMENT

This section describes the public health and environmental concerns resulting from Site 8. Contaminants identified at this site are TPHCs (163 $\mu\text{g/L}$)--which were found in the fuel lateral trench backfill using soil-gas samples.

The risk assessment for the base, including details of exposure pathways, exposure scenarios, toxicity of chemicals, and risk characterization is presented in Appendix J.

The following evaluation of potentially contaminated media demonstrates that there is presently no exposure from contamination at Site 8.

7.6.1 Exposure Assessment

7.6.1.1 Air

Air emissions were evaluated with a hand-held survey meter at ground level. The data showed that there were no emissions from the site. Soil-gas measurements, however, did demonstrate that anomalous concentrations of TPHCs were present in the subsurface. The concentrations were so low that, in

combination with the concrete ramp, any transport to the surface would be minute and quickly diluted such that exposure to the public or even military personnel using the site would be insignificant.

7.6.1.2 Groundwater

Monitoring wells installed by ORNL/CAT surrounding the area indicated that groundwater downgradient of this site is not contaminated.

7.6.1.3 Surface Water

Contaminants leaching from Site 8 presumably could migrate in the trench backfill to the storm drainage system. The storm sewers were backfilled with native clay soil which will inhibit migration, although not as much as undisturbed soil would inhibit migration.

7.6.1.4 Soil

None of the ORNL/CAT soil samples collected at this site were contaminated. A soil sample collected by Weston in boring B2 contained 51,000 $\mu\text{g/kg}$ of oil and grease. The oil and grease in boring B2 is probably due to fuel in the backfill of trenches or buried tanks near the pumphouse (building 674) or a spill north of the pumphouse. This indicates that exposures to fuel derived hydrocarbons could result if excavation occurred near the trenches or the pumphouse. No exposure to humans or the environment would occur for present usage of the site.

7.6.2 Risk Evaluation

Risks presented by contamination in the unconsolidated sediments and groundwater at Site 8, refueling hydrant on lateral 7, were evaluated using the construction worker and off-base resident scenario (Appendix J). Under the construction worker scenario, exposure could occur via either inhalation or dermal absorption of contaminated groundwater or surface water; under the resident scenario, exposure could occur via ingestion, inhalation, or dermal absorption of groundwater. Hazard indices for all routes of exposure for both scenarios indicate no potential for adverse health effects from this site.

The only potential risk is exposure of workers to air contaminants or possible explosion hazards if the trench backfill were excavated. The explosion hazard results from the possibility of relatively high concentrations of fuel vapors or possible free product in a confined space (trench).

7.7 SUMMARY AND CONCLUSION

7.7.1 Summary

Groundwater and soil surrounding Site 8 are not contaminated; however, fuel is present in the backfill of the buried fuel lateral. Fuel in the trench backfill is contained by the tight clay soils.

7.7.2 Conclusion

No risk to the public or environment exists from Site 8, but any excavation near the trenches could result in exposure to workers or possible explosion hazards. The preferred alternative is no action with continued restricted access to the site.

8. SITE 9, AREA ADJACENT TO REFUELING HYDRANT, LATERAL 8

8.1 SITE BACKGROUND

The area adjacent to the refueling hydrant, located on lateral 8, was included in the IRP study based on a recommendation from the Phase I records search (HMTc 1986). HMTc calculated a HARM score of 65 for this site. Sites 7, 8, and 9 were grouped together for the HARM rating due to similarities of substances spilled, probable quantities, and relative location.

8.1.1 Site Description

Site 9 consists of the area surrounding the first fuel hydrant (southwest end) on fuel lateral 8 east of building 679 (Plate 1 and Fig. 8.1). Here, the flat ramp is drained by grated catchment basins flush with the surface. These are attached to a storm sewer system which drains into the small pond noted in Site 6 (Sect. 5).

The fuel hydrants are located in the aircraft parking ramp. The hydrants allow a direct connection to aircraft for fueling and defueling. A flush-mounted lid covers the connections. Ramp construction consists of an 18 to 22 in. reinforced concrete pad with a 2 to 4 in. asphalt overlay. The fuel lines are buried approximately 3.5 ft under the concrete with a tee connection to each fuel hydrant. Lateral 8 receives fuel from pumphouse G.

8.1.2 Site History

The aircraft parking ramp was constructed between 1954 and 1959, as shown by aerial photographs taken in those years.

According to the Phase I records search, the largest spill from any of the fuel hydrants was thought to have occurred at Site 9 in 1983. The spill involved the loss of up to 3000 gal of JP-4. Discovery of the leak came when someone observed JP-4 emanating from pavement joints adjacent to Site 9. During pressurization to locate the leak, an unknown quantity of JP-4 escaped under the concrete pad. Subsequently, the fuel migrated to a storm sewer catch basin at the northwest corner of the base. The storm sewer drains into the ditch (Site 6) at the small ponding area. Fuel lateral 8 is still in use.

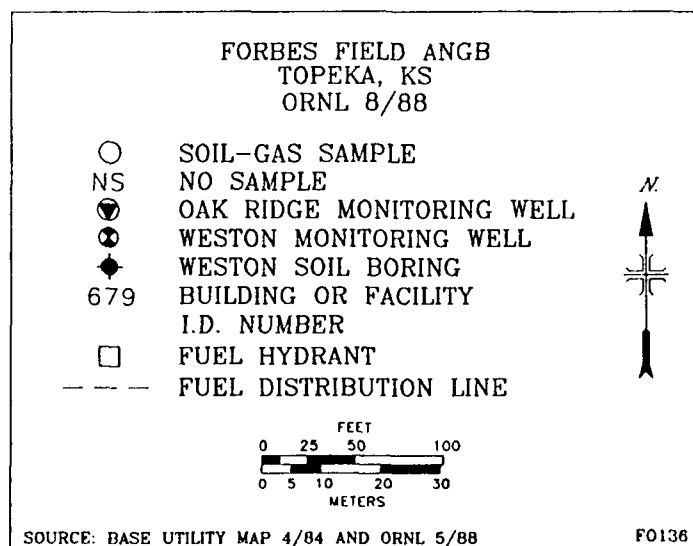
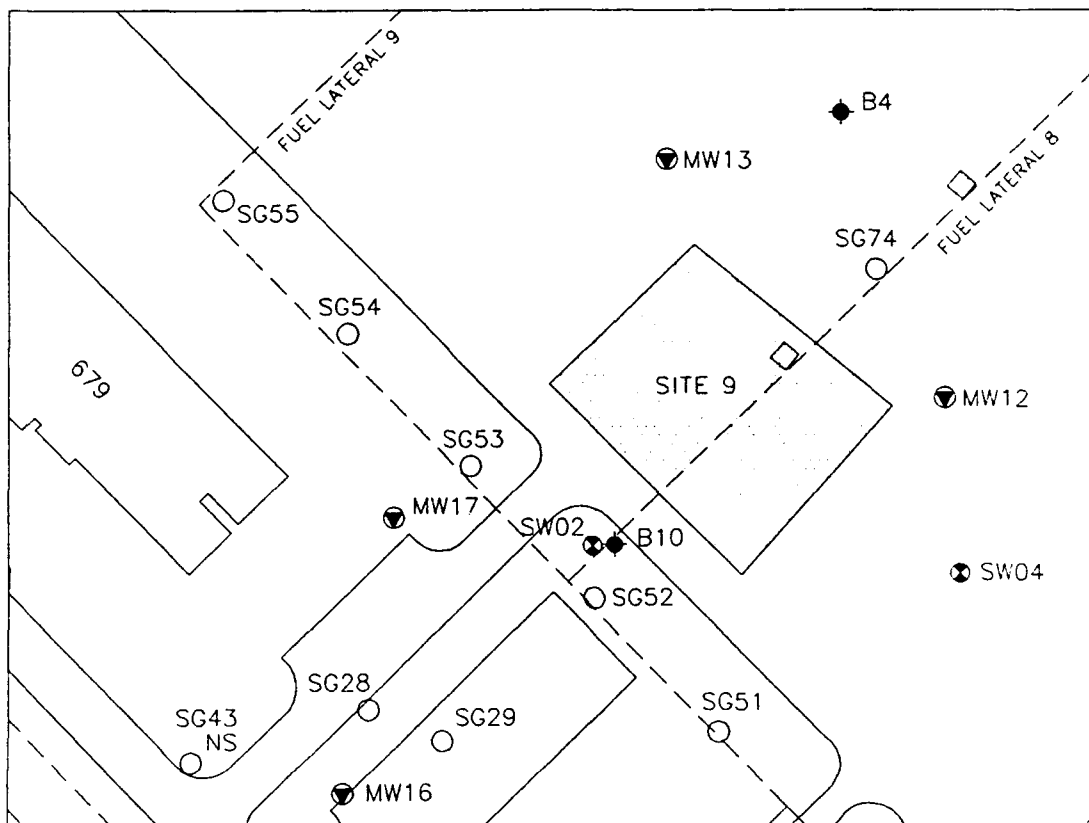


Fig. 8.1. Map of Site 9.

8.1.3 Previous Investigations

Weston (1985) inspected and surveyed storm sewer manholes on and adjacent to the refueling ramp (Fig 1.3). This consisted of visual observations and measurements with an OVA and an HNU PID. No organic vapors were detected near Site 9.

Weston drilled two monitoring wells near Site 9. SW002 is near the southeast end of fuel lateral 8 and downgradient of the hydrant. SW004 is between the fuel hydrants at Site 8 and Site 9 on the aircraft parking ramp. The Weston groundwater samples, using oil and grease analysis, a screening technique, showed 1750 and 450 $\mu\text{g/L}$ in SW002 and SW004, respectively. The ORNL groundwater samples collected in March 1988 revealed no detectable TPHCs in SW002 and 190 $\mu\text{g/L}$ of TPHCs in SW004.

Weston also drilled two soil borings in the vicinity of Site 9 (Fig. 8.1): one about 30 ft east of SW002 (B10) and another about 60 ft north of lateral 8, midway between the second and third fuel hydrants (B4). Boring B10 is south of lateral 9 and was apparently drilled in the trench backfill of the fuel line. The log shows silty sand and gravel from 1 to 3.6 ft. The fuel laterals are buried ~3.5 ft deep. A soil sample from 1.7 to 6.7 ft in B4 contained 36,000 $\mu\text{g/kg}$ of oil and grease. The soil sample from 1 to 4 ft in B10 contained 686,000 $\mu\text{g/kg}$ of oil and grease.

The only other investigation was during the Phase I records search. This consisted of interviewing base personnel, reviewing documents, and visiting the site.

8.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

8.2.1 Surface Water Hydrology

Since the area surrounding Site 9 is part of the parking ramp and is paved, all of the precipitation occurring in the area becomes surface runoff. Due to the relatively flat topography, the runoff occurs as sheet flow and is routed through the storm sewer and eventually into the unnamed tributary to the south branch of Shunganunga Creek (Site 6, Sect. 5). General surface water hydrology information for Forbes Field ANGB is discussed in Sect. 2.2.3.

8.2.2 Geology

Site 9 rests on unconsolidated sediments deposited during the Kansan Glaciation. Beneath these sediments lies a thin zone of weathered bedrock and then competent bedrock of the Howard Limestone and Severy Shale. A complete description of the geology at the base is presented in Section 2.2.4.

8.2.3 Soils

Site 9 soils are Ladysmith (Ld), 0 to 1% slope (USDA 1970). General soil information for the base is discussed in Sect. 2.2.5 and Table 2.7.

8.2.4 Hydrogeology

The only water bearing unit of interest underlying Site 9 is the unconsolidated aquifer in which water is found in the lower portion of the glacial drift or the underlying weathered bedrock. This unconsolidated aquifer is completely absent in portions of the base. The underlying bedrock consists of impermeable limestones and shales of the Howard Limestone which isolate the lower permeable Nodaway Coal unit.

A complete description of the Forbes Field ANGB hydrogeology is presented in Sect. 2.2.6. Groundwater flow directions and rates for the area are discussed in Sect. 8.3.6.

8.2.5 Demographics and Land Use

Building 679, the squadron operations building, is 300 ft downgradient of Site 9. This building contains offices and other work areas. Site 9 is covered with a concrete and asphalt pad used for aircraft parking and fueling. No people reside within approximately 1200 ft of the site. The site is within the secured and patrolled portion of the base.

General demographics and land use for the base and Shawnee County are discussed in Sect. 2.2.11.

8.2.6 Ecology

No vegetation or wildlife is supported, as this site is covered with a concrete and asphalt pad. General ecology of the base is discussed in Sect. 2.2.12.

8.3 STUDY AREA INVESTIGATION

8.3.1 Surface Features

Field activities at Site 9 involved surveying to accurately map the fuel laterals, hydrants, soil-gas sample points, and monitoring well locations and elevations. A general description of surface features on the base is presented in Sect. 2.2.1.

8.3.2 Contaminant Source Investigation

The contaminant source investigation at Site 9 included a review of the Phase I records search. This search identified the source of contamination as jet fuel that leaked from the first fuel hydrant.

8.3.3 Surface Water and Sediment Investigations

Surface water at Site 9 drains into the storm sewer system which then drains into the nearby unnamed tributary (Site 6) to the south branch of Shunganunga Creek. Surface water and sediment investigations for Site 6 are discussed in Sect. 5.0.

8.3.4 Geological Investigation

Surface lithology information for the fuel lateral 8 area was obtained during the drilling of MW012, MW013, and MW017. With the use of a continuous sampler, a complete lithologic record was kept for each hole. The well summary forms with well construction and lithologic descriptions are attached in Appendix G.

The surface lithology consists of unstratified silty clays deposited by melt waters from the receding glaciers. These clays are predominantly very dark gray to dark brown, plastic, occasionally organic, stained with limonite oxide, locally micaceous, and marked by scattered greenish-gray silts. The sediments range between 10 and 14.5 ft. A gravelly interval, consisting of angular limestone fragments in a dark gray, sticky clay matrix, was encountered at 8 ft in MW013. This lens most likely represents an erratic deposited by either floating ice or as a glaciofluvial deposit. The sediments in all three of the monitoring wells were dry.

The sediments overlie a weathered yellow-brown claystone interbedded with gray and black carbonaceous shales. Visible relict bedding and abundant fossils (crinoid stems and bryozoan imprints) were encountered in the claystone. Moisture was encountered in all three wells in the bottom 1.5 to 2.5 ft of weathered claystone. The weathered bedrock in the area of Site 8 is part of the lower Howard Limestone. The underlying bedrock consists of the impermeable limestones and shales of the lower Howard Limestone.

8.3.5 Vadose Zone and Soil Investigations

8.3.5.1 Vadose Zone

Soil-gas and water samples were collected from beneath the refueling apron along laterals 1 through 12 and lateral 20 (Plate 1). The samples were collected by drilling a 1.5 in. hole through the concrete, then driving the probe to a depth of about 3.5 ft.

Soil-gas samples were collected when the backfill was dry. If the backfill was wet, a water sample was collected by allowing the water to seep into the soil-gas probe hole and collecting the water with a bailer.

The fuel lateral distribution lines branch from the main trunkline every 300 ft, running about 3.5 ft beneath the surface of the apron. The lateral lines are bedded in a coarse sand which fills the trench to the undersurface of the apron. All the trenches contained water; some had water standing to the undersurface of the concrete.

Three samples were collected from the trench backfill of fuel lateral 8, as shown on Fig. 8.1 and Plate 1. Samples SG72, SG73, and SG74 were collected from the northeast, center, and southwest portions of the lateral, respectively. Results are discussed in Sect. 8.4.2.

Section 2.1.2.2 provides details on soil-gas collection methods.

8.3.5.2 Soils

Soil samples were collected from a 5-ft continuous sampler during the drilling of MW012, MW013, and MW017. Samples were inspected visually for contamination and monitored along their length with an HNU PID. If elevated readings were noted, a grab sample was taken. Otherwise, samples for chemical analysis were collected every 3 ft until the water table was reached. Soil samples from Site 9 were analyzed for VOAs and TPHCs. Analytical results are discussed in Sect. 8.4.2.

8.3.6 Groundwater Investigation

Three monitoring wells were installed in the area to determine the lithology, hydraulic conductivity, depth to water, groundwater flow directions, and the presence of contamination in the groundwater. Potentiometric maps, based on water-level measurements taken in July and September 1988, are shown in Fig. 2.13. These maps indicate a general groundwater flow direction to the northwest, toward the tributary to Shunganunga Creek (Site 6).

Based on groundwater flow directions, MW013 is located downgradient of the Weston soil boring B4 and the northeast end of lateral 8 and MW017 is downgradient of Site 9 and the Weston soil boring B10. MW012 was installed upgradient of Site 9.

Bail tests were performed on MW012, MW013, and MW017 to measure the permeability of the unconsolidated aquifer in the area. The permeability for the wells tested in this area ranged from 2.6×10^{-4} cm/s (0.53 ft/d) at MW012 to 7.1×10^{-4} cm/s (2.0 ft/d) at MW013. The results indicate that the unconsolidated aquifer in the area of Site 9 is relatively homogeneous.

A discussion of the base hydrogeology and results of the aquifer tests are presented in Sect. 2.2.6.

8.4 NATURE AND EXTENT OF CONTAMINATION

8.4.1 Sources

The contamination source at Site 9 is jet fuel which leaked from the southwest fuel hydrant on fuel lateral 8.

8.4.2 Vadose Zone and Soils

8.4.2.1 Vadose Zone

A soil-gas sample taken from the fuel lateral trench just northeast of Site 9 (SG74) contained 56 µg/L of TPHCs. Farther northeast in fuel lateral 8, two soil-gas samples (SG72 and SG73) revealed 34 µg/L each. These low results suggest that fuel was not present in the trench where the soil-gas samples were collected.

Samples SG51 through SG55 were collected near the fuel distribution line trench. Unfortunately, they were not collected from the trench backfill as planned. Those plans failed either because the trench was not where it was expected to be or because it was backfilled with compacted native soil and not distinguishable from the surrounding material. SG54 contained 202 µg/L TPHCs. This sample may have been close enough to the trench to detect fuel within the trench backfill. The remaining four samples contained background levels of TPHCs. Since the samples were not collected from the trench backfill, no conclusions regarding the trench can be drawn from these results. Results from the soil-gas survey are provided in Appendix D.

8.4.2.2 Soils

Soil samples from MW012, MW013, and MW017 were analyzed for VOAs and TPHCs. No contamination was detected in any of the samples. Significant analytical results are provided in Appendix E.

8.4.3 Groundwater

Groundwater samples were collected from MW012, MW013, and MW017 (Fig. 8.1). Samples collected in July were analyzed for VOAs, TPHCs, HSL metals, and major cations/anions. Samples collected in September/October were analyzed for VOAs and TPHCs. None of the samples contained detectable quantities of contamination. Significant analytical results are provided in Appendix E.

8.4.4 Surface Water and Sediments

No surface water or sediment samples were collected at Site 9.

8.4.5 Air

Routine air monitoring during drilling was performed with an HNU model PI-101 PID. No anomalous readings were obtained while monitoring ambient air, indicating that even though organic compounds are present in the subsurface, volatilization to the atmosphere is insignificant.

8.5 CONTAMINANT FATE AND TRANSPORT

No contamination was found in the ORNL/CAT monitoring wells at Site 9. The absence of VOAs and TPHCs in the monitoring wells indicates that all fuel spilled at the site is confined to the fuel trenches.

8.5.1 Contaminant Persistence

A discussion on the persistence of JP-4 derived contaminants is present in Sect. 3.5.1.

8.5.2 Potential Routes of Migration

The potential route of exposure to a receptor from contamination at Site 9 is leaching to the nearby drainage ditch. MW013 and MW017 are downgradient of the area and both are uncontaminated. MW012 is upgradient and is also uncontaminated.

Additional potential routes of migration include air emissions and flow in the backfill around the buried fuel lines and pipes. Field measurements demonstrated that there are no detectable hydrocarbon emissions from the site. Thus, unless the area were excavated, there is no significant air exposure. Since drilling was always performed to avoid hitting fuel lines, migration in the backfill is a possibility that cannot be discounted.

8.5.3 Contaminant Migration

The clay soils encountered at this site apparently confine the spilled fuel to the backfill within the fuel-line trenches. There is no evidence that a contaminant plume is migrating from the area.

Contamination in the groundwater from the Weston well SW004 and in soil boring B4 is probably due to fuel that migrated in the backfill under the concrete ramp when the leak at Site 9 occurred. The contaminated soil Weston discovered in boring B10 and contaminated groundwater in SW002 may be due to the fact that the borings were drilled in the trench backfill adjacent to fuel lateral 8, 10 ft from the edge of the aircraft parking ramp. This indicates that the fuel has migrated in the trench backfill at least as far as the edge of the ramp. The Weston contamination, however, was identified by oil and grease analysis, a screening technique. ORNL/CAT's MW013 is downgradient of boring B4; MW016 and MW017 are downgradient of SW002 and boring B10. None of the ORNL/CAT monitoring wells contained detectable contamination.

See Sect. 3.5.3 for additional details.

8.6 BASELINE RISK ASSESSMENT

This section describes the public health and environmental concerns resulting from Site 9. Contaminants identified at this site are TPHCs (202 $\mu\text{g/L}$), which were found in the fuel lateral trench backfill using soil-gas samples.

The risk assessment for the base, including details of exposure pathways, exposure scenarios, toxicity of chemicals, and risk characterization is presented in Appendix J.

The following evaluation of potentially contaminated media demonstrates that there is presently no exposure to the public from contamination at Site 9.

8.6.1 Exposure Assessment

8.6.1.1 Air

Air emissions were evaluated with a hand-held survey meter at ground level. The data showed that there were no emissions from the site. Soil-gas measurements, however, did demonstrate that anomalous concentrations of TPHCs were present in the subsurface. The concentrations were so low that, in combination with the concrete ramp, any transport to the surface would be minute and quickly diluted such that exposure to the public or even military personnel using the site would be insignificant.

8.6.1.2 Groundwater

Monitoring wells installed by ORNL/CAT surrounding the area indicated that groundwater at this site is not contaminated.

8.6.1.3 Surface Water

Contaminants leaching from Site 9 presumably could migrate in the trench backfill to the storm drainage system. The storm sewers were backfilled with native clay soil which will inhibit migration, although not as much as undisturbed soil would inhibit migration.

8.6.1.4 Soil

None of the ORNL/CAT soil samples collected at this site were contaminated. Soil samples collected by Weston in borings B4 and B10 contained 36,000 and 686,000 $\mu\text{g/kg}$ of oil and grease, respectively. These data indicate that exposures to fuel derived hydrocarbons could result if the area were excavated. No exposure to humans or the environment would occur for present usage of the site.

8.6.2 Risk Evaluation

Risks presented by contamination in the unconsolidated sediments and groundwater at Site 9, refueling hydrant on lateral 8, were evaluated using the construction worker and off-base resident scenario (Appendix J). Under the construction worker scenario, exposure could occur via either inhalation or dermal absorption of contaminated groundwater or surface water; under the resident scenario, exposure could occur via ingestion, inhalation, or dermal absorption of groundwater. Hazard indices for all routes of exposure for both scenarios indicate no potential for adverse health effects from this site.

The only potential risk is exposure of workers to air contaminants or possible explosion hazards if the trench backfill were excavated. The explosion hazard results from the possibility of relatively high concentrations of fuel vapors or possible free product in a confined space (trench).

8.7 SUMMARY AND CONCLUSION

8.7.1 Summary

Groundwater and soil surrounding Site 9 are not contaminated; however, fuel is present in the backfill of the buried fuel lateral. Fuel in the trench backfill is contained by the tight clay soils.

8.7.2 Conclusion

No risk to the public or environment exists from Site 9, but any excavation near the trenches could result in exposure to workers or possible explosion hazards. The preferred alternative is no action with continued restricted access to the site.

9. SOUTHEAST CORNER OF FORBES FIELD ANGB PROPERTY

9.1 SITE BACKGROUND

The southeastern corner of Forbes Field ANGB property was included in the IRP study based on recommendations by Weston (1985) and HMTC (1986). The site was identified as an area of concern following discovery of oil and grease in groundwater (Weston 1985). The HMTC (1986) did not rate this area using the HARM.

9.1.1 Site Description

The southeast corner of Forbes Field ANGB property encompasses an undetermined area of the aircraft parking ramp (Plate 1, Fig. 9.1). Here, the flat ramp is drained by grated catchment basins flush with the surface. These are attached to a storm sewer system which drains into the small pond noted in Site 6 (Sect. 5).

The ramp continues south and east of base property as part of the MTAA airport. The fuel distribution laterals are on base property and on the MTAA property immediately to the south. These fuel hydrants are located in the aircraft parking ramp and allow a direct connection to aircraft for fueling and defueling. A flush-mounted lid covers the connections. Ramp construction consists of an 18 to 22 in. reinforced concrete pad with a 2 to 4 in. asphalt overlay. The fuel lines are buried approximately 3.5 ft under the concrete with a tee connection to each fuel hydrant.

9.1.2 Site History

The aircraft parking ramp was constructed between 1954 and 1959, as shown by aerial photographs taken in those years.

No contaminant spills or leaks have been reported in this area. The Phase I records search did not discover any information pertinent to the area other than the Weston (1985) report of groundwater contamination.

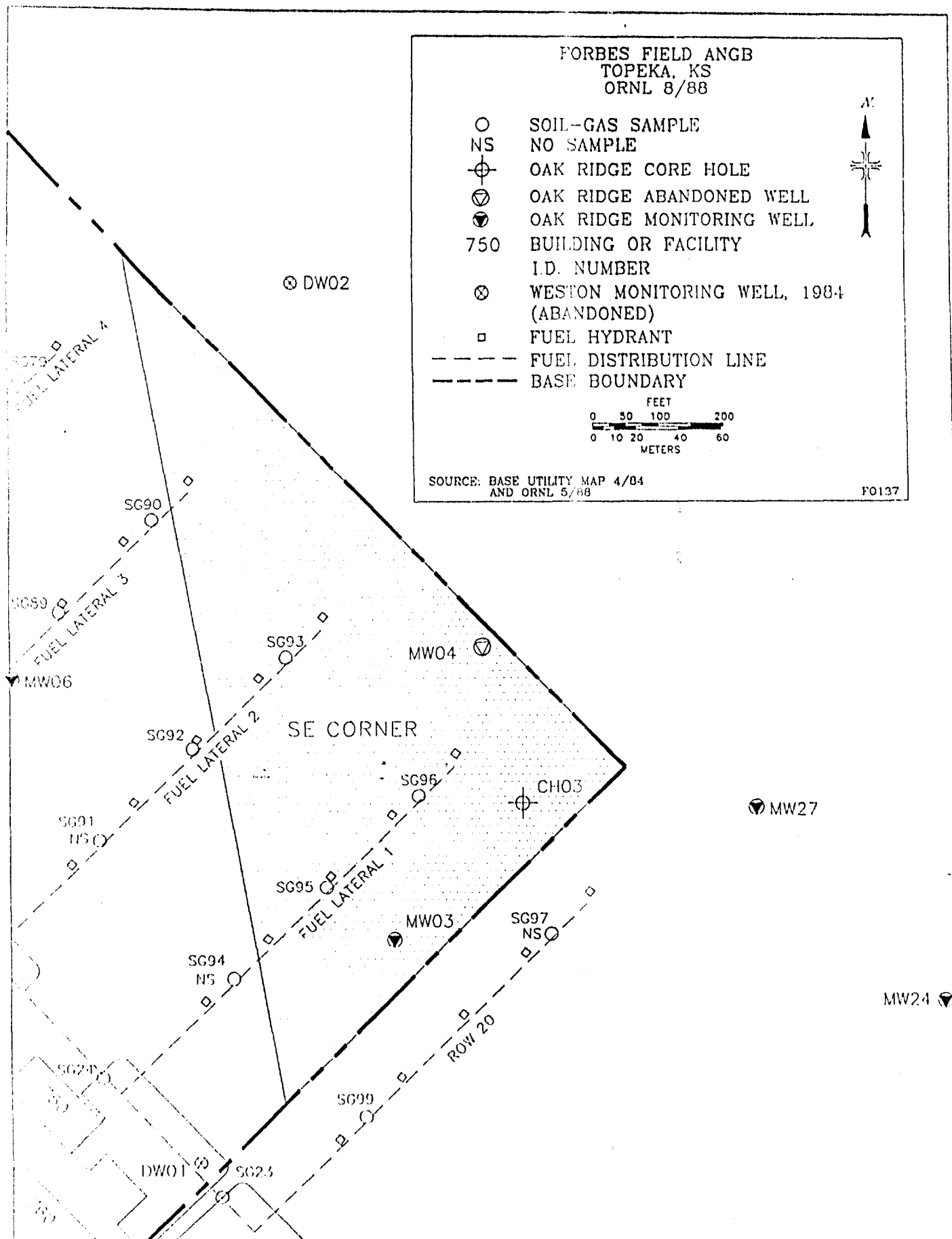


Fig. 9.1. Map of the southeast corner of Forbes Field ANGB.

9.1.3 Previous Investigations

Weston (1985) drilled a deep monitoring well (DW001) approximately 900 ft southwest of the southeast corner of the base property (Fig. 9.1). This well cased off the alluvial aquifer and intercepted the bedrock aquifer. The Weston groundwater samples, using oil and grease analysis, showed 710 $\mu\text{g/L}$ of oil and grease in DW001. ORNL/CAT collected a stagnant groundwater sample from DW001 in March 1988; the sample contained no detectable contamination. However, a fresh groundwater sample contained 680 $\mu\text{g/L}$ TPHCs plus a trace of benzene and xylenes (compound present but below quantifiable levels). No soil borings or shallow monitoring wells were drilled in the area prior to the ORNL/CAT investigation.

Weston also drilled DW002 approximately 900 ft northwest of the southeast corner of base property and about 20 ft east of the base property line. Weston (1985) groundwater samples contained less than the detection limit of 100 $\mu\text{g/L}$ of oil and grease. The ORNL groundwater sample collected in March 1988 showed 100 $\mu\text{g/L}$ of TPHCs in a stagnant water sample. A fresh water sample contained a trace (compounds present, but below quantifiable levels) of TPHCs. Neither sample contained benzene, toluene, ethylbenzene, or xylenes.

9.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

9.2.1 Surface Water Hydrology

Since the area surrounding the southeast corner of Forbes Field ANGB is part of the parking ramp and is paved, all of the precipitation occurring in the area becomes surface runoff. Due to the relatively flat topography, the runoff occurs as sheet flow and is routed through the storm sewer and eventually into the unnamed tributary to the South Branch of Shunganunga Creek (Site 6, Sect. 5). General surface water hydrology information for Forbes Field ANGB is discussed in Sect. 2.2.3.

9.2.2 Geology

The southeast corner of the base rests on unconsolidated sediments deposited during the Kansan Glaciation. Beneath these sediments lies a thin

zone of weathered bedrock and then competent bedrock of the Howard Limestone and Severy Shale. A complete description of base geology is presented in Section 2.2.4.

9.2.3 Soils

The southeast corner of Forbes Field ANGB soils are Ladysmith (Ld), 0 to 1% slope (USDA 1970). General soil information for the base is discussed in Sect. 2.2.5. and Table 2.7

9.2.4 Hydrogeology

The water bearing unit of interest underlying the southeast corner of the base is the unconsolidated aquifer in which water is found in the lower portion of the glacial drift or the underlying weathered bedrock. This unconsolidated aquifer is completely absent in portions of the base. The underlying bedrock consists of impermeable limestones and shales of the Howard Limestone which isolate the lower permeable Nodaway Coal unit.

A complete description of the Forbes Field ANGB hydrogeology is presented in Sect. 2.2.6. Groundwater flow direction and rates for the site are discussed in Sect. 9.3.6.

9.2.5 Demographics and Land Use

The large hangar, building 662, is 800 to 1000 ft downgradient. Building 662 contains offices and work stations for employees. The southeast corner is covered with a concrete and asphalt pad used for aircraft parking and fueling. No people reside within about 4000 ft of the site. The site is within the secured and patrolled portion of the base.

General demographics and land use for the base and Shawnee County are discussed in Sect. 2.2.11.

9.2.6 Ecology

No vegetation or wildlife is supported, as this site is covered with a concrete and asphalt pad. General ecology of the base is discussed in Sect. 2.2.12.

9.3 STUDY AREA INVESTIGATION

9.3.1 Surface Features

Field activities at the southeast corner of the base involved surveying to accurately map the fuel laterals, hydrants, soil-gas sample points, and monitoring well locations and elevations. A general description of base surface features is presented in Sect. 2.2.1.

9.3.2 Contaminant Source Investigation

The Phase I records search did not identify a source for the contamination. Weston (1985) concluded that the source of contamination was from past leaks in off-site laterals as well as a fire training area which was located to the east. This fire training area is located on the opposite side of the old Air Force Base and across the surface water and alluvial groundwater drainage divide. The local drainage divide follows the main runway in the vicinity of the base and controls the alluvial aquifer locally; therefore, the fire training area is not a source to this site.

9.3.3 Surface Water and Sediment Investigations

Surface water at the southeast corner of the base drains into the storm sewer system which then drains into the nearby unnamed tributary (Site 6) to the South Branch of Shunganunga Creek. Surface water and sediment investigations for Site 6 are discussed in Sect. 5.

9.3.4 Geological Investigation

The surface lithology information for the southeast corner of the base was obtained from borings of MW003, MW007, MW024, MW027, and abandoned hole MW004. With the use of a continuous sampler, a complete lithologic record was kept for each hole. Borehole 4, designated as MW004, was plugged and abandoned due to its inability to produce water. The well summary forms with well construction and lithologic descriptions are attached in Appendix G.

The surface lithology consists of unstratified silty clays deposited by melt waters from the receding glaciers; however, a slight variation in this lithology occurs southeast of the base in MW024 and MW027, discussed below. Surface sediments described from MW003, MW004, and MW007 are comprised of silty clays: gray to brown with greenish-gray mottling and very similar to those found in many of the other boreholes to the northwest. The sediments range from 16.5 ft in MW003 to 14.5 ft in MW004; however, in MW024 and MW027, these surficial deposits thicken considerably (up to 42 ft in MW024). In MW024, the sediments are comprised of yellowish-brown silts and silty clays with 2 in. stringers of fine-grained sand at 28 and 30 ft. At 38 ft, a 5.5 ft medium-grained, well-sorted sand was found overlying the bedrock sandstone. Similar sediments were found in MW027. Yellowish-brown silty clays were observed to 22 ft, grading to medium-grained sand overlying the claystone bedrock. Total depth of these sediments was 24 ft. The reason for these thicker deposits can be attributed to a much lower-energy erosional environment acting on these broad, relatively flat upland areas. The basal channel sand found overlying the bedrock in MW024, and to a lesser extent in MW027, can best be explained as a pre-existing paleo-channel which had scoured the bedrock before any glacial sediments were deposited.

MW003 was damp from 8.5 to 9 ft and wet from 17.5 to 18 ft. The bottom 1 ft of MW007 was damp; MW004 was abandoned as a dry well. The 5 ft of sand at the bottom of MW024 was wet; the sediments above were dry, with the exception of a trace of moisture from 26 to 27 ft. Sediments in MW027 were dry to about 18 ft, increasing to wet by 22 ft.

The bedrock in MW003, MW004, and MW007 consists of yellow-brown weathered claystone with visible relict bedding. The upper part of the bedrock in MW024 consists of yellowish-brown, fine-grained, noncalcareous sandstone, with some silty and oxidized mineral laminations, followed by a yellow-brown laminated claystone which is also noncalcareous. In MW027, the bedrock is a very weathered yellow-brown claystone marked by a pronounced erosional angle scoured by a paleo-channel prior to glacial sediment deposition. Directly underneath is a 2 in. sequence of gray calcite and a calcareous yellow-brown siltstone.

Weathered bedrock in all wells was thin (2 to 3 ft). The weathered bedrock was wet in MW003 and MW007, moist in MW027, and dry in MW024. Bedrock in the southeast corner is the upper Howard Limestone.

9.3.5 Vadose Zone and Soil Investigation

9.3.5.1 Vadose Zone

Soil-gas and water samples were collected from beneath the refueling apron along laterals 1 through 12 and lateral 20 (Plate 1). The samples were collected by drilling a 1.5 in. hole through the concrete, then driving the probe to a depth of about 3.5 ft. The fuel lateral distribution lines branch from the main trunkline every 300 ft, running about 3.5 ft beneath the surface of the apron. The lateral lines are bedded in a coarse sand which fills the trench to the undersurface of the apron. All the trenches contained water; some had water standing to the undersurface of the concrete.

Several samples were collected from the trench backfill of fuel laterals in the southeast corner of the base (Fig. 9.1). Results are discussed in Sect. 9.4.2.

Section 2.1.2.2 provides details on soil-gas collection methods.

9.3.5.2 Soils

Soil samples were collected with a 5-ft continuous sampler during the drilling of MW003, MW004, MW007, MW024, and MW027. Samples were inspected visually for contamination and monitored along their length with an HNU PID. If elevated readings were noted, a grab sample was taken. Otherwise, samples for chemical analysis were collected every 3 ft until the water table was reached. Samples were collected at 9-ft intervals in MW024 and MW027 since the wells were deeper and upgradient. Soil samples from the southeast corner were analyzed for VOAs and TPHCs. Analytical results are discussed in Sect. 9.4.2.

9.3.6 Groundwater Investigation

Five monitoring wells were installed in the area to determine the lithology, hydraulic conductivity, depth to water, groundwater flow direction, and the presence of contamination in the groundwater. Potentiometric maps, based on water-level measurements taken in July and September 1988, are shown in Fig. 2.13. These maps indicate a general groundwater flow direction to the northwest, toward the tributary to Shunganunga Creek (Site 6).

Based on groundwater flow direction, MW003, MW004, and MW007 are located downgradient of the suspected source area. These wells are near the property lines. MW004 was dry and was abandoned following drilling. In addition, MW006, an upgradient well for Site 7, provided downgradient water quality information for the southeast corner area.

Two monitoring wells, drilled about 300 and 500 ft southeast of base property, are the upgradient background wells for the project. However, they also provide information whether contaminants enter the base from a source further east. These two wells (MW024 and MW027) were drilled just east of the taxiway and upgradient of all fuel laterals and hydrants.

CH003 was drilled in the southeast corner of the base to determine if the bedrock aquifer is contaminated at the base property line.

Bail tests were performed on MW003, MW024, and MW027 to measure the permeability of the unconsolidated aquifer in the area. At MW003, there was insufficient water present in the well to perform the test. This is consistent with other wells in the area which were dry holes. MW024 and MW027 are located upgradient of the area. MW027 is located in the channel deposits discussed in Sect. 2.2.4. Surprisingly, this unit does not yield sufficient water for a reliable test. Only MW024 yielded a test from which the permeability could be calculated [hydraulic conductivity value of 4.0×10^{-5} cm/s (0.11 ft/d)].

A discussion of the base hydrogeology and results of the aquifer tests are presented in Sect. 2.2.6.

9.4 NATURE AND EXTENT OF CONTAMINATION

9.4.1 Sources

The likely source for the hydrocarbons discovered in DW001 in March 1988 is leachate from the Nodaway Coal. A soil sample from the coal seam revealed that the coal would give positive results on an oil and grease analysis (Sect. 2.1.2.13). Deep well DW001 penetrated the Nodaway Coal at a depth of 20 to 30 ft below ground level (as determined from the regional dip of bedrock and lithology logs from CH003).

The likely source for contamination detected in the Weston well DW002 is also hydrocarbon leaching in from the Nodaway Coal. Deep well DW002 was installed in the coal (as determined by lithology logs from CH003); therefore, the contamination in DW002 probably came from the coal.

9.4.2 Vadose Zone and Soils

9.4.2.1 Vadose Zone

Eight soil-gas samples were collected in the vicinity of the southeast corner; the values for these samples are:

<u>Sample number</u>	<u>mg/L</u>	<u>Sample number</u>	<u>mg/L</u>
SG79	34	SG93	58,400
SG89	79,200	SG95	99,200
SG90	169,000	SG96	21,600
SG92	721	SG99	15

These soil-gas values show significant levels of hydrocarbons in the northeast ends of fuel laterals 1, 2, and 3 (21,600; 58,400; and 169,000 $\mu\text{g/L}$, respectively). Samples from the southwest end of lateral 3 contained 21 $\mu\text{g/L}$; samples in the southwest end of laterals 1 and 2 could not be collected. Samples from the distribution line southwest of the ramp showed 18 to 67 $\mu\text{g/L}$.

Thus, fuel appears to be "pooling" in the northeast end or near the middle of the laterals. Complete results from the soil-gas survey are provided in Appendix D.

9.4.2.2 Soils

Soil samples from MW003, MW004, MW007, MW024, and MW027 were analyzed for VOAs and TPHCs. No contamination was detected in any of the samples. Significant analytical results are provided in Appendix E.

9.4.3 Groundwater

Groundwater samples were collected from MW003, MW007, MW024, MW027 and CH003 (Fig. 9.1). Samples collected in July were analyzed for VOAs, TPHCs,

metals, and major cations/anions. In addition, groundwater samples from MW027 and CH003 were analyzed for HSL pesticides, PCBs, and semi-volatiles. Samples collected in September/October were analyzed for VOAs and TPHCs. The July groundwater sample from CH003 contained 1 $\mu\text{g/L}$ of toluene, which is at the detection limit, but no other detectable contamination. The September/October sample contained no detectable contaminants. Significant analytical results are provided in Appendix E.

9.4.4 Surface Water and Sediments

No surface water or sediment samples were collected at the southeast corner of the base.

9.4.5 Air

Routine air monitoring during drilling was performed with an HNU model PI-101 PID. No anomalous readings were obtained while monitoring ambient air.

9.5 CONTAMINANT FATE AND TRANSPORT

No contamination was found in the soil at the southeast corner of the base. Apparent contamination in the Weston wells is probably due to leaching from the Nodaway Coal. The absence of VOAs and TPHCs in the monitoring wells indicates that all fuel spilled at the site is confined to the fuel trenches.

9.5.1 Contaminant Persistence

A discussion on the persistence of JP-4 derived contaminants is presented in Sect. 3.5.1.

9.5.2 Potential Routes of Migration

The potential route of exposure to a receptor from contamination at the southeast corner is leaching to the drainage ditch. No contamination was found in soil or groundwater samples collected from ORNL/CAT monitoring wells at this site.

9.5.3 Contaminant Migration

The clay soils encountered at this site apparently confine the spilled fuel to the backfill within the fuel line trenches. There is no evidence that a contaminant plume is migrating from the area.

See Sect. 3.5.3 for additional details.

9.6 BASELINE RISK ASSESSMENT

This section describes the public health and environmental concerns resulting from the southeast corner of the base. Contaminants identified at this site are TPHCs (21,600 $\mu\text{g/L}$), which were found in the fuel lateral 1 trench backfill using soil-gas samples.

The risk assessment for the base, including details of exposure pathways, exposure scenarios, toxicity of chemicals, and risk characterization is presented in Appendix J.

The following evaluation of potentially contaminated media demonstrates that there is no present exposure from contamination at the southeast corner.

9.6.1 Exposure Assessment

9.6.1.1 Air

Air emissions were evaluated with a hand-held survey meter at ground level. The data showed that there were no emissions from the site; however, soil-gas measurements did demonstrate that anomalous concentrations of TPHCs were present in the subsurface. The concentrations were so low that, in combination with the concrete ramp, any transport to the surface would be minute and quickly diluted so that exposure to the public or even military personnel using the site would be insignificant.

9.6.1.2 Groundwater

Monitoring wells installed by ORNL/CAT surrounding the area indicated that groundwater at this site is not contaminated.

9.6.1.3 Surface Water

There is no possibility of surface water contamination, since there is no contamination in the subsurface.

9.6.1.4 Soil

None of the soil samples collected at this site were contaminated.

9.6.2 Risk Evaluation

No contaminants of concern were detected in the unconsolidated sediments and groundwater at the southeast corner. Consequently, there is no potential for carcinogenic or non-carcinogenic health effects from exposure to contaminated media at the southeast corner.

The only potential risk is exposure of workers to air contaminants or possible explosion hazards if the trench backfill were excavated. The explosion hazard results from the possibility of relatively high concentrations of fuel vapors or possible free product in a confined space (trench).

9.7 SUMMARY AND CONCLUSIONS

9.7.1 Summary

Groundwater and soil surrounding this site are not contaminated; however, fuel may be present in the backfill of buried fuel lines. Fuel in the trench backfill is contained by the tight clay soils.

9.7.2 Conclusions

No contamination is entering the southeast corner of the base from an off-base source. Contamination in the area is confined to sandy backfill in the fuel lateral trenches. Any excavation of the trenches could result in exposure to workers or possible explosion hazards. The preferred alternative is no action with continued restricted access to the site.

10. LATERAL 6, HYDRANT 3 - "HOT-SPOT"

10.1 SITE BACKGROUND

The lateral 6, hydrant 3 "hot-spot" was investigated to provide additional information for the IRP sites associated with the aircraft parking ramp. For ease of discussion, the term "hot-spot" will be used to designate the site at lateral 6, hydrant 3.

10.1.1 Site Description

The hot-spot consists of the area surrounding the middle fuel hydrant on fuel lateral 6, northeast of building 671 (Plate 1). Here, the flat ramp is drained by grated catchment basins set flush with the surface. These are attached to the storm sewer system which drains into the small pond noted in Site 6 (Sect. 5).

The fuel hydrants are located on the aircraft parking ramp. Each hydrant allows a direct connection to aircraft for fueling and defueling. A flush mounted lid covers the connections. Ramp construction consists of an 18 to 22 in. reinforced concrete pad with a 2 to 4 in. asphalt overlay. The fuel lines are buried approximately 3.5 ft under the concrete with a tee connection to each fuel hydrant. Lateral 6 receives fuel from pumphouse E, building 671 (Sect. 4).

10.1.2 Site History

The aircraft parking ramp was constructed between 1954 and 1959 as shown by aerial photographs taken in those years.

No fuel spills or leaks have been reported in connection with fuel lateral 6.

This site was investigated because a soil-gas sample, collected by ORNL/CAT near hydrant 3 on lateral 6 contained 7550 $\mu\text{g/L}$ of TPHCs; the highest soil-gas measurement near sites 8 and 9. Fuel lateral 6 is still in use.

10.1.3 Previous Investigations

No previous work has been performed near the hot-spot.

10.2 PHYSICAL CHARACTERISTICS OF THE STUDY AREA

10.2.1 Surface Water Hydrology

Since the area surrounding the hot-spot is part of the parking ramp and is paved, all of the precipitation occurring in the area becomes surface runoff. Due to the relatively flat topography, the runoff occurs as sheet flow and is routed through the storm sewer and eventually into the unnamed tributary to the South Branch of Shunganunga Creek (Site 6, Sect. 5). General surface water hydrology information for Forbes Field ANGB is discussed in Sect. 2.2.3.

10.2.2 Geology

The fuel lateral 6 area rests on unconsolidated sediments deposited during the Kansan Glaciation. Beneath these sediments lies a thin zone of weathered bedrock and then competent bedrock of the Howard Limestone and Severy Shale. A complete description of the geology at the base is presented in Section 2.2.4.

10.2.3 Soils

Hot-spot soils are Ladysmith (Ld), 0 to 1% slope (USDA 1970). General soil information for the base is discussed in Sect. 2.2.5 and Table 2.7.

10.2.4 Hydrogeology

The only water bearing unit of interest underlying the hot-spot is the unconsolidated aquifer in which water is found in the lower portion of the glacial drift or the underlying weathered bedrock. This unconsolidated aquifer is completely absent in portions of the base. The underlying bedrock consists of impermeable limestones and shales of the Howard Limestone which isolate the lower permeable Nodaway Coal unit.

A complete description of the Forbes Field ANGB hydrogeology is presented in Sect. 2.2.6. Groundwater flow direction and rates for the site are discussed in Sect. 10.3.6.

10.2.5 Demographics and Land Use

Building 679, the squadron operations building, is 900 ft downgradient of the site. Building 679 contains offices and other work areas. The hot-spot is covered with a concrete and asphalt pad used for aircraft parking and fueling. No people reside within approximately 1200 ft of the site.

General demographics and land use for the base and Shawnee County are discussed in Sect. 2.2.11.

10.2.6 Ecology

No vegetation or wildlife is supported as this site is covered with a concrete and asphalt pad. General ecology of the base is discussed in Sect. 2.2.12.

10.3 STUDY AREA INVESTIGATION

10.3.1 Surface Features

Field activities at the hot-spot involved surveying to accurately map the fuel lateral, hydrants, soil-gas sample points, and monitoring well locations and elevations. A general description of surface features on the base is presented in Sect. 2.2.1.

10.3.2 Contaminant Source Investigations

The contaminant source investigation at lateral 6, hydrant 3 included a review of base documentation of fuel lateral tests and the Phase I records search. The Phase I did not identify a source for the contamination. Probable sources include surface spills which have migrated through crevices in the ramp or past small leaks in the fuel line.

10.3.3 Surface Water and Sediment Investigations

Surface water in the area of the hot-spot drains into the storm sewer system which then drains into the nearby unnamed tributary (Site 6) to the South Branch of Shunganunga Creek. Surface water and sediment investigations for Site 6 are discussed in Sect. 5.

10.3.4 Geological Investigation

Surface lithology information for the fuel lateral 6 area was obtained from the boring of MW023. With the use of a continuous sampler, a complete lithologic record was kept for the hole. The well summary form, with well construction and lithologic descriptions, is attached in Appendix G.

The surface lithology around this site consists of unstratified silty clays deposited by melt water from the receding glaciers. These clays are predominantly very dark gray to grayish-brown, plastic, stained with limonite oxide, locally micaceous, and marked by scattered greenish-gray silts. The sediments are 12.5 ft thick. Sediments become damp about 6 in. from the weathered bedrock.

The surface lithology in this area is very consistent with adjacent areas, but the upper 7.5 ft might be backfill material; this suspicion is raised by the presence of fine root matter at 7.5 ft. However, since the backfill material is most likely derived from nearby areas to the south and east, which were topographically higher, it is difficult to distinguish backfill from native sediments.

The sediments overlie a weathered yellow-brown claystone interbedded with gray and black carbonaceous shales. Visible relict bedding was encountered in the claystone. Moisture was encountered in the well at 13.2 ft. The weathered bedrock in the hot-spot is part of the lower Howard Limestone. The underlying bedrock consists of the impermeable limestones and shales of the Howard Limestone.

10.3.5 Vadose Zone and Soil Investigations

10.3.5.1 Vadose Zone

Soil-gas and water samples were collected from beneath the refueling apron along laterals 1 through 12 and lateral 20 (Plate 1). The samples were collected by drilling a 1.5 in. hole through the concrete, then driving the probe to a depth of about 3.5 ft. The fuel lateral distribution lines branch from the main trunkline every 300 ft, running about 5 ft beneath the surface of the apron. The lateral lines are bedded in a coarse sand which fills the trench to the undersurface of the apron. All the trenches contained water; some had water standing to the undersurface of the concrete.

One sample was collected from the backfill of fuel lateral 6, as shown on Plate 1. Sample SG83 was collected adjacent to hydrant 3. Results are discussed in Sect. 10.4.2.

Section 2.1.2.2 provides details on soil-gas collection methods.

10.3.5.2 Soils

Soil samples were collected with a 5-ft continuous sampler during the drilling of MW023. The samples were inspected visually for contamination and monitored along their length with an HNU PID. If elevated readings were noted, a grab sample was taken. Otherwise, samples for chemical analysis were collected every 3 ft until the water table was reached. Soil samples from hot-spot were analyzed for VOAs and TPHCs. Analytical results are discussed in Sect. 10.4.2.

10.3.6 Groundwater Investigations

Several monitoring wells were installed in the surrounding area to determine the lithology, hydraulic conductivity, depth to water, groundwater flow direction, and the presence of contamination in the groundwater. Potentiometric maps, based on water-level measurements taken in July and September 1988, are shown in Fig. 2.13. These maps indicate a general groundwater flow direction to the northwest, toward the tributary to Shunganunga Creek (Site 6).

Based on the groundwater flow direction, MW023 is located downgradient of the soil-gas hot-spot. This location was chosen to determine if fuel in the trench was leaching into the surrounding soil. MW011, upgradient to Site 8 and downgradient of the hot-spot, would also intercept contamination leaving the site. MW007, installed to monitor the southeast corner and upgradient of the hot-spot, would identify any contamination entering the site from another source.

A bail test was performed on MW023 to measure the permeability of the unconsolidated aquifer in the area. The permeability was insufficient to yield reliable results. Permeability for other wells in the area ranged from insufficient results to 7.1×10^{-4} cm/s (2.0 ft/d), indicating some discontinuity in the aquifer permeability.

A discussion of the base hydrogeology and results of the aquifer tests are presented in Sect. 2.2.6.

10.4 NATURE AND EXTENT OF CONTAMINATION

10.4.1 Sources

Hydrocarbons were discovered in the fuel lateral trench and in the soil 1 ft below the aircraft ramp just downgradient of the trench. The two likely sources are as follows:

1. Past fuel spills on the surface which migrated through crevices in the ramp into the trench. Activities which could cause small spills include connecting and disconnecting aircraft and bleeding of air from the fuel lines -- over a period of thirty years, accumulations could be detectable.
2. Small leaks in the fuel lateral; although recent base pressure tests show that fuel lateral 6 is not leaking.

Either of these sources, or some combination of both, is likely the source of hydrocarbons in the trench.

10.4.2 Vadose Zone and Soils

10.4.2.1 Vadose Zone

A water sample, collected and analyzed using the soil-gas equipment, was collected from the sandy backfill at hydrant 3 on lateral 6. This sample (SG83, Plate 1) revealed 7550 $\mu\text{g/L}$ of TPHCs. Further northeast in this lateral, a sample revealed 989 $\mu\text{g/L}$ of TPHCs (SG82). Complete results from the soil-gas survey are provided in Appendix D.

10.4.2.2 Soils

Soil samples collected from MW023 revealed 16,000 $\mu\text{g/kg}$ of TPHCs at 3 ft. A soil sample at 6 ft revealed 22 $\mu\text{g/kg}$ of toluene with no other fuel components detected. Samples from 9 ft were clean. The 3 ft soil sample was collected only 1 ft below the bottom of the concrete pad. Significant analytical results are provided in Appendix E.

10.4.3 Groundwater

Groundwater samples were collected from MW023 (Plate 1). A sample collected in July was analyzed for VOAs, TPHCs, HSL metals, and major cations/anions. No contaminants were detected in the sample.

During September/October two groundwater samples were collected from MW023, these samples were analyzed for VOAs and TPHCs. A sample was collected both before and after purging the monitoring well. These two samples were collected because the soil samples from 3 ft and 6 ft contained fuel compounds, but the groundwater sample collected in July contained no detectable contamination. Sampling the groundwater from MW023 prior to purging would determine if contamination was present in the stagnant water in the well. The sample collected prior to purging contained 3 $\mu\text{g/L}$ toluene; no other contamination was detected in either sample. No conclusion can be drawn from the toluene since no other fuel compounds are present and the level is very low. Significant analytical results are provided in Appendix E.

10.4.4 Surface Water and Sediments

No surface water or sediment samples were collected at lateral 6, hydrant 3.

10.4.5 Air

Routine air monitoring during drilling was performed with an HNU model PI-101 PID. No anomalous readings were obtained while monitoring ambient air, indicating that even though organic compounds are present in the subsurface, volatilization to the atmosphere is insignificant.

10.5 CONTAMINANT FATE AND TRANSPORT

Contamination in the soil at the hot-spot is the result of jet fuel which spilled or leaked in the fuel lateral trench backfill. The absence of chlorinated solvents and other non-fuel related compounds has been established by both soil and groundwater analyses.

10.5.1 Contaminant Persistence

A discussion on the persistence of JP-4 derived contaminants is presented in Sect. 3.5.1.

10.5.2 Potential Routes of Migration

The potential route of exposure to a receptor from contamination at the hot-spot is leaching to the nearby drainage ditch. MW011 (upgradient well at Site 8) is downgradient of the hot-spot and MW007 (monitoring well for the southeast corner) is upgradient of the hot-spot. MW023, downgradient of the hot spot, contains contaminated soil at 3 ft but no further significant soil or groundwater contamination. MW007 and MW011 are uncontaminated.

Additional potential routes of migration include air emissions and flow in the backfill around the buried fuel lines and pipes. Field measurements demonstrated that there are no detectable hydrocarbon emissions from the site. Thus, unless the area were excavated, there is no significant air exposure. Since drilling was always performed to avoid hitting fuel lines, migration in the backfill is a possibility that cannot be discounted.

10.5.3 Contaminant Migration

The clay soils at this site apparently confine the fuel to the backfill within the fuel line trench. The fuel located in the soil under the concrete at MW023 probably indicates migration under the pad rather than through the clay soil. Since the groundwater downgradient of the hot-spot in the trench is uncontaminated, the fuel apparently is not migrating down to the water table due to the tight clay soil.

See Sect. 3.5.3 for additional details.

10.6 BASELINE RISK ASSESSMENT

This section describes the public health and environmental concerns resulting from the lateral 6, hydrant 3 hot-spot. Contaminants at this site are TPHCs, which were found in the soil-gas survey (7550 $\mu\text{g/L}$) and in soil samples (16,000 mg/kg); however, groundwater samples from the site were uncontaminated.

The risk assessment for the base, including details of exposure pathways, exposure scenarios, toxicity of chemicals, and risk characterization is presented in Appendix J.

The following evaluation of potentially contaminated media demonstrates that there is presently no exposure from contamination near the lateral 6, hydrant 3 hot-spot.

10.6.1 Exposure Assessment

10.6.1.1 Air

Air emissions were evaluated with a hand-held survey meter at ground level. The data showed that there were no emissions from the site. Soil-gas measurements, however, did demonstrate that anomalous concentrations of TPHCs were present in the subsurface. The concentrations were so low that, in combination with the concrete ramp, any transport to the surface would be minute and quickly diluted such that exposure to the public or even military personnel using the site would be insignificant.

10.6.1.2 Groundwater

The monitoring well at this site indicated that the groundwater is not contaminated.

10.6.1.3 Surface Water

Contaminants leaching from the area presumably could migrate in the trench backfill to the storm drainage system. The storm sewers were backfilled with native clay soil which will inhibit migration, although not as much as undisturbed soil would inhibit migration.

10.6.1.4 Soil

Soil samples taken from MW023 contained 16,000 $\mu\text{g}/\text{kg}$ of TPHCs at a depth of 3 ft. The data indicate that exposures to fuel-derived hydrocarbons could result if the area were excavated. No exposure to humans or the environment would occur for present usage of the site.

10.6.2 Risk Evaluation

The actual risks from contamination in the unconsolidated sediments and groundwater at the hot-spot were not calculated since the area was not an identified site in the IRP. The characteristics of the site are the same as for Site 8 and the contaminants of concern are the same as for Site 5, with

two exceptions: the levels of contamination are lower at the hot-spot than the levels at Site 5 and there is no groundwater contamination. Therefore, risks will be less and there will be no off-base risk.

Using the risk evaluation scenarios and conditions from Sites 5 and 8, construction workers could be exposed to four of the contaminants of concern (benzene, ethylbenzene, toluene, and xylene) via inhalation or dermal absorption of contaminants in subsurface soils. Estimation of possible exposures via volatilization from soils assumes that 100% of the concentrations found in the soil will volatilize and be inhaled by the receptors. Estimation of dermal absorption exposures assumes a 100% absorption across the skin barrier.

Construction worker exposures to contaminated subsurface soil indicates a negligible probability of carcinogenic effects resulting from either inhalation or dermal absorption of benzene. In addition, the hazard indices for these exposure routes are well below levels of concern.

The only potential risk is exposure of workers to air contaminants or possible explosion hazards if the trench backfill were excavated. The explosion hazard results from the possibility of relatively high concentrations of fuel vapors or possible free product in a confined space (trench).

10.7 SUMMARY AND CONCLUSIONS

10.7.1 Summary

Soil samples from MW023 show contamination at 3 ft; however, no contamination has leached into the groundwater. Indeed, the contamination at 3 ft is likely a sign of fuel migrating just under the pad. Fuel in the trench backfill is contained by the tight clay soils.

10.7.2 Conclusion

No risk to the public or environment exists from the lateral 6, hydrant 3 hot-spot, but any excavation near the trenches could result in exposure to workers or possible explosion hazards. The preferred alternative is no action with continued restricted access to the site.

11. CONCLUSIONS AND RECOMMENDATIONS

11.1 MAJOR FINDINGS

Fuel is present in the subsurface environment at Forbes Field ANGB. This fuel, however, is mostly held within backfill surrounding the fuel laterals under the aircraft ramp. Fuel also exists in the soil under the tank farm area and in sediments in the drainage ditch. None of these sources of fuel appear to be leaching into the groundwater. In fact, the only contaminated groundwater discovered was in wells drilled into a known spill area (MW009); sludge burial areas (MW019 and MW021) and near the pumphouse (MW028) in the tank farm; and storm sewer/fuel line backfill (SW005, Weston). Wells drilled downgradient of each of these areas contained no detectable contamination.

The tight clay soils inhibit groundwater flow. In wells with a measurable value, hydraulic conductivity values range from 4.0×10^{-5} to 3.4×10^{-4} cm/s (0.11 to 0.97 ft/day). Most of the wells yield values below the measurable range using single well tests. Thus, groundwater as a potential pathway for contaminant migration appears to be insignificant. For example, MW021 (Site 1) showed 760 $\mu\text{g/L}$ of TPHCs while MW026, located less than 50 ft downgradient, contained no detectable contamination.

Groundwater quality at the base and upgradient of the base is poor. Even if the hydraulic conductivity allowed production of usable quantities of groundwater, the poor quality would preclude both domestic use and most irrigation use.

Sediments in a ditch draining the site contain TPHCs, polynuclear aromatics, and pesticides; however, the contamination pattern is not consistent throughout the course of the ditch. Thus, these compounds are probably the result of small spills and inflow from roads and the aircraft ramp. Low-flow surface water samples do not show contamination from the above compounds.

Low-flow surface water samples collected at the head of the ditch, below the storm sewer outflow at the south end of the base, show contamination by chlorinated hydrocarbons ($<50 \mu\text{g/L}$). This storm sewer drains a portion of the southwest end of the base, half of the large aircraft hangar (building 662), and part of the old Air Force Base which is presently occupied by light industry. No source for the chlorinated hydrocarbons has been determined; however, it is unlikely that any of the sites studied in this investigation are the source.

Since the tight clay soils severely inhibit contaminant migration, fuel in the lateral trenches is essentially confined by the soil and, therefore, "pools" at the low point (as if in a bathtub). Since the water table lies 3 to 9 ft below the bottom of the lateral trenches, the groundwater will not contact the fuel within the trench. Water levels reported by Weston (1984) show only minor variation with levels measured by ORNL in 1988, indicating that the water level under the ramp is stable. Because the leaching process is so slow, high concentrations of fuel may never reach the water table under the ramp.

Two other pathways for off-base subsurface migration were evaluated: the domestic gas lines and water lines crossing the base from north to south along the west side of the base. The north end of these lines passes over the top of the main storm sewer just east of the pond. Near the center of the base, these gas and water lines also pass over the fuel lines from the tank farm to the base. Thus, since these domestic lines are located above the potential contaminant sources, fuel migrating in the storm sewer trench and fuel line backfill would not enter the trenches for the domestic lines.

The baseline risk assessment indicates little likelihood of exposure to humans or biota from any site except the drainage ditch (Site 6). Exposure from the ditch is minimal and is mitigated by the conservative assumptions used in the risk assessment.

11.2 DATA NEEDS

Periodic monitoring of the drainage ditch (Site 6), in accordance with Air National Guard Regulation 19-7, is recommended as part of the base's environmental monitoring program.

The chlorinated hydrocarbons in the surface water at the head of the ditch indicate a source within the southern storm drainage system. An investigation of individual tributaries to the storm sewer system is needed to locate the source of the contaminants.

11.3 RECOMMENDATIONS

1. No action is recommended for each of the study sites with the exception that monitoring should be instituted for the drainage ditch (Site 6), in accordance with Air National Guard Regulation 19-7.

2. A focused feasibility study should be prepared to determine a method for disposal of contaminated soil which will be excavated during the aircraft parking ramp construction.
3. A study should be conducted to determine the source of chlorinated hydrocarbons in the storm sewer system at the south end of the base.
4. No future excavations near fuel distribution lines or laterals should be undertaken without being prepared to deal with fuel-contaminated backfill. Construction workers could be exposed to significant air contaminants and possible explosion hazards. The explosion hazard results from the possibility of relatively high concentrations of fuel vapors or possible free product in a confined space (trench).
5. After closure of the sites involved in this IRP study, the monitoring wells should be abandoned.

APPENDIX A

GLOSSARY AND ACRONYMS

GLOSSARY

ADSORPTION: Adherence of gas molecules or ions or molecules in solution to the surfaces of solids with which they are in contact.

AEOLIAN (EOLIAN): Pertaining to the wind; said of geologic processes (such as erosion and deposition) accomplished by the wind.

ALKANES: Any of a series of straight chain saturated hydrocarbons C_nH_{2n+2} (as methane).

ALLUVIAL: Pertaining to materials eroded, transported and deposited by streams or running water.

ANALYTES: Chemical elements or compounds which are identified by specific laboratory methods of analyses.

ANION: An ion having a negative charge. Anions in a liquid subjected to electric potential collect at the positive pole or anode.

ANNULAR HEADSPACE: The ring-shaped space between the outer wall of a drill pipe suspended in a borehole and the casing or the side of the open hole or the inner side of a larger pipe, or a similar space between the casing and the wall of a hole.

AQUIFER: Rock or sediment in a formation, group of formations, or part of a formation which is saturated and sufficiently permeable to transmit water to wells and springs.

AQUIFER, CONFINED: An aquifer bounded above and below by impermeable strata or by geologic units of distinctly lower permeability than that of the aquifer itself.

AQUIFER, UNCONFINED: An aquifer in which there are no confining beds between the zone of saturation and the surface. There will be a water table in an unconfined aquifer.

ARGILLACEOUS: Largely composed of, or containing clay-size particles or clay minerals.

AROMATIC: A major group of unsaturated cyclic hydrocarbons containing one or more rings; these are typified by benzene which has a 6-carbon ring containing three double bonds. There are vast numbers of compounds of this important group. They are derived chiefly from petroleum and coal tar.

BACKFILL: Earth or other material used to replace material removed during construction, mining, or drilling.

BAIL TEST: A test to determine the hydraulic conductivity of the aquifer by instantaneously removing a volume of water from a well and then measuring the water level recovery as a function of time.

BEDROCK: Any solid rock exposed at the surface of the earth or overlain by unconsolidated material.

BENZENE: A colorless, volatile, flammable, carcinogenic, toxic, aromatic liquid hydrocarbon, C_6H_6 , used in organic synthesis, as a solvent, and as a component of JP-4, gasoline, and diesel fuel.

BIODEGRADABLE: Capable of being broken down especially into innocuous products by the action of living things (as microorganisms).

BORROW DITCH: A term used chiefly in western U.S. for a borrow pit; especially a ditch dug along a roadway to furnish fill for the road, also used for drainage along the side of a road.

BROMODICHLOROMETHANE: $CHBrCl_2$; a colorless liquid used as a fire extinguisher fluid ingredient and a solvent for fats, waxes, and resins.

CALCAREOUS: Said of a substance that contains calcium carbonate.

CAPILLARY FRINGE: The zone immediately above the water table, where water is drawn upward by capillary attraction.

CARBONACEOUS: Said of a rock or sediment that is rich in carbon; coaly.

CARCINOGENIC: Able to produce cancer in living cells.

CATION: An ion having a positive charge. Cations in a liquid subjected to electrical potential collect at the negative pole or cathode.

CHLOROFORM: CHCl_3 ; a colorless, heavy, volatile, carcinogenic liquid; used in refrigerants, propellants, solvents, insecticides and fire extinguishing.

COMPOUND: A substance composed of atoms or ions of two or more elements in chemical combination. The constituents are united by bonds or valence forces. A compound has characteristic properties quite different from those of its constituent elements.

CONDUCTIVITY: See electrical conductivity.

CONTAMINANT: Any substance accidentally or unwillingly introduced into air, water, soil or food products which has the effect of rendering them toxic or otherwise harmful.

CONTAMINATION: The degradation of natural water, soil, or air quality to the extent that its usefulness is impaired; there is no implication of any specific limits since the degree of permissible contamination depends upon the intended end use or uses of the contaminated substrate.

CYCLOTHEMS: A geologic term for a series of beds deposited during a single sedimentary cycle of the type that prevailed during the Pennsylvanian Period. Because of extremely variable development, a cyclothem cannot be defined rigidly in terms of the members actually present at any locality. Cyclothems are typically associated with unstable shelf or interior basin conditions in which alternate marine transgressions and regressions occur; nonmarine sediments usually occur in the lower half of a cyclothem, marine sediments in the upper half.

DECANE: Any of several isomeric liquid hydrocarbons $\text{C}_{10}\text{H}_{22}$ of the methane series.

DESORPTION: The process of removing an adsorbed material from the solid on which it is adsorbed. Desorption may be accomplished by heating, by reduction of pressure, by the presence of another more strongly adsorbed substance, or by a combination of these means.

DIAGENESIS: The process involving physical and chemical changes in sediment after deposition that converts it to consolidated rock.

DIBROMOCHLOROMETHANE: CHBr_2Cl ; a clear, colorless, heavy, irritant and narcotic liquid; used in fire extinguishers, aerosol agents, and organic synthesis.

DIELDRIN: Complex chlorinated compound; light tan, flaked solid; used as an insecticide. Carcinogenic.

DIP: The angle measured from the horizontal that a structural feature makes. Structural features may include bedding, folds, faults, etc. Dip is measured in degrees of the vertical plane, normal to strike.

DISCONTINUITY: Any stratigraphic interruption in sedimentation: usually a manifestation of non-deposition and accompanying erosion.

DOWNGRAIENT: In the direction of decreasing hydraulic static head; the direction in which ground water flows.

DRAWDOWN: A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of groundwater from wells.

DUPLICATES: Identical splits of individual samples which are analyzed by the laboratory to test for method reproducibility.

ELECTRICAL CONDUCTIVITY: A measure of the ease with which a conduction current can be caused to flow through a material under the influence of an applied electric field. It is reciprocal of resistivity and is measured in mhos per meter.

EQUIPMENT RINSATE: The final analyte-free water rinse from equipment cleaning collected daily during a sampling event.

ETHYLBENZENE: A colorless flammable aromatic hydrocarbon used as a solvent and intermediate in production of styrene.

FIELD BLANK: Blank collected and analyzed to determine the level of contamination introduced into the sample due to sampling technique.

GAS CHROMATOGRAPHY: The process in which components of a mix are separated from one another by volatilizing the sample into a carrier gas stream which is passing through and over a bed of packing. Different components move through the bed of packing at different rates and so appear at the effluent end, where they are detected and measured by thermal conductivity changes, density differences, or ionization detectors. Gas chromatography is advantageous as a means of analysis of minute quantities of complex mixtures.

GLACIOFLUVIAL: Pertaining to the meltwater streams flowing from wasting glacier ice and especially to the deposits and landforms produced by such streams.

GLACIOLACUSTRINE: Deposited in glacial lakes

GROUNDWATER: The water contained in interconnected pores located below the water table in an unconfined or confined aquifer.

HEADWARD EROSION: The lengthening and cutting back upstream of a young valley or gully above the original source of its stream.

HEAVY METALS: Metallic elements, including the transition series, which include many elements required for plant and animal nutrition in trace concentrations but which become toxic at higher concentrations.

HNU MODEL PI101: Photoionization meter, organic vapor detector.

HYDRAULIC CONDUCTIVITY: A coefficient of proportionality describing the rate at which water can move through a permeable medium. The density and kinematic viscosity of the water must be considered in determining hydraulic conductivity.

HYDROCARBONS: Organic chemical compounds composed of hydrogen and carbon atoms that are chemically bonded. Hydrocarbons may be straight chain, cyclic, branched chain, aromatic, or polycyclic, depending upon the arrangement of carbon atoms. Halogenated hydrocarbons are hydrocarbons in which one or more hydrogen atoms have been replaced by a halogen atom.

INDAN: A bicyclic hydrocarbon; a colorless liquid insoluble in water, soluble in alcohol and ether, combustible, a derivative of coal tar.

INORGANIC: Composed of substances that are not compounds of carbon, with the exception of carbon oxides and carbon disulfide. Being or composed of matter other than plant or animal: mineral.

JETTING (air jetting): A well development technique whereby nitrogen gas is injected into the water column and through the screen slots in order to sort filter pack and surrounding formation materials to facilitate flow of sediment-free water to the screen.

KINEMATIC VISCOSITY: The ratio of dynamic viscosity to mass density. It is obtained by dividing dynamic viscosity by the fluid density. Units of kinematic viscosity are square meters per second.

LACUSTRINE: Pertaining to, produced by, or formed in a lake or lakes.

LEACHATE: A solution resulting from the separation or dissolving of soluble or particulate constituents from solid waste or other media by percolation of water.

LEACHING: The process by which soluble materials in the soil, such as nutrients, pesticide chemicals or contaminants, are washed into a lower layer of soil or are dissolved and carried away by water.

LIMONITE: A general field term for a group of brown, amorphous, naturally occurring hydrous ferric oxides.

LIQUINOX: A non-phosphate laboratory detergent used in decontamination of field sampling equipment.

LITHOLOGY: The description of the physical character of a rock.

LOESS: A widespread, homogenous, commonly unstratified, porous, friable, unconsolidated blanket deposit consisting predominantly of silt with subordinate amounts of very fine sand and/or clay.

MATRIX SPIKE: An aliquot of a matrix (water or soil) spiked with known quantities of compounds and subjected to the entire analytical procedure in order to indicate the appropriateness of the method for the matrix by measuring recovery.

MATRIX SPIKE DUPLICATE: A second aliquot of the same matrix (as the matrix spike) that is spiked in order to determine the precision of the method.

METHOD BLANK: A blank sample run to ensure reported analytical results are not the results of laboratory contamination.

METALS: See "Heavy Metals"

MICA: A group of minerals that are characterized by low hardness and by perfect basal cleavage, readily splitting into thin, tough, somewhat elastic laminae or plates with a pearly luster. They range in color from colorless, silvery white to black. Micas are prominent rock-forming constituents of igneous and metamorphic rocks, and commonly occur as flakes, scales, or shreds.

MICACEOUS: Consisting of, containing, or pertaining to mica.

MICROBES: Microorganisms; forms of life that are either too small to be seen with the unaided eye or are barely discernible.

MONITORING WELL: A well used to measure groundwater levels and to obtain groundwater samples for water quality analyses. As distinguished from observation wells, monitoring wells are often designed for longer term operations. They are constructed of materials for the site-specific climatic, hydrogeologic and contaminant conditions.

MUNSELL SOIL COLOR SYSTEM: A system of color classification that is applied in geology to the color of rocks and soil. Color is defined by its hue, value or brilliance, and chroma (purity).

NAPHTHALENE: A crystalline aromatic hydrocarbon usually obtained by distillation of coal tar and used especially in organic synthesis.

NEUMAN'S TYPE CURVE: A plot of dimensionless theoretical response for a well in an unconfined system used in pumping test analysis.

OCTANE: Any of several isomeric liquid paraffin hydrocarbons C_8H_{18} ; flammable; used as a solvent and in organic synthesis.

OLEFIN: A class of unsaturated aliphatic hydrocarbons having one or more double bonds, obtained by cracking naphtha or other petroleum fractions at high temperatures (1500-1700 F).

ORGANIC: Being, containing or relating to carbon compounds, especially in which hydrogen is attached to carbon.

OXIDATION: The term "oxidation" originally meant a reaction in which oxygen combines chemically with another substance, but its usage has long been broadened to include any reaction in which electrons are transferred. Oxidation and reduction always occur simultaneously (redox reactions), and the substance which gains electrons is termed the oxidizing agent.

PACKER TESTS: An in situ method for determining rock permeability in an uncased borehole. The technique consists of isolating an interval in the borehole using pneumatic packers and injecting a known volume of water under a known pressure.

PENNSYLVANIAN: A period of the Paleozoic Era after the Mississippian, thought to have covered the span of time between 320 and 280 million years ago.

PERMEABILITY: The relative rate of water flow through a porous medium. The USDA Soil Conservation Service describes permeability qualitatively as follows:

very slow	<0.06	inches/hour
slow	0.06 to 0.2	inches/hour
moderately slow	0.2 to 0.6	inches/hour
moderate	0.6 to 2.0	inches/hour
moderately rapid	2.0 to 6.0	inches/hour
rapid	6.0 to 20	inches/hour
very rapid	>20	inches/hour

PETROLEUM: (Crude oil) A highly complex mixture of paraffinic, cycloparaffinic (naphthenic), and aromatic hydrocarbons, containing a low percentage of sulfur and trace amounts of nitrogen and oxygen compounds. The most important petroleum fractions, obtained by cracking or distillation, are various hydrocarbon gases (butane, ethane, propane), naphtha of several grades, gasoline, kerosene, fuel oils, gas oil, lubricating oils, paraffin wax, and asphalt. From the hydrocarbon gases, ethylene, butylene, and propylene are obtained: these are important industrial intermediates, being the source of alcohols, ethylene glycols and monomers of a wide range of plastics, elastomers, and pharmaceuticals. Benzene, phenol, toluene, and xylene can also be made from petroleum.

PETROLEUM HYDROCARBONS: (See Petroleum)

pH: A value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the logarithm of the reciprocal of the hydrogen-ion concentration of a solution. On a scale from 0 to 14, 7 represents neutrality, numbers less than 7 increasing acidity, and numbers greater than 7 increasing alkalinity.

PHASE I: Records search phase of the Installation Restoration Program.

PHASE II: Remedial Investigation and Feasibility Study phase of the
Installation Restoration Program

PHYSIOGRAPHY: A description of the features and phenomena of nature; same as
physical geography or geomorphology.

PLASTIC (geology): Said of a body in which strain produces continuous,
permanent deformation without rupture.

POLLUTANT (water): Any solute or cause of change in physical properties that
renders water unfit for a given use.

POLYNUCLEAR AROMATIC COMPOUNDS: Compounds in which aromatic rings that share
a pair of carbon atoms are fused. The simplest and most important of the
fused-ring hydrocarbons is naphthalene, $C_{10}H_8$.

POTENTIOMETRIC MAP: A contour map of the potentiometric surface of a
particular hydrogeologic unit.

POTENTIOMETRIC SURFACE: The imaginary surface to which water in an artesian
aquifer would rise in tightly screened wells penetrating it.

PUMPING TESTS: A test made by pumping a well for a period of time and
measuring the observed water level changes in a nearby observation well.
A pumping test may be used to determine the capacity of the well and the
hydraulic characteristics of the aquifer.

PURGE: To evacuate the stagnant water in a well.

RECHARGE: The addition of water to the ground water system by natural or
artificial processes.

RELICT: Said of a feature that remains after other parts of the
feature have been removed or have disappeared.

SEMI-VOLATILE ORGANIC COMPOUNDS (semi-volatiles): Base-neutral and acid-extractable priority pollutants. Includes plasticizers and polynuclear aromatic hydrocarbons.

SHEET FLOW: Laminar flow. Water flow in which the stream lines remain distinct and in which the flow direction at every point remains unchanged with time.

SOIL-GAS TESTING: A method of testing for volatile organic compounds in unsaturated zones. Gas withdrawn from the soil is analyzed at the surface by a variety of techniques.

STORAGE VALUE: Storativity. The volume of water an aquifer releases from or takes into storage per unit surface.

STRATIGRAPHIC: The systematic arrangement or partitioning of the sequence of rock strata of the earth's crust into units with reference to any or all of the many different characters, properties, or attributes which the strata may possess.

SUB-BITUMINOUS COAL: A black coal intermediate in rank between lignite and bituminous coals. It is distinguishable from lignite by higher carbon and lower moisture contents.

SURROGATES: Compounds added to every blank, sample, matrix spike, matrix spike duplicate, and standard and used to evaluate analytical efficiency of the method by measuring recovery. Surrogates are brominated, fluorinated, or isotopically labelled compounds not expected to be detected in environmental media. These are typically used in organic analytical methods.

TETRALIN: TM for tetrahydronaphthalene

TOLUENE: An alkylbenzene compound. A volatile, aromatic, organic compound associated with jet fuel. A colorless liquid with an aromatic odor like benzene.

TOXICITY: The ability of a material to produce injury or disease upon exposure, ingestion, inhalation, or assimilation by a living organism.

TRANSMISSIVITY: The rate at which water is transmitted through a unit width of aquifer under a unit hydraulic gradient.

TRICHLOROETHENE: (TCE) CCL_2CHCl ; a nonflammable liquid used especially as a solvent, in dry cleaning, and for removing grease from metal; a suspected carcinogen.

UNCONSOLIDATED MATERIAL: A sediment that is loosely arranged or unstratified, or whose particles are not cemented together, occurring either at the surface or at depth.

VADOSE ZONE: Also called the unsaturated zone. The zone between the land surface and the water table including the root zone, intermediate zone, and capillary fringe. The pore spaces contain water at less than atmospheric pressure as well as air and other gases. Saturated bodies, such as perched groundwater, may exist in the unsaturated zone.

VINYL CHLORIDE: CH_2CHCl ; a flammable gaseous carcinogenic compound that is used to make vinyl resins. It is also a biodegradation product of trichloroethene.

VOLATILE: The tendency of a solid or liquid material to pass into the vapor state at a given temperature.

WATER TABLE: Surface of a body of unconfined water at which the pressure is equal to that of the atmosphere.

WEATHERING: The group of processes (such as chemical action of air and rainwater, the biological action of plants and animals, and the mechanical action of changes in temperature) whereby rocks and minerals, on exposure to the weather, change in character, disintegrate and decompose.

XYLENE: Any of three toxic flammable isomeric aromatic hydrocarbons that are dimethyl homologs of benzene and are usually obtained from petroleum or natural gas distillates; also a mixture of xylenes and ethylbenzene used chiefly as a solvent.

ACRONYMS

ANGB: Air National Guard Base

AIC: Acceptable Intake for Chronic exposure. The highest human intake of chemical, expressed as mg/kg/day, that does not cause adverse effects when exposure is short-term (but not acute). The AIC is usually based on chronic animal studies.

API: American Petroleum Institute

AREFG: Air Refueling Group

Base: Forbes Field Air National Guard Base

BGL: Below ground level

BNA: Base Neutral/Acid Extractable compounds (see Semi-Volatile Organic Compounds)

BTXE: Benzene, Toluene, Total Xylenes, Ethylbenzene

CAT: Chemical Assessments Team

CERCLA: Comprehensive Environmental Response Compensation and Liability Act

CH: Corehole

CLP: Contract Laboratory Program

DDE: (p,p-DDE) Abbreviation for dichlorodiphenyldichloroethylene. It is a degradation product of DDT found as an impurity in DDT residues.

DDT: (p,p-DDT and o,p-DDT) Abbreviation for dichlorodiphenyltrichloroethane.
A colorless odorless water-insoluble crystalline insecticide that tends
to accumulate in ecosystems and has toxic effects in many vertebrates.

DRMO: Defense Reutilization and Marketing Office

DW: Deep well

EC: Electrical Conductivity.

EPA: Environmental Protection Agency

EPM: Equivalents per million

FS: Feasibility studies

gal/min: gallon(s) per minute

HARM: Hazard Assessment Rating Method

HAZWAP: Hazardous Waste Remedial Action Program

HMTC: Hazardous Materials Technical Center

HSL: Hazardous Substance List

ID: Inside diameter

IRP: Installation Restoration Program

IT: International Technology

JP-4: Jet Propulsion Fuel Number Four; contains both kerosene and gasoline
fractions.

KAL: Kansas Action Level

KDHE: Kansas Department of Health and Environment

KSANG: Kansas Air National Guard

LOD: Limit of detection

MCL: Maximum Contaminant Level set by the EPA as required by the SDWA. Based on health factors and the technological and economic feasibility of removing the contaminant from the water supply.

MCLG: Maximum Contaminant Level Goal set by the EPA as required by the SDWA. MCLGs are entirely health based; thus, they are always less than or equal to MCLs.

mg/L: Milligrams per liter

MS/MSD: Matrix spike/matrix spike duplicate

MTAA: Metropolitan Topeka Airport Authority

MW: Monitoring well

NDI: Nondestructive Inspection

NGB: U.S. National Guard Bureau

OD: Outside diameter

OEHL: Occupational and Environmental Health Laboratory

ORGDP: Oak Ridge Gaseous Diffusion Plant

ORNL/CAT: Oak Ridge National Laboratory/Chemical Assessments Team

ORNL: Oak Ridge National Laboratory

OVA: Organic Vapor Analyzer

PAH: Polynuclear aromatic hydrocarbons

PCB: Polychlorinated biphenyl. One of several aromatic compounds containing two benzene nuclei with two or more substituent chlorinations. They are colorless liquids. Because of their persistence, toxicity, and ecological damage, their manufacture was discontinued in the U.S. in 1976.

PCC: Prevalent chemical character

PHC: Petroleum Hydrocarbon (see TPHC)

PID: Photoionization Detector. An instrument which detects organic vapors that ionize within a specific range of voltage, such as the HNU PI-101.

POL: Petroleum, oil and lubricant

PPM: Parts per million

PVC: Polyvinyl chloride

RfD: Reference dose

RI: Remedial Investigation

RI/FS: Remedial Investigation/Feasibility Study

RIR: Remedial Investigation Report

SAC: Strategic Air Command

SCS: Soil Conservation Service

SDWA: Safe Drinking Water Act

SG: Soil-gas

SOW: Statement of work

SW: Shallow well

TAC: Tactical Air Command

TCE: Trichloroethene

TCLP: Toxicity Characteristic Leaching Procedure

TDS: Total Dissolved Solids

TPHC: Total Petroleum Hydrocarbons

µg/L: micrograms per liter

VOA: Volatile Organic Analyses

VOC: Volatile Organic Compounds

VOL: See VOA

WQC: Water Quality Criteria - Federal criteria which are non-enforceable guidelines. Many states use in the development of enforceable ambient water quality standards.

WS: Sample of surface water

ZHE: Zero headspace extraction

APPENDIX B

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APPENDIX C

PERSONAL CONTACTS

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APPENDIX D

SOIL-GAS RESULTS

SOIL-GAS RESULTS

The soil-gas investigation was performed to evaluate the near-surface distribution of total petroleum hydrocarbons (TPHCs), aromatic compounds, and chlorinated hydrocarbons on the site. Particular areas of interest included fuel storage areas and fuel line laterals. Detection limits were less than or equal to 0.01 $\mu\text{g/L}$ for all compounds analyzed.

The soil-gas data collected at Forbes Field ANGB is not an indicator of TPHCs in the groundwater. The data are most useful for spotting gross anomalies and trends, especially in the tight clay soil present at the base.

Table D.1 presents the measured concentrations of TPHCs. Table D.2 shows halocarbon concentrations.

Soil-gas sampling points were located and surveyed in May 1988 by ORNL/CAT. During the soil-gas sampling in June 1988, several locations were deleted, some were added, and others were moved from their locations. These moves, deletions, and additions were caused by changes in site conditions during the sample collection (e.g., a background level of TPHC downgradient of a site precluded sampling further downgradient to delineate a plume). Gaps in the numbering sequence are due to the sampling locations which were deleted.

Samples SG29 and SG40 were taken under marginal conditions, i.e., the soil was nearly too tight to withdraw soil-gas. The sampling probe was reinserted a few feet from the original holes and water samples were collected the following day. Both soil-gas and water were used at these locations to ensure that groundwater contamination was not undetected due to low soil-gas sample volume.

Those samples coded by "NS" are locations where a sample was attempted but for technical reasons, usually the tight clay soil, could not be collected.

The aromatic species concentrations correlated well with the TPHC levels, where TPHCs levels were $<100 \mu\text{g/L}$. All of the aromatic concentrations were less than $1.0 \mu\text{g/L}$ except point SG112 ($1.67 \mu\text{g/L}$ toluene and $1.11 \mu\text{g/L}$ ethyl benzene).

In this environment, the soil-gas information provides an excellent screening tool. Use of the tool as a screen, however, implies selecting a level above which results are "elevated" and below which results are "background."

Information from the subcontractor provided a possible "cut-off" level. Hydro Geo Chem, Inc., reviewed the data and conditions at the base and suggested a cut-off level near 100 $\mu\text{g/L}$ of TPHCs. The conclusion was based on the tight clay soils, the possibility of horizontal migration of vapors through the soils, and naturally occurring compounds in the soil. Since horizontal migration of vapors through the soils could provide a false-positive at a sample point when, in fact, there was no contamination in the subsurface, the 100 $\mu\text{g/L}$ level was suggested.

The field blanks showed trace levels of aromatics and some of the chlorinated hydrocarbons. Total hydrocarbon levels ranged from 3.4 to 21.9 $\mu\text{g/L}$ in the field blanks. These levels are not uncommon in the atmosphere, particularly where fuels are being stored or used. Obviously, values below 22 $\mu\text{g/L}$ could not be considered elevated.

A review of the data by ORNL revealed a break between 50 $\mu\text{g/L}$ and 80 $\mu\text{g/L}$, with only four samples falling in this range. Several sample points had values between 22 and 50 $\mu\text{g/L}$ and between 80 and 100 $\mu\text{g/L}$. Based on the above information, a level of 80 $\mu\text{g/L}$ was determined as the best cut-off level and that value was used in data interpretation.

TABLE D.1. Summary of soil-gas and water survey data,
total petroleum hydrocarbons and aromatics
($\mu\text{g/L}$)

Sampling location	Total petroleum hydrocarbons	Benzene	Toluene	Ethylbenzene	Meta-, Para-Xylenes	Ortho-Xylene
SG2	33.80	0.14	0.25	0.06	0.15	0.05
SG7	38.90	0.24	0.42	0.00	0.15	0.00
SG8	18.50	0.01	0.02	0.06	0.09	0.04
SG9	23.10	0.03	0.03	0.00	0.00	0.02
SG10	30.20	0.33	0.26	0.10	0.19	0.09
SG11W	516.00	0.17	0.65	0.66	1.00	1.38
SG12	32.60	0.38	0.25	0.07	0.14	0.06
SG19	58.30	0.34	0.36	0.12	0.34	0.22
SG20	31.10	0.31	0.24	0.12	0.20	0.07
SG22	53.40	0.08	0.43	0.17	0.33	0.16
SG23	18.10	0.12	0.01	0.07	0.09	0.05
SG24	67.40	0.21	0.22	0.06	0.29	0.04
SG25	14.80	0.08	0.06	0.05	0.05	0.03
SG27	24.50	0.27	0.28	0.09	0.18	0.09
SG28W	70.00	0.21	0.35	0.09	0.20	0.10
SG29	39.20	0.00	0.02	0.01	0.06	0.03
SG29W	44.00	0.00	0.01	0.06	0.01	0.03
SG30	170.00	0.05	0.31	0.31	0.04	0.12
SG31	35.50	0.01	0.04	0.01	0.03	0.03
SG32	572.00	0.37	0.48	0.16	0.40	0.24
SG33	21.30	0.01	0.03	0.00	0.03	0.02
SG34	174.00	2.13	3.65	0.73	1.96	1.09
SG35	201.00	1.86	2.85	0.31	1.16	0.43
SG36	9.11	0.04	0.06	0.02	0.05	0.02
SG37	277.00	1.87	5.53	1.65	2.09	1.10
SG38	133.00	0.58	1.40	0.21	0.68	0.25
SG39	27.60	0.01	0.27	0.04	0.10	0.05
SG40	17.70	0.01	0.07	0.02	0.08	0.06
SG40W	87.60	0.11	0.05	0.22	0.44	0.10
SG41	63.00	0.44	3.72	0.18	0.64	0.24
SG42	861.00	0.36	0.79	0.84	5.85	1.54
SG43	NS					
SG47	243.00	2.45	2.43	0.21	0.74	0.25
SG48	151.00	1.40	2.49	0.38	0.93	0.37
SG49	6.93	0.00	0.04	0.03	0.00	0.01
SG50	20.60	0.03	0.23	0.04	0.14	0.05
SG51	34.40	0.04	0.40	0.08	0.24	0.08
SG52	37.70	0.06	0.92	0.18	0.56	0.24
SG53	10.10	0.00	0.03	0.02	0.04	0.02
SG54	202.00	0.18	0.28	0.40	0.26	0.04
SG55	1.92	0.01	0.02	0.00	0.01	0.00
SG57	147.00	1.66	2.31	0.29	1.06	0.35
SG60	26.80	0.25	0.29	0.10	0.21	0.10
SG62	98.50	0.29	0.30	0.13	0.32	0.15
SG63	18.70	0.08	0.06	0.08	0.01	0.01

TABLE D.1. (continued)

Sampling location	Total petroleum hydrocarbons	Benzene	Toluene	Ethylbenzene	Meta-, Para-Xylenes	Ortho-Xylene
SG64	23.00	0.11	0.04	0.09	0.01	0.01
SG65	35.80	0.05	0.18	0.07	0.13	0.05
SG66W	45.50	0.02	0.08	0.22	0.00	0.03
SG67	20.50	0.09	0.07	0.05	0.05	0.01
SG68	19.40	0.12	0.08	0.04	0.06	0.03
SG69W	162.00	0.90	4.73	5.65	1.67	6.05
SG70	25,900.00	128.00	126.00	485.00	78.80	233.00
SG71	3,000.00	11.50	15.90	34.80	13.80	24.30
SG72	33.90	0.20	0.14	0.14	0.14	0.05
SG73	34.50	0.16	0.16	0.05	0.16	0.08
SG74	55.50	0.15	0.22	0.07	0.19	0.09
SG75	22.20	0.18	0.13	0.15	0.00	0.05
SG76	28.20	0.22	0.15	0.11	0.26	0.09
SG77	163.00	1.35	0.48	0.33	0.04	0.14
SG79	33.50	0.05	0.21	0.14	0.10	0.06
SG80	18.50	0.01	0.02	0.06	0.09	0.04
SG81	NS					
SG82W	989.00	89.80	7.98	7.04	1.16	3.05
SG83W	7,550.00	53.60	86.00	149.00	29.90	99.20
SG84	NS					
SG85W	1,850.00	446.00	6.60	7.70	10.10	5.52
SG86W	1,300.00	2.80	12.30	21.80	12.90	10.30
SG87	6,070.00	27.90	29.80	57.00	35.90	32.50
SG88	21.00	0.14	0.20	0.04	0.12	0.05
SG89	79,200.00	73.30	124.00	320.00	346.00	464.00
SG90	169,000.00	3.15	32.60	103.00	67.50	109.00
SG91	NS					
SG92	721.00	6.07	2.30	7.76	6.93	11.70
SG93	58,400.00	32.50	1.63	0.28	1.70	7.42
SG94	NS					
SG95	99,200.00	23.00	110.00	147.00	104.00	155.00
SG96	21,600.00	31.80	71.40	92.00	96.00	120.00
SG97	NS					
SG99	15.00	0.00	0.02	0.01	0.03	0.02
SG101	25.20	0.13	0.12	0.09	0.05	0.03
SG106	44.0	0.15	0.23	0.12	0.16	0.19
SG107W	86,800.00	90.40	164.00	456.00	571.00	800.00
SG108W	30.40	0.11	0.22	0.09	0.08	0.05
SG109	97.00	0.70	1.00	0.25	0.55	0.22
SG110	NS					
SG111	19.90	0.19	0.21	0.05	0.13	0.06
SG112	18.40	0.70	1.67	1.11	0.78	0.44
SG113	747.00	0.11	6.86	7.19	2.71	5.44
SG114W	31.60	0.02	0.20	0.13	0.14	0.08

TABLE D.1. (continued)

Sampling location	Total petroleum hydrocarbons	Benzene	Toluene	Ethylbenzene	Meta-, Para-Xylenes	Ortho-Xylene
SG115W	92.50	0.13	0.23	0.08	0.13	0.08
SG116W	30,700.00	80.40	12.90	172.00	130.00	287.00
SG117	4.50	0.02	0.03	0.01	0.02	0.01
SG118W	395.00	0.12	0.24	0.08	0.18	0.13
SG121	19.60	0.25	0.31	0.10	0.21	0.08
SG122W	50.10	0.17	0.20	0.07	0.12	0.07
SG123	20.00	0.13	0.09	0.04	0.10	0.03
SG124W	1,290.00	19.70	11.40	3.61	4.47	7.02
SG126	17.60	0.07	0.08	0.07	0.11	0.03
SG127	50.80	0.07	0.31	0.08	0.22	0.08
SG128	40.10	0.08	0.09	0.09	0.01	0.04
SG129	73.50	0.15	0.20	0.05	0.14	0.01
SG130	26.80	0.10	0.08	0.09	0.13	0.08
SG131	11.20	0.02	0.08	0.02	0.38	0.20
SG132	17.00	0.11	0.12	0.04	0.07	0.04
SG133	24.00	0.29	0.24	0.14	0.17	0.07
SG134	33.70	0.32	0.27	0.06	0.18	0.09
SGFB14JU	21.90	0.03	0.21	0.02	0.11	0.04
SGFB15JU	17.70	0.03	0.21	0.03	0.11	0.04
SGFB16JU	19.10	0.05	0.50	0.06	0.20	0.08
SGFB17JU	5.26	0.01	0.01	0.01	0.02	0.01
SGFB18JU	4.89	0.01	0.02	0.01	0.02	0.01
SGFB19JU	5.20	0.00	0.01	0.01	0.02	0.01
SGFB20JU	5.34	0.01	0.04	0.01	0.02	0.01
SGFB21JU	3.42	0.00	0.02	0.01	0.01	0.01
SGFB22JU	4.83	0.00	0.03	0.01	0.02	0.01

W - denotes water sample

FB - denotes field blank; "14JU" denotes sample collection date (JU=June)

NS - sample attempted, unable to collect

TABLE D.2. Summary of soil-gas and water survey data,
chlorinated hydrocarbons
($\mu\text{g/L}$)

Sampling location	Trichloro-ethene	Vinyl chloride	Sample depth
SG2	0.00	0.00	5.0
SG7	0.00	0.00	3.5
SG8	0.00	0.00	5.0
SG9	0.00	0.00	5.0
SG10	0.00	0.00	5.0
SG11W	0.00	0.00	5.0
SG12	0.00	0.00	5.0
SG19	0.00	0.00	5.0
SG20	0.00	0.00	5.0
SG22	0.00	0.00	5.0
SG23	0.00	0.00	5.0
SG24	0.00	0.00	5.0
SG25	0.00	0.00	5.0
SG27	0.00	0.00	5.0
SG28W	0.00	0.00	5.0
SG29	0.00	0.00	12.0
SG29W	0.00	0.00	10.0
SG30	0.00	0.00	10.0
SG31	1.70	0.03	5.0
SG32	0.00	0.00	5.0
SG33	0.00	0.00	9.5
SG34	0.00	0.00	5.0
SG35	0.18	0.00	5.0
SG36	0.14	0.00	5.0
SG37	0.01	0.00	5.0
SG38	0.15	0.00	5.0
SG39	0.00	0.00	5.0
SG40	0.00	0.00	8.5
SG40W	0.00	0.00	12.0
SG41	0.00	0.00	12.0
SG42	0.08	0.00	5.0
SG43	0.00	0.00	5.0
SG47	NS	NS	NS
SG48	0.06	0.00	5.0
SG49	0.15	0.00	5.0
SG50	0.00	0.00	5.0
SG51	0.01	0.00	5.0
SG52	0.00	0.00	5.0
SG53	0.04	0.00	5.0
SG54	0.00	0.00	12.0
SG55	0.00	0.00	12.0
SG57	0.00	0.00	12.0
SG60	0.09	0.00	5.5
SG62	0.00	0.00	3.5
SG63	0.00	0.00	3.5
SG64	0.00	0.00	3.5

TABLE D.2. (continued)

Sampling location	Trichloro-ethene	Vinyl chloride	Sample depth
SG65	0.00	0.00	3.5
SG66W	0.00	0.00	5.0
SG67	0.00	0.00	3.5
SG68	0.00	0.00	3.5
SG69W	0.00	0.00	5.0
SG70	0.00	0.00	3.5
SG71	0.00	0.00	3.5
SG72	0.00	0.00	3.5
SG73	0.00	0.00	3.5
SG74	0.00	0.00	3.5
SG75	0.00	0.00	3.5
SG76	0.00	0.00	3.5
SG77	0.00	0.00	3.5
SG79	0.00	0.00	3.5
SG80	0.00	0.00	3.5
SG81	NS	NS	NS
SG82W	0.00	0.00	5.0
SG83W	0.00	0.00	5.0
SG84	NS	NS	NS
SG85W	0.00	0.00	5.0
SG86W	0.00	0.00	5.0
SG86W	0.00	0.00	5.0
SG87	0.00	0.00	3.5
SG88	0.00	0.00	3.5
SG89	0.00	0.00	3.5
SG90	0.00	0.00	3.5
SG91	NS	NS	NS
SG92	0.00	0.00	3.5
SG93	0.00	0.00	3.5
SG94	NS	NS	NS
SG95	0.00	0.00	3.5
SG96	0.00	0.00	3.5
SG97	NS	NS	NS
SG99	0.00	0.00	3.5
SG101	0.00	0.00	5.0
SG106	0.00	0.00	12.0
SG107W	0.00	0.00	12.0
SG108W	0.00	0.00	8.0
SG109	0.00	0.00	7.0
SG110	NS	NS	NS
SG111	0.00	0.00	9.0
SG112	0.00	0.00	9.5
SG113	0.00	0.00	9.5
SG114W	0.00	0.00	10.0
SG115W	0.00	0.00	10.5

TABLE D.2. (continued)

Sampling location	Trichloro-ethene	Vinyl chloride	Sample depth
SG116W	0.00	0.00	9.5
SG117	0.00	0.00	7.0
SG118W	0.00	0.00	11.0
SG121	0.00	0.00	5.0
SG122W	0.00	0.00	6.0
SG123	0.00	0.00	12.0
SG124W	0.00	0.00	10.5
SG126	0.00	0.00	9.0
SG127	0.00	0.00	5.0
SG128	0.00	0.00	12.0
SG129	0.00	0.00	12.0
SG130	0.00	0.00	12.0
SG131	0.00	0.00	5.0
SG132	0.00	0.00	5.0
SG133	0.00	0.00	5.0
SG134	0.00	0.00	5.0
SGFB14JU	0.03	0.00	0.0
SGFB15JU	0.00	0.00	0.0
SGFB16JU	0.06	0.00	0.0
SGFB17JU	0.00	0.00	0.0
SGFB18JU	0.00	0.00	0.0
SGFB19JU	0.00	0.00	0.0
SGFB20JU	0.00	0.00	0.0
SGFB21JU	0.00	0.00	0.0
SGFB22JU	0.00	0.00	0.0

W - denot water sample

FB - denotes field blank; "14JU" denotes sample collection date (JU=June)

NS - sample attempted, unable to collect

APPENDIX E

ANALYTICAL DATA

Analytical Data

I. Discussion

Table E.1 is arranged by site and contains all the analytes detected during the sampling program. Table E.2 lists the target compounds and metals, along with detection limits, in soil and water.

Samples listed in Table E.1 are sorted according to the site from which the sample was collected. The site is listed at the top of the page. Several samples were collected which do not apply to a specific site, but to the project in general; these samples were assigned a "site" which most accurately describes the area from which they were collected. If the sample could not be identified with a specific site, it was assigned the code N/A.

II. Column headings in Table E.1 are defined as follows:

Sample location:	DW - deep well (Weston)	TB - trip blank
	SW - shallow well (Weston)	FB - field blank
	MW - monitoring well (ORNL)	SD - sediment
	ER - equipment rinse	WS - surface water
	CH - core hole (ORNL)	OT - other

The numeric segment of the string refers to the monitoring well or corehole number where the sample was collected. Sediments and surface waters are numbered sequentially in the order taken. Trip blanks were made in the lab prior to going to the field and have no numerical reference for location.

Sample date: Date the samples were collected in the field.

Sample interval: Soil samples taken during the drilling of monitoring wells and coreholes are listed according to the depth below ground surface at which they were collected. Samples of sediments, surface waters, groundwater, and blanks are listed according to the ordinal sequence in which they were collected on a given day. For example, a triplicate sample of groundwater taken from monitoring well MW023 on 7/10/88 would have interval values of 01, 02, and 03. Samples

taken from the same well on consecutive days would each have a sample interval 01.

Field number: Each sample collected is given a unique four-digit number which is recorded in the project sample log book, chain-of-custody form, field data base, and ORNL/CAT data base in Grand Junction, Colorado. Replicate samples are numbered sequentially.

Sample matrix: GW - ground water SR - soil replicate
 SO - soil WR - water replicate
 SD - sediment RI - rinsate
 WT - water (other than groundwater)

Analytical method:

<u>Sample code</u>	<u>Comments</u>	<u>Analytical method</u> <u>soil/water</u>
SEMI	base/neutral and acid extractable semi-volatile organic compounds	8270/625
VOLS	volatile organic compounds	8240/624
METALS	HSL metals	SW846
TPHCs	Total petroleum hydrocarbons, recoverable benzene/toluene/ xylenes/ethylbenzene (BTXE)	8015/8015,418.1 8020/8020
PEST	pesticides/PCBs	8080/608
ANIONS	Cl, F, SO ₄ , PO ₄ , NO ₃	300.0

TCLP Toxicity characteristic
 leaching procedure, zero
 headspace extraction
 defined in Federal Register
 Vol. 51 No. 216, Friday,
 Nov. 7, 1986, pp. 40643 -
 40653

- * In June 1988, the EPA proposed (Fed. Reg. 21648 et. seq.) to expand the toxicity characteristic test and to replace the EP extraction procedure with a new procedure called TCLP (toxicity characteristic leaching procedure). Like the EP toxicity test, the TCLP is designed to generate a leachate for the purpose of evaluating the potential for contaminants to migrate into the groundwater. The most significant differences between the two procedures are the requirements in the TCLP for the generation of a second leachate to measure volatile organics using a zero headspace extractor (ZHE), and the requirement to analyze each phase of a multi-phase leachate separately and combine the results mathematically.

Analyte: Volatiles possessing cis/trans or ortho/meta/para isomerism are reported as total compound present.

Result: Organics between 1 and 10 reporting units - one significant digit;
<10 reporting units - 2 significant digits.

Code: B - compound was detected in the method blank as well as in the sample.
 J - analytical result is an estimated value. For example, methylene chloride typically has a limit of detection (LOD) of 1 µg/L. The lowest quantity which can be reported with certainty is ~5 µg/L. Values between the LOD and the reporting level are denoted by J.
 E - compound was quantitated above the CLP calibration limit, but was within the instrument's demonstrated range of linearity.
 D - value was reported from a dilution. Typically, if matrix interferences obscure the peaks of interest, the sample is

diluted to reduce the concentration of interferent. Dilution also raises detection limits of the target compounds.

A - Aldol condensation product.

P - probable identification.

Units: Self explanatory.

III. Complete Sample Information

Two supplements to this report are available on request. Number One contains copies of all laboratory analytical reports including laboratory QA/QC samples. Number Two contains copies of all field sample data records which were filled out at the time of sample acquisition. These supplements can be obtained by contacting:

Oak Ridge National Laboratory
Grand Junction Office
P.O. Box 2567
Grand Junction, CO 81502
Attn: Forbes Field ANGB Site Manager

or

Hazardous Waste Remedial Action Program
FEDC Building
104 Union Valley Road
Oak Ridge, TN 37830
Attn: Forbes Field ANGB Project Manager

Table E.1. Analytical data

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 1

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
DW006	03/11/88	01	0021	GW	VOLS	hexane	11.00		ug/L
MW018	06/20/88	03	5096	SO	SVOLS	methylene chloride	8.00	B	ug/kg
MW018	06/20/88	03	5096	SO	SVOLS	acetone	6.00	JB	ug/kg
MW018	06/20/88	03	5096	SO	SVOLS	toluene	6.00	B	ug/kg
MW018	06/20/88	06	5097	SO	SVOLS	methylene chloride	19.00	B	ug/kg
MW018	06/20/88	06	5097	SO	SVOLS	toluene	9.00	B	ug/kg
MW018	06/20/88	06	5098	SR	SVOLS	methylene chloride	5.00	JB	ug/kg
MW018	06/20/88	06	5098	SR	SVOLS	toluene	5.00	JB	ug/kg
MW018	06/20/88	09	5099	S	STCLP	methylene chloride	2.00	JB	ug/L
MW018	06/20/88	09	5099	SO	STCLP	acetone	21.00	B	ug/L
MW018	06/20/88	09	5099	SO	STCLP	2-butanone	2.00	J	ug/L
MW018	06/20/88	09	5099	SO	STCLP	4-methyl-2-pentanone	49.00	B	ug/L
MW018	06/20/88	09	5099	SO	STCLP	toluene	3.00	J	ug/L
MW018	06/20/88	09	5099	SO	STCLP	ethylbenzene	2.00	J	ug/L
MW018	06/20/88	12	5100	SO	SPHCS	petroleum hydrocarbons	140000.00		ug/kg
MW018	06/20/88	12	5100	SO	SPHCS	xylene(s)(total)	3700.00		ug/kg
MW018	06/20/88	12	5100	SO	SPHCS	toluene	900.00		ug/kg
MW018	06/20/88	12	5100	SO	SVOLS	methylene chloride	12.00	B	ug/kg
MW018	06/20/88	12	5100	SO	SVOLS	acetone	63.00	B	ug/kg
MW018	06/20/88	12	5100	SO	SVOLS	carbon disulfide	6.00	JB	ug/kg
MW018	06/20/88	12	5100	SO	SVOLS	2-butanone	6.00	J	ug/kg
MW018	07/09/88	01	5174	GW	ANIONS	Cl	3.50		mg/L
MW018	07/09/88	01	5174	GW	ANIONS	F	1.30		mg/L
MW018	07/09/88	01	5174	GW	ANIONS	SO4	330.00		mg/L
MW018	07/09/88	01	5174	GW	METALS	Zn	0.03		mg/L
MW018	07/09/88	01	5174	GW	PHCS	toluene	1.00		ug/L
MW018	07/09/88	01	5174	GW	VOLS	acetone	5.00	J	ug/L
MW018	10/04/88	01	5266	WR	VOLS	acetone	6.00	JB	ug/L
MW019	06/20/88	03	5121	SO	SVOLS	methylene chloride	31.00	B	ug/kg
MW019	06/20/88	03	5121	SO	SVOLS	acetone	8.00	JB	ug/kg
MW019	06/20/88	03	5121	SO	SVOLS	toluene	12.00	B	ug/kg
MW019	06/20/88	06	5122	SO	SVOLS	methylene chloride	12.00	B	ug/kg
MW019	06/20/88	06	5122	SO	SVOLS	acetone	17.00	B	ug/kg
MW019	07/07/88	01	5165	GW	ANIONS	Cl	7.80		mg/L
MW019	07/07/88	01	5165	GW	ANIONS	F	1.00		mg/L
MW019	07/07/88	01	5165	GW	ANIONS	SO4	160.00		mg/L
MW019	07/07/88	01	5165	GW	METALS	As	0.01		mg/L
MW019	07/07/88	01	5165	GW	METALS	Pb	0.01		mg/L
MW019	07/07/88	01	5165	GW	METALS	Zn	0.01		mg/L
MW019	07/07/88	01	5165	GW	PHCS	toluene	1.00		ug/L
MW019	07/07/88	01	5165	GW	PHCS	petroleum hydrocarbons	83.00		ug/L
MW019	07/07/88	01	5165	GW	VOLS	methylene chloride	1.00	JB	ug/L
MW019	07/07/88	01	5165	GW	VOLS	acetone	6.00	J	ug/L
MW019	07/07/88	02	5166	WR	ANIONS	Cl	7.00		mg/L
MW019	07/07/88	02	5166	WR	ANIONS	F	0.20		mg/L
MW019	07/07/88	02	5166	WR	ANIONS	SO4	162.00		mg/L
MW019	07/07/88	02	5166	WR	METALS	Ba	0.11		mg/L
MW019	07/07/88	02	5166	WR	METALS	Na	77.00		mg/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 1

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW019	07/07/88	02	5166	WR	METALS	K	3.00		mg/L
MW019	07/07/88	02	5166	WR	METALS	Ca	91.00		mg/L
MW019	07/07/88	02	5166	WR	METALS	Mg	20.00		mg/L
MW019	07/07/88	02	5166	WR	VOLS	1,1,2-trichloroethane	5.00		ug/L
MW019	07/07/88	02	5166	WR	VOLS	toluene	1.00	J	ug/L
MW019	07/07/88	02	5166	WR	VOLS	hydrocarbon #1	9.00	JB	ug/L
MW019	07/07/88	02	5166	WR	VOLS	hydrocarbon #2	7.00	JB	ug/L
MW019	07/07/88	02	5166	WR	VOLS	hydrocarbon #3	4.00	J	ug/L
MW019	07/07/88	02	5166	WR	VOLS	benzene	0.50	J	ug/L
MW019	10/04/88	01	5263	GW	PHCS	benzene	1.40		ug/L
MW019	10/04/88	01	5263	GW	PHCS	petroleum hydrocarbons	71.00		ug/L
MW019	10/04/88	01	5263	GW	VOLS	methylene chloride	1.00	JB	ug/L
MW019	10/04/88	01	5263	GW	VOLS	acetone	6.00	JB	ug/L
MW019	10/04/88	01	5263	GW	VOLS	carbon disulfide	3.00	J	ug/L
MW020	06/20/88	03	5125	SO	SVOLS	methylene chloride	17.00	B	ug/kg
MW020	06/20/88	03	5125	SO	SVOLS	acetone	17.00	B	ug/kg
MW020	06/20/88	06	5126	SO	SVOLS	methylene chloride	5.00	JB	ug/kg
MW020	06/20/88	06	5126	SO	SVOLS	acetone	11.00	B	ug/kg
MW020	06/20/88	06	5126	SO	SVOLS	chloroform	2.00	J	ug/kg
MW020	06/20/88	09	5127	SO	SVOLS	methylene chloride	6.00	B	ug/kg
MW020	06/20/88	09	5127	SO	SVOLS	acetone	18.00	B	ug/kg
MW020	06/20/88	12	5128	SO	SVOLS	methylene chloride	4.00	JB	ug/kg
MW020	06/20/88	12	5128	SO	SVOLS	acetone	10.00	JB	ug/kg
MW020	07/08/88	01	5169	GW	ANIONS	Cl	5.30		mg/L
MW020	07/08/88	01	5169	GW	ANIONS	F	1.30		mg/L
MW020	07/08/88	01	5169	GW	ANIONS	SO4	410.00		mg/L
MW020	07/08/88	01	5169	GW	METALS	Pb	0.02		mg/L
MW020	07/08/88	01	5169	GW	METALS	Zn	0.01		mg/L
MW020	07/08/88	01	5169	GW	VOLS	acetone	2.00	J	ug/L
MW020	07/09/88	01	5169	GW	VOLS	4-methyl-2-pentanone	2.00	J	ug/L
MW020	10/04/88	01	5262	GW	VOLS	methylene chloride	1.00	JB	ug/L
MW020	10/04/88	01	5262	GW	VOLS	acetone	15.00	B	ug/L
MW021	06/20/88	03	5129	SO	SVOLS	methylene chloride	8.00	B	ug/kg
MW021	06/20/88	03	5129	SO	SVOLS	acetone	20.00	B	ug/kg
MW021	06/20/88	03	5129	SO	SVOLS	bromodichloromethane	2.00	J	ug/kg
MW021	06/20/88	06	5130	SO	SPHCS	petroleum hydrocarbons	490000.00		ug/kg
MW021	06/20/88	06	5130	SO	SPHCS	xlenes(total)	31000.00		ug/kg
MW021	06/20/88	06	5130	SO	SVOLS	2-butanone	260.00	J	ug/kg
MW021	06/20/88	06	5130	SO	SVOLS	benzene	380.00	J	ug/kg
MW021	06/20/88	06	5130	SO	SVOLS	toluene	1600.00		ug/kg
MW021	06/20/88	06	5130	SO	SVOLS	ethylbenzene	1600.00		ug/kg
MW021	06/20/88	06	5130	SO	SVOLS	xlenes(total)	4200.00		ug/kg
MW021	06/20/88	09	5131	SO	SPHCS	petroleum hydrocarbons	34000.00		ug/kg
MW021	06/20/88	09	5131	SO	SPHCS	toluene	550.00		ug/kg
MW021	06/20/88	09	5131	SO	SPHCS	xlenes(total)	1100.00		ug/kg
MW021	06/20/88	09	5131	SO	SVOLS	methylene chloride	2.00	J	ug/kg
MW021	06/20/88	09	5131	SO	SVOLS	acetone	110.00	B	ug/kg
MW021	06/20/88	09	5131	SO	SVOLS	2-butanone	4.00	J	ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 1

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW021	06/20/88	09	5131	SO	SVOLS	xylenes(total)	9.00		ug/kg
MW021	06/20/88	06	5132	SO	STCLP	methylene chloride	1.00	JB	ug/L
MW021	06/20/88	06	5132	SO	STCLP	acetone	10.00	B	ug/L
MW021	06/20/88	06	5132	SO	STCLP	4-methyl-2-pentanone	26.00	B	ug/L
MW021	06/20/88	06	5132	SO	STCLP	xylenes(total)	39.00		ug/L
MW021	07/08/88	01	5170	GW	ANIONS	Cl	8.80		mg/L
MW021	07/08/88	01	5170	GW	ANIONS	F	1.40		mg/L
MW021	07/08/88	01	5170	GW	ANIONS	SO4	320.00		mg/L
MW021	07/08/88	01	5170	GW	METALS	Zn	0.02		mg/L
MW021	07/08/88	01	5170	GW	PHCS	toluene	1.00		ug/L
MW021	07/08/88	01	5170	GW	PHCS	xylenes(total)	10.00		ug/L
MW021	07/08/88	01	5170	GW	PHCS	benzene	2.80		ug/L
MW021	07/08/88	01	5170	GW	SEMI	bis(2-ethylhexyl)phthalate	14.00	B	ug/L
MW021	07/08/88	01	5170	GW	VOLS	xylenes(total)	7.00		ug/L
MW021	07/08/88	01	5170	GW	VOLS	benzene	2.00	J	ug/L
MW021	10/04/88	01	5264	GW	PHCS	benzene	9.20		ug/L
MW021	10/04/88	01	5264	GW	PHCS	toluene	1.00		ug/L
MW021	10/04/88	01	5264	GW	PHCS	xylenes(total)	93.00		ug/L
MW021	10/04/88	01	5264	GW	PHCS	petroleum hydrocarbons	760.00		ug/L
MW021	10/04/88	01	5264	GW	VOLS	methylene chloride	1.00	JB	ug/L
MW021	10/04/88	01	5264	GW	VOLS	acetone	6.00	JB	ug/L
MW021	10/04/88	01	5264	GW	VOLS	benzene	11.00		ug/L
MW021	10/04/88	01	5264	GW	VOLS	ethylbenzene	3.00	J	ug/L
MW021	10/04/88	01	5264	GW	VOLS	xylenes(total)	110.00		ug/L
MW026	06/23/88	03	5159	SO	SVOLS	methylene chloride	15.00	B	ug/kg
MW026	06/23/88	03	5159	SO	SVOLS	acetone	8.00	JB	ug/kg
MW026	06/23/88	03	5159	SO	SVOLS	toluene	2.00	J	ug/kg
MW026	06/23/88	06	5160	SO	SVOLS	methylene chloride	14.00	B	ug/kg
MW026	06/23/88	06	5160	SO	SVOLS	acetone	120.00	B	ug/kg
MW026	06/23/88	06	5160	SO	SVOLS	2-butanone	24.00		ug/kg
MW026	06/23/88	06	5160	SO	SVOLS	toluene	2.00	J	ug/kg
MW026	07/08/88	01	5173	GW	ANIONS	Cl	3.90		mg/L
MW026	07/08/88	01	5173	GW	ANIONS	F	1.10		mg/L
MW026	07/08/88	01	5173	GW	ANIONS	SO4	200.00		mg/L
MW026	07/08/88	01	5173	GW	VOLS	acetone	6.00	J	ug/L
MW026	07/08/88	01	5173	GW	VOLS	4-methyl-2-pentanone	2.00	J	ug/L
MW026	09/30/88	01	5242	GW	VOLS	acetone	5.00	J	ug/L
MW026	10/05/88	01	5281	GW	VOLS	acetone	3.00	J	ug/L
MW028	11/01/88	03	5295	SO	SVOLS	methylene chloride	34.00	B	ug/kg
MW028	11/01/88	03	5295	SO	SVOLS	acetone	67.00	B	ug/kg
MW028	11/01/88	07	5296	SO	SPHCS	toluene	1800.00		ug/kg
MW028	11/01/88	07	5296	SO	SPHCS	xylenes(total)	5900.00		ug/kg
MW028	11/01/88	07	5296	SO	SPHCS	petroleum hydrocarbons	145000.00		ug/kg
MW028	11/01/88	07	5296	SO	SVOLS	methylene chloride	120.00	B	ug/kg
MW028	11/01/88	07	5296	SO	SVOLS	acetone	720.00	B	ug/kg
MW028	11/01/88	09	5297	SO	SVOLS	methylene chloride	20.00	B	ug/kg
MW028	11/01/88	09	5297	SO	SVOLS	acetone	160.00	B	ug/kg
MW028	11/01/88	09	5297	SO	SVOLS	4-methyl-2-pentanone	3.00	J	ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 1

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW028	11/18/88	01	5301	GW	PHCS	toluene	30.00		ug/L
MW028	11/18/88	01	5301	GW	PHCS	petroleum hydrocarbons	2000.00		ug/L
MW023	11/18/88	01	5301	GW	VOLS	acetone	10.00		ug/L
MW028	11/18/88	02	5307	GW	PHCS	benzene	0.90		ug/L
MW028	11/18/88	02	5307	GW	PHCS	toluene	20.00		ug/L
MW028	11/18/88	02	5307	GW	PHCS	xylene(total)	7.00		ug/L
MW028	11/18/88	02	5307	GW	PHCS	petroleum hydrocarbons	200.00		ug/L
MW028	11/18/88	02	5307	GW	VOLS	acetone	9.00	J	ug/L
MW028	11/18/88	02	5307	GW	VOLS	vinyl acetate	3.00	J	ug/L
MW028	11/18/88	02	5307	GW	VOLS	benzene	4.00	J	ug/L
MW028	11/18/88	02	5307	GW	VOLS	ethylbenzene	2.00	J	ug/L
MW028	12/15/88	01	5311	GW	PHCS	benzene	4.40		ug/L
MW028	12/15/88	01	5311	GW	PHCS	toluene	20.00		ug/L
MW028	12/15/88	01	5311	GW	PHCS	xylene(total)	4.00		ug/L
MW028	12/15/88	01	5311	GW	PHCS	petroleum hydrocarbons	270.00		ug/L
MW028	12/15/88	01	5311	GW	VOLS	acetone	13.00		ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 5

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW009	06/17/88	03	5052	SO	SVOLS	acetone	280.00	EB	ug/kg
MW009	06/17/88	03	5052	SO	SVOLS	methylene chloride	22.00	B	ug/kg
MW009	06/17/88	03	5052	SO	SVOLS	2-butanone	17.00	B	ug/kg
MW009	06/17/88	06	5053	SO	SPHCS	petroleum hydrocarbons	26000.00		ug/kg
MW009	06/17/88	06	5053	SO	SPHCS	xylene(s)(total)	2600.00		ug/kg
MW009	06/17/88	06	5053	SO	SVOLS	xylene(s)(total)	2600.00		ug/kg
MW009	06/17/88	06	5053	SO	SVOLS	methylene chloride	17.00	B	ug/kg
MW009	06/17/88	06	5053	SO	SVOLS	acetone	290.00	EB	ug/kg
MW009	06/17/88	06	5053	SO	SVOLS	methylene chloride	220.00	J	ug/kg
MW009	06/17/88	06	5053	SO	SVOLS	acetone	600.00	JB	ug/kg
MW009	06/17/88	06	5053	SO	SVOLS	2-butanone	590.00	J	ug/kg
MW009	06/17/88	06	5054	SO	STCLP	chloroform	310.00	E	ug/L
MW009	06/17/88	06	5054	SO	SVOLS	methylene chloride	1.00	J	ug/kg
MW009	06/17/88	06	5054	SO	SVOLS	acetone	12.00	B	ug/kg
MW009	06/17/88	06	5054	SO	SVOLS	1,1,1-trichloroethane	4.00	J	ug/kg
MW009	06/17/88	06	5054	SO	SVOLS	4-methyl-2-pentanone	28.00	B	ug/kg
MW009	07/11/88	01	5192	GW	ANIONS	Cl	49.00		mg/L
MW009	07/11/88	01	5192	GW	ANIONS	F	1.10		mg/L
MW009	07/11/88	01	5192	GW	ANIONS	SO4	33.00		mg/L
MW009	07/11/88	01	5192	GW	PHCS	benzene	17.00		ug/L
MW009	07/11/88	01	5192	GW	PHCS	toluene	7.00		ug/L
MW009	07/11/88	01	5192	GW	PHCS	ethylbenzene	12.00		ug/L
MW009	07/11/88	01	5192	GW	PHCS	xylene(s)(total)	39.00		ug/L
MW009	07/11/88	01	5192	GW	PHCS	petroleum hydrocarbons	580.00		ug/L
MW009	07/11/88	01	5192	GW	VOLS	benzene	26.00		ug/L
MW009	07/11/88	01	5192	GW	VOLS	ethylbenzene	20.00		ug/L
MW009	07/11/88	01	5192	GW	VOLS	acetone	5.00	J	ug/L
MW009	07/11/88	01	5192	GW	VOLS	1,2-dichloroethene (total)	4.00	J	ug/L
MW009	10/05/88	01	5287	GW	PHCS	benzene	18.00		ug/L
MW009	10/05/88	01	5287	GW	PHCS	toluene	10.00		ug/L
MW009	10/05/88	01	5287	GW	PHCS	ethylbenzene	13.00		ug/L
MW009	10/05/88	01	5287	GW	PHCS	xylene(s)(total)	34.00		ug/L
MW009	10/05/88	01	5287	GW	PHCS	petroleum hydrocarbons	1100.00		ug/L
MW009	10/05/88	01	5287	GW	VOLS	1,2-dichloroethene (total)	4.00	J	ug/L
MW009	10/05/88	01	5287	GW	VOLS	benzene	22.00		ug/L
MW009	10/05/88	01	5287	GW	VOLS	ethylbenzene	17.00		ug/L
MW010	06/17/88	03	5056	SO	SVOLS	methylene chloride	6.00		ug/kg
MW010	06/17/88	03	5056	SO	SVOLS	acetone	17.00	B	ug/kg
MW010	06/17/88	06	5057	SO	SVOLS	methylene chloride	37.00		ug/kg
MW010	06/17/88	06	5057	SO	SVOLS	acetone	130.00	B	ug/kg
MW010	07/11/88	01	5191	GW	ANIONS	Cl	11.00		mg/L
MW010	07/11/88	01	5191	GW	ANIONS	F	0.90		mg/L
MW010	07/11/88	01	5191	GW	ANIONS	SO4	24.00		mg/L
MW010	07/11/88	01	5191	GW	METALS	Zn	0.01		mg/L
MW014	06/18/88	03	5075	SO	SVOLS	methylene chloride	11.00		ug/kg
MW014	06/18/88	03	5075	SO	SVOLS	acetone	54.00		ug/kg
MW014	06/18/88	03	5075	SO	SVOLS	chloroform	3.00	J	ug/kg
MW014	06/18/88	03	5075	SO	SVOLS	toluene	2.00	J	ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 5

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW014	06/18/88	06	5076	SO	SVOLS	methylene chloride	13.00		ug/kg
MW014	06/18/88	06	5076	SO	SVOLS	acetone	24.00		ug/kg
MW014	06/18/88	06	5076	SO	SVOLS	4-methyl-2-pentanone	1.00	J	ug/kg
MW014	06/18/88	06	5076	SO	SVOLS	toluene	3.00	J	ug/kg
MW014	06/18/88	06	5077	SR	SVOLS	methylene chloride	6.00	J	ug/kg
MW014	06/18/88	06	5077	SR	SVOLS	acetone	11.00		ug/kg
MW014	06/18/88	06	5077	SR	SVOLS	toluene	2.00	J	ug/kg
MW014	06/18/88	09	5078	SO	SVOLS	methylene chloride	10.00		ug/kg
MW014	06/18/88	09	5078	SO	SVOLS	acetone	13.00		ug/kg
MW014	06/18/88	12	5079	SO	SVOLS	methylene chloride	16.00		ug/kg
MW014	06/18/88	12	5079	SO	SVOLS	acetone	12.00		ug/kg
MW014	07/11/88	01	5190	GW	ANIONS	Cl	8.70		mg/L
MW014	07/11/88	01	5190	GW	ANIONS	F	1.20		mg/L
MW014	07/11/88	01	5190	GW	ANIONS	SO4	99.00		mg/L
MW014	09/30/88	01	5237	GW	VOLS	acetone	6.00	J	ug/L
MW014	10/03/88	01	5257	GW	VOLS	carbon disulfide	6.00		ug/L
SW005	03/10/88	01	0010	GW	PHCS	petroleum hydrocarbons	8900.00		ug/L
SW005	03/10/88	01	0010	GW	PHCS	benzene	180.00		ug/L
SW005	03/10/88	01	0010	GW	PHCS	ethylbenzene	300.00		ug/L
SW005	03/10/88	01	0010	GW	PHCS	xylene (total)	390.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	benzene	150.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	ethylbenzene	320.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	xylene (total)	380.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclohexane	680.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclopentane, methyl-	470.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	pentane, 3-methyl-	120.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclohexane, methyl	1500.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclopentane, ethyl	89.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclopentane, 1,1,3-trimethyl-	210.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclopropane, 1-(1-dimethylethyl)	130.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	1-heptanol, 2,4-dimethyl	110.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclohexane, ethyl	650.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclohexane, 1,2-dimethyl-, cis	200.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclohexane, 1,2-dimethyl-, trans	200.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	cyclohexane, 1,1,3-trimethyl	270.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	1-undecene	140.00		ug/L
SW005	03/10/88	01	0010	GW	VOLS	acetone	32.00	B	ug/L
SW005	03/11/88	02	0017	GW	PHCS	petroleum hydrocarbons	12000.00		ug/L
SW005	03/11/88	02	0017	GW	PHCS	benzene	640.00		ug/L
SW005	03/11/88	02	0017	GW	PHCS	ethylbenzene	690.00		ug/L
SW005	03/11/88	02	0017	GW	PHCS	xylene (total)	750.00		ug/L
SW005	03/11/88	02	0017	GW	VOLS	benzene	610.00		ug/L
SW005	03/11/88	02	0017	GW	VOLS	ethylbenzene	740.00		ug/L
SW005	03/11/88	02	0017	GW	VOLS	xylene (total)	720.00		ug/L
SW005	03/11/88	02	0017	GW	VOLS	cyclohexane	650.00		ug/L
SW005	03/11/88	02	0017	GW	VOLS	1-pentene, 2-methyl-	350.00		ug/L
SW005	03/11/88	02	0017	GW	VOLS	cyclohexane, methyl-	980.00		ug/L
SW005	03/11/88	02	0017	GW	VOLS	methylene chloride	13.00	JB	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 5

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
SW005	03/11/88	02	0017	GW	VOLS	acetone	47.00	J	ug/L
SW005	03/11/88	03	0018	GW	PHCS	petroleum hydrocarbons	13000.00		ug/L
SW005	03/11/88	03	0018	GW	PHCS	benzene	490.00		ug/L
SW005	03/11/88	03	0018	GW	PHCS	ethylbenzene	670.00		ug/L
SW005	03/11/88	03	0018	GW	PHCS	xlenes(total)	760.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	benzene	530.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	ethylbenzene	690.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	xlenes(total)	690.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	cyclohexane	740.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	cyclopentane,methyl-	460.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	pentane,3-methyl-	71.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	cyclohexane,methyl-	1000.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	cyclopentane,1,1,3-trimethyl-	57.00		ug/L
SW005	03/11/88	03	0018	GW	VOLS	methylene chloride	12.00	JB	ug/L
SW005	03/11/88	03	0018	GW	VOLS	acetone	37.00	J	ug/L
SW005	09/30/88	01	5238	GW	PHCS	benzene	210.00		ug/L
SW005	09/30/88	01	5238	GW	PHCS	xlenes(total)	1300.00		ug/L
SW005	09/30/88	01	5238	GW	PHCS	petroleum hydrocarbons	9500.00		ug/L
SW005	09/30/88	01	5238	GW	VOLS	methylene chloride	10.00	J	ug/L
SW005	09/30/88	01	5238	GW	VOLS	acetone	250.00		ug/L
SW005	09/30/88	01	5238	GW	VOLS	benzene	100.00		ug/L
SW005	09/30/88	01	5238	GW	VOLS	ethylbenzene	190.00		ug/L
SW005	09/30/88	01	5238	GW	VOLS	xlenes(total)	320.00		ug/L
SW005	10/05/88	01	5293	GW	PHCS	benzene	570.00		ug/L
SW005	10/05/88	01	5293	GW	PHCS	ethylbenzene	580.00		ug/L
SW005	10/05/88	01	5293	GW	PHCS	xlenes(total)	620.00		ug/L
SW005	10/05/88	01	5293	GW	PHCS	petroleum hydrocarbons	8700.00		ug/L
SW005	10/05/88	01	5293	GW	VOLS	methylene chloride	12.00	JB	ug/L
SW005	10/05/88	01	5293	GW	VOLS	acetone	76.00	JB	ug/L
SW005	10/05/88	01	5293	GW	VOLS	benzene	490.00		ug/L
SW005	10/05/88	01	5293	GW	VOLS	ethylbenzene	710.00		ug/L
SW005	10/05/88	01	5293	GW	VOLS	xlenes(total)	630.00		ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW001	06/14/88	03	5013	SO	SVOLS	methylene chloride	13.00		ug/kg
MW001	06/14/88	06	5014	SO	SVOLS	methylene chloride	7.00		ug/kg
MW001	06/14/88	06	5014	SO	SVOLS	acetone	46.00	B	ug/kg
MW001	06/14/88	06	5014	SO	SVOLS	toluene	2.00	J	ug/kg
MW001	06/14/88	09	5015	SO	SVOLS	acetone	23.00		ug/kg
MW001	06/14/88	09	5015	SO	SVOLS	methylene chloride	6.00		ug/kg
MW001	06/14/88	09	5015	SO	SVOLS	toluene	1.00	J	ug/kg
MW001	06/14/88	12	5016	SO	SVOLS	methylene chloride	15.00		ug/kg
MW001	06/14/88	12	5016	SO	SVOLS	acetone	18.00		ug/kg
MW001	07/07/88	01	5168	GW	ANIONS	Cl	11.00		mg/L
MW001	07/07/88	01	5168	GW	ANIONS	F	1.70		mg/L
MW001	07/07/88	01	5168	GW	ANIONS	SO4	620.00		mg/L
MW001	07/07/88	01	5168	GW	METALS	Zn	0.01		mg/L
MW001	07/07/88	01	5168	GW	SEMI	bis(2-ethylhexyl)phthalate	15.00	B	ug/L
MW001	07/07/88	01	5168	GW	VOLS	4-methyl-2-pentanone	2.00	J	ug/L
MW001	10/03/88	01	5259	GW	VOLS	acetone	7.00	J	ug/L
MW002	06/14/88	03	5019	SO	SVOLS	methylene chloride	26.00		ug/kg
MW002	06/14/88	03	5019	SO	SVOLS	acetone	19.00		ug/kg
MW002	06/14/88	03	5019	SO	SVOLS	toluene	2.00	J	ug/kg
MW002	06/14/88	06	5020	SO	SVOLS	methylene chloride	4.00	JB	ug/kg
MW002	06/14/88	06	5020	SO	SVOLS	acetone	33.00	B	ug/kg
MW002	06/14/88	06	5020	SO	SVOLS	chloroform	3.00	JB	ug/kg
MW002	06/14/88	09	5021	SO	SVOLS	methylene chloride	10.00	B	ug/kg
MW002	06/14/88	09	5021	SO	SVOLS	acetone	110.00	B	ug/kg
MW002	06/14/88	09	5021	SO	SVOLS	chloroform	3.00	JB	ug/kg
MW002	07/10/88	01	5185	GW	ANIONS	Cl	15.00		mg/L
MW002	07/10/88	01	5185	GW	ANIONS	F	1.50		mg/L
MW002	07/10/88	01	5185	GW	ANIONS	SO4	450.00		mg/L
MW002	07/10/88	01	5185	GW	VOLS	acetone	5.00	JB	ug/L
MW022	06/21/88	03	5135	SO	SVOLS	methylene chloride	20.00		ug/kg
MW022	06/21/88	03	5135	SO	SVOLS	acetone	16.00		ug/kg
MW022	06/21/88	06	5136	SO	SVOLS	methylene chloride	14.00		ug/kg
MW022	06/21/88	06	5136	SO	SVOLS	acetone	30.00		ug/kg
MW022	06/21/88	08	5137	SO	SPHCS	oil&grease	360.00		mg/kg
MW025	07/12/88	01	5196	WR	ANIONS	Cl	4.00		mg/L
MW025	07/12/88	01	5196	WR	ANIONS	F	0.50		mg/L
MW025	07/12/88	01	5196	WR	ANIONS	SO4	102.00		mg/L
MW025	07/12/88	01	5196	WR	METALS	Ba	0.11		mg/L
MW025	07/12/88	01	5196	WR	METALS	Zn	0.02		mg/L
MW025	07/12/88	01	5196	WR	METALS	Na	24.00		mg/L
MW025	07/12/88	01	5196	WR	METALS	K	4.30		mg/L
MW025	07/12/88	01	5196	WR	METALS	Ca	130.00		mg/L
MW025	07/12/88	01	5196	WR	METALS	Mg	29.00		mg/L
MW025	07/12/88	01	5196	WR	SEMI	unknown #1	3.00	J	ug/L
MW025	07/12/88	01	5196	WR	SEMI	diacetone alcohol	100.00	JA	ug/L
MW025	07/12/88	01	5196	WR	SEMI	unknown #2	6.00	JB	ug/L
MW025	07/12/88	01	5196	WR	SEMI	unknown #3	9.00	JB	ug/L
MW025	07/12/88	01	5196	WR	SEMI	unknown #4	2.00	J	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW025	07/12/88	01	5196	WR	SEMI	poss alkoxy/hydroxy/alkene	7.00	JB	ug/L
MW025	07/12/88	01	5196	WR	SEMI	unknown #5	5.00	JB	ug/L
MW025	07/12/88	01	5196	WR	SEMI	dioctyl adipate	10.00	J	ug/L
MW025	07/12/88	01	5196	WR	SEMI	unknown phthalate ester	5.00	J	ug/L
MW025	07/12/88	01	5196	WR	SEMI	unknown #6	9.00	J	ug/L
MW025	07/12/88	01	5196	WR	SEMI	unknown #7	9.00	J	ug/L
MW025	07/12/88	01	5196	WR	SEMI	unknown #8	9.00	J	ug/L
MW025	07/12/88	01	5196	WR	VOLS	benzene	14.00		ug/L
MW025	07/12/88	01	5196	WR	VOLS	toluene	7.00		ug/L
MW025	07/12/88	01	5196	WR	VOLS	ethylbenzene	3.00	JB	ug/L
MW025	07/12/88	01	5196	WR	VOLS	xylene(s)(total)	2.00	J	ug/L
MW025	07/12/88	01	5196	WR	VOLS	probable hydrocarbon #1	6.00	JB	ug/L
MW025	07/12/88	01	5196	WR	VOLS	probable hydrocarbon #2	5.00	J	ug/L
MW025	07/13/88	01	5217	GW	ANIONS	Cl	4.80		mg/L
MW025	07/13/88	01	5217	GW	ANIONS	F	1.30		mg/L
MW025	07/13/88	01	5217	GW	ANIONS	SO4	230.00		mg/L
MW025	07/13/88	01	5217	GW	METALS	Zn	0.03		mg/L
MW025	07/13/88	01	5217	GW	VOLS	acetone	6.00	J	ug/L
MW025	07/13/88	02	5218	WR	ANIONS	Cl	3.80		mg/L
MW025	07/13/88	02	5218	WR	ANIONS	F	1.30		mg/L
MW025	07/13/88	02	5218	WR	ANIONS	SO4	210.00		mg/L
MW025	07/13/88	02	5218	WR	METALS	Zn	0.03		mg/L
MW025	07/13/88	02	5218	WR	METALS	As	0.00		mg/L
MW025	07/13/88	02	5218	WR	VOLS	acetone	6.00	J	ug/L
MW025	07/13/88	03	5219	WR	ANIONS	Cl	3.90		mg/L
MW025	07/13/88	03	5219	WR	ANIONS	F	1.30		mg/L
MW025	07/13/88	03	5219	WR	ANIONS	SO4	180.00		mg/L
MW025	07/13/88	03	5219	WR	METALS	Zn	0.03		mg/L
MW025	07/13/88	03	5219	WR	VOLS	acetone	6.00	J	ug/L
MW025	10/03/88	01	5260	GW	VOLS	acetone	3.00	J	ug/L
SD001	06/14/88	01	5000	SO	SMETAL	As	4.00		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Be	0.40		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Cd	0.90		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Cr	9.00		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Cu	14.00		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Pb	61.00		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Hg	0.02		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Ni	12.00		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Tl	4.00		mg/kg
SD001	06/14/88	01	5000	SO	SMETAL	Zn	425.00		mg/kg
SD001	06/14/88	01	5000	SO	SPHCS	petroleum hydrocarbons	120000.00		ug/kg
SD001	06/14/88	01	5000	SO	SPHCS	xylene(s)(total)	14000.00		ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	2-methylnaphthalene	1700.00		ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	bis(2-ethylhexyl)phthalate	1400.00	JB	ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	phenanthrene	180.00	J	ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	anthracene	180.00	J	ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	fluoranthene	270.00	J	ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	pyrene	260.00	J	ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
SD001	06/14/88	01	5000	SO	SSEMI	benzo(a)anthracene	260.00	J	ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	chrysene	240.00	J	ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	benzo(b)fluoranthene	410.00	J	ug/kg
SD001	06/14/88	01	5000	SO	SSEMI	benzo(k)fluoranthene	330.00	J	ug/kg
SD001	06/14/88	01	5000	SO	SVOLS	acetone	190.00	B	ug/kg
SD001	06/14/88	01	5000	SO	SVOLS	methylene chloride	77.00		ug/kg
SD001	06/14/88	01	5000	SO	SVOLS	xylenes(total)	930.00	D	ug/kg
SD002	06/23/88	01	5001	SO	SMETAL	As	3.90		mg/kg
SD002	06/23/88	01	5001	SO	SMETAL	Be	0.70		mg/kg
SD002	06/23/88	01	5001	SO	SMETAL	Cr	6.00		mg/kg
SD002	06/23/88	01	5001	SO	SMETAL	Cu	11.00		mg/kg
SD002	06/23/88	01	5001	SO	SMETAL	Pb	35.00		mg/kg
SD002	06/23/88	01	5001	SO	SMETAL	Hg	0.05		mg/kg
SD002	06/23/88	01	5001	SO	SMETAL	Ni	14.00		mg/kg
SD002	06/23/88	01	5001	SO	SMETAL	Zn	52.00		mg/kg
SD002	06/23/88	01	5001	SO	SSEMI	n-nitrosodiphenylamine	600.00	JB	ug/kg
SD002	06/23/88	01	5001	SO	SSEMI	pentachlorophenol	180.00	J	ug/kg
SD002	06/23/88	01	5001	SO	SSEMI	phenanthrene	100.00	J	ug/kg
SD002	06/23/88	01	5001	SO	SSEMI	fluoranthene	100.00	J	ug/kg
SD002	06/23/88	01	5001	SO	SSEMI	pyrene	340.00	J	ug/kg
SD002	06/23/88	01	5001	SO	SSEMI	benzo(a)anthracene	150.00	J	ug/kg
SD002	06/23/88	01	5001	SO	SSEMI	chrysene	150.00	J	ug/kg
SD002	06/23/88	01	5001	SO	SSEMI	bis(2-ethylhexyl)phthalate	720.00	JB	ug/kg
SD002	06/23/88	01	5001	SO	SSEMI	benzo(b)fluoranthene	110.00	J	ug/kg
SD002	06/23/88	01	5001	SO	SVOLS	toluene	9.00		ug/kg
SD002	06/23/88	01	5001	SO	SVOLS	methylene chloride	9.00		ug/kg
SD002	06/23/88	01	5001	SO	SVOLS	acetone	9.00	J	ug/kg
SD003	06/23/88	01	5002	SO	SMETAL	As	5.30		mg/kg
SD003	06/23/88	01	5002	SO	SMETAL	Be	0.70		mg/kg
SD003	06/23/88	01	5002	SO	SMETAL	Cr	5.00		mg/kg
SD003	06/23/88	01	5002	SO	SMETAL	Cu	8.00		mg/kg
SD003	06/23/88	01	5002	SO	SMETAL	Pb	15.00		mg/kg
SD003	06/23/88	01	5002	SO	SMETAL	Hg	0.04		mg/kg
SD003	06/23/88	01	5002	SO	SMETAL	Ni	7.00		mg/kg
SD003	06/23/88	01	5002	SO	SMETAL	Zn	12.60		mg/kg
SD003	06/23/88	01	5002	SO	SSEMI	n-nitrosodiphenylamine	1100.00	B	ug/kg
SD003	06/23/88	01	5002	SO	SSEMI	bis(2-ethylhexyl)phthalate	400.00	JB	ug/kg
SD003	06/23/88	01	5002	SO	SVOLS	methylene chloride	22.00		ug/kg
SD003	06/23/88	01	5002	SO	SVOLS	acetone	32.00		ug/kg
SD003	06/23/88	01	5002	SO	SVOLS	2-butanone	15.00		ug/kg
SD003	06/23/88	01	5002	SO	SVOLS	trichloroethene	3.00	J	ug/kg
SD003	06/23/88	01	5002	SO	SVOLS	toluene	26.00		ug/kg
SD004	06/23/88	01	5003	SO	SMETAL	As	6.40		mg/kg
SD004	06/23/88	01	5003	SO	SMETAL	Be	0.40		mg/kg
SD004	06/23/88	01	5003	SO	SMETAL	Cd	0.90		mg/kg
SD004	06/23/88	01	5003	SO	SMETAL	Cr	4.00		mg/kg
SD004	06/23/88	01	5003	SO	SMETAL	Cu	10.00		mg/kg
SD004	06/23/88	01	5003	SO	SMETAL	Pb	29.00		mg/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
SD004	06/23/88	01	5003	SO	SMETAL	Hg	0.07		mg/kg
SD004	06/23/88	01	5003	SO	SMETAL	Ni	37.00		mg/kg
SD004	06/23/88	01	5003	SO	SMETAL	Zn	112.00		mg/kg
SD004	06/23/88	01	5003	SO	SPHCS	petroleum hydrocarbons	11000.00		ug/kg
SD004	06/23/88	01	5003	SO	SSEMI	bis(2-ethylhexyl)phthalate	3700.00	B	ug/kg
SD004	06/23/88	01	5003	SO	SSEMI	n-nitrosodiphenylamine	2100.00	B	ug/kg
SD004	06/23/88	01	5003	SO	SSEMI	phenanthrene	2000.00		ug/kg
SD004	06/23/88	01	5003	SO	SSEMI	anthracene	420.00	J	ug/kg
SD004	06/23/88	01	5003	SO	SSEMI	fluoranthene	2700.00		ug/kg
SD004	06/23/88	01	5003	SO	SSEMI	benzo(a)anthracene	1000.00	J	ug/kg
SD004	06/23/88	01	5003	SO	SSEMI	chrysene	1100.00	J	ug/kg
SD004	06/23/88	01	5003	SO	SVOLS	acetone	23.00		ug/kg
SD004	06/23/88	01	5003	SO	SVOLS	vinyl chloride	2.00	J	ug/kg
SD004	06/23/88	01	5003	SO	SVOLS	methylene chloride	2.00	J	ug/kg
SD004	06/23/88	01	5003	SO	SVOLS	1,1-dichloroethane	6.00	J	ug/kg
SD004	06/23/88	01	5003	SO	SVOLS	1,2-dichloroethene (total)	6.00	J	ug/kg
SD005	06/23/88	01	5004	SO	SMETAL	As	5.90		mg/kg
SD005	06/23/88	01	5004	SO	SMETAL	Be	0.60		mg/kg
SD005	06/23/88	01	5004	SO	SMETAL	Cr	3.00		mg/kg
SD005	06/23/88	01	5004	SO	SMETAL	Cu	6.00		mg/kg
SD005	06/23/88	01	5004	SO	SMETAL	Pb	7.00		mg/kg
SD005	06/23/88	01	5004	SO	SMETAL	Hg	0.04		mg/kg
SD005	06/23/88	01	5004	SO	SMETAL	Ni	6.00		mg/kg
SD005	06/23/88	01	5004	SO	SMETAL	Zn	6.80		mg/kg
SD005	06/23/88	01	5004	SO	SSEMI	n-nitrosodiphenylamine	1600.00	B	ug/kg
SD005	06/23/88	01	5004	SO	SSEMI	pentachlorophenol	150.00	J	ug/kg
SD005	06/23/88	01	5004	SO	SSEMI	phenanthrene	250.00	J	ug/kg
SD005	06/23/88	01	5004	SO	SSEMI	fluoranthene	630.00	J	ug/kg
SD005	06/23/88	01	5004	SO	SSEMI	pyrene	640.00	J	ug/kg
SD005	06/23/88	01	5004	SO	SSEMI	benzo(a)anthracene	220.00	J	ug/kg
SD005	06/23/88	01	5004	SO	SSEMI	bis(2-ethylhexyl)phthalate	2600.00	B	ug/kg
SD005	06/23/88	01	5004	SO	SSEMI	benzo(b)fluoranthene	220.00	J	ug/kg
SD005	06/23/88	01	5004	SO	SSEMI	benzo(k)fluoranthene	280.00	J	ug/kg
SD006	06/23/88	01	5005	SO	SMETAL	As	2.50		mg/kg
SD006	06/23/88	01	5005	SO	SMETAL	Be	0.80		mg/kg
SD006	06/23/88	01	5005	SO	SMETAL	Cr	6.00		mg/kg
SD006	06/23/88	01	5005	SO	SMETAL	Cu	9.00		mg/kg
SD006	06/23/88	01	5005	SO	SMETAL	Pb	14.00		mg/kg
SD006	06/23/88	01	5005	SO	SMETAL	Hg	0.04		mg/kg
SD006	06/23/88	01	5005	SO	SMETAL	Ni	6.00		mg/kg
SD006	06/23/88	01	5005	SO	SMETAL	Zn	19.60		mg/kg
SD006	06/23/88	01	5005	SO	SSEMI	bis(2-ethylhexyl)phthalate	860.00	B	ug/kg
SD006	06/23/88	01	5005	SO	SSEMI	diethylphthalate	44.00	J	ug/kg
SD006	06/23/88	01	5005	SO	SSEMI	n-nitrosodiphenylamine	330.00	JB	ug/kg
SD006	06/23/88	01	5005	SO	SSEMI	di-n-butylphthalate	54.00	J	ug/kg
SD006	06/23/88	01	5005	SO	SVOLS	acetone	7.00	J	ug/kg
SD007	06/23/88	01	5006	SO	SMETAL	As	0.60		mg/kg
SD007	06/23/88	01	5006	SO	SMETAL	Cr	2.00		mg/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
SD007	06/23/88	01	5006	SO	SMETAL	Cu	8.00		mg/kg
SD007	06/23/88	01	5006	SO	SMETAL	Pb	9.00		mg/kg
SD007	06/23/88	01	5006	SO	SMETAL	Hg	0.02		mg/kg
SD007	06/23/88	01	5006	SO	SMETAL	Zn	22.60		mg/kg
SD007	06/23/88	01	5006	SO	SSEMI	bis(2-ethylhexyl)phthalate	1300.00	B	ug/kg
SD007	06/23/88	01	5006	SO	SSEMI	n-nitrosodiphenylamine	300.00	JB	ug/kg
SD007	06/23/88	01	5006	SO	SSEMI	di-n-butylphthalate	68.00	J	ug/kg
SD007	06/23/88	01	5006	SO	SVOLS	acetone	20.00		ug/kg
SD007	06/23/88	01	5006	SO	SVOLS	methylene chloride	2.00	J	ug/kg
SD008	06/23/88	01	5007	SO	SMETAL	As	6.70		mg/kg
SD008	06/23/88	01	5007	SO	SMETAL	Be	0.20		mg/kg
SD008	06/23/88	01	5007	SO	SMETAL	Cd	0.50		mg/kg
SD008	06/23/88	01	5007	SO	SMETAL	Cr	3.00		mg/kg
SD008	06/23/88	01	5007	SO	SMETAL	Cu	5.00		mg/kg
SD008	06/23/88	01	5007	SO	SMETAL	Pb	18.00		mg/kg
SD008	06/23/88	01	5007	SO	SMETAL	Hg	0.08		mg/kg
SD008	06/23/88	01	5007	SO	SMETAL	Ni	11.00		mg/kg
SD008	06/23/88	01	5007	SO	SMETAL	Zn	88.30		mg/kg
SD008	06/23/88	01	5007	SO	SSEMI	bis(2-ethylhexyl)phthalate	3400.00	B	ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	n-nitrosodiphenylamine	2600.00	B	ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	phenanthrene	23000.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	anthracene	2600.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	fluoranthene	47000.00	D	ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	pyrene	41000.00	D	ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	benzo(a)anthracene	23000.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	chrysene	20000.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	benzo(b)fluoranthene	23000.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	benzo(k)fluoranthene	17000.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	benzo(a)pyrene	15000.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	indeno(1,2,3-cd)pyrene	12000.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	benzo(g,h,i)perylene	19000.00		ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	acenaphthylene	590.00	J	ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	acenaphthene	770.00	J	ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	dibenzofuran	760.00	J	ug/kg
SD008	06/23/88	01	5007	SO	SSEMI	fluorene	1300.00	J	ug/kg
SD008	06/23/88	01	5007	SO	SVOLS	acetone	46.00		ug/kg
SD009	06/23/88	01	5008	SO	SMETAL	Zn	44.00		mg/kg
SD009	06/23/88	01	5008	SO	SMETAL	Ni	8.00		mg/kg
SD009	06/23/88	01	5008	SO	SMETAL	Hg	0.05		mg/kg
SD009	06/23/88	01	5008	SO	SMETAL	Pb	19.00		mg/kg
SD009	06/23/88	01	5008	SO	SMETAL	Cu	8.00		mg/kg
SD009	06/23/88	01	5008	SO	SMETAL	Cr	4.00		mg/kg
SD009	06/23/88	01	5008	SO	SMETAL	Be	0.50		mg/kg
SD009	06/23/88	01	5008	SO	SMETAL	As	2.60		mg/kg
SD009	06/23/88	01	5008	SO	SPEST	dieldrin	47.00	D	ug/kg
SD009	06/23/88	01	5008	SO	SPEST	4,4'-DDE	30.00		ug/kg
SD009	06/23/88	01	5008	SO	SPEST	4,4'-DDT	65.00		ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	phenanthrene	2300.00		ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
SD009	06/23/88	01	5008	SO	SSEMI	fluoranthene	3400.00		ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	pyrene	3100.00		ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	bis(2-ethylhexyl)phthalate	2700.00	B	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	naphthalene	190.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	acenaphthene	240.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	fluorene	270.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	n-nitrosodiphenylamine	1400.00	JB	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	anthracene	520.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	benzo(a)anthracene	1400.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	chrysene	1500.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	benzo(b)fluoranthene	1600.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	benzo(k)fluoranthene	1700.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	benzo(a)pyrene	1200.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SSEMI	benzo(g,h,i)perylene	1400.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SVOLS	methylene chloride	2.00	J	ug/kg
SD009	06/23/88	01	5008	SO	SVOLS	acetone	14.00		ug/kg
SD010	06/23/88	01	5009	SR	SMETAL	Zn	56.20		mg/kg
SD010	06/23/88	01	5009	SR	SMETAL	Ni	7.00		mg/kg
SD010	06/23/88	01	5009	SR	SMETAL	Hg	0.15		mg/kg
SD010	06/23/88	01	5009	SR	SMETAL	Pb	31.00		mg/kg
SD010	06/23/88	01	5009	SR	SMETAL	Cu	8.00		mg/kg
SD010	06/23/88	01	5009	SR	SMETAL	Cr	5.00		mg/kg
SD010	06/23/88	01	5009	SR	SMETAL	Be	0.40		mg/kg
SD010	06/23/88	01	5009	SR	SMETAL	As	4.50		mg/kg
SD010	06/23/88	01	5009	SR	SPHCS	petroleum hydrocarbons	6000.00		ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	bis(2-ethylhexyl)phthalate	2500.00	B	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	pyrene	3000.00		ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	fluoranthene	3400.00		ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	n-nitrosodiphenylamine	2200.00	B	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	phenanthrene	1700.00	J	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	anthracene	330.00	J	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	benzo(a)anthracene	1500.00	J	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	chrysene	1700.00	J	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	benzo(b)fluoranthene	1800.00	J	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	benzo(k)fluoranthene	1700.00	J	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	benzo(a)pyrene	1400.00	J	ug/kg
SD010	06/23/88	01	5009	SR	SSEMI	benzo(g,h,i)perylene	1400.00	J	ug/kg
SD010	06/23/88	01	5009	SR	SVOLS	methylene chloride	19.00		ug/kg
SD010	06/23/88	01	5009	SR	SVOLS	acetone	37.00		ug/kg
SD011	06/24/88	01	5010	SO	SMETAL	Zn	20.30		mg/kg
SD011	06/24/88	01	5010	SO	SMETAL	Ni	5.00		mg/kg
SD011	06/24/88	01	5010	SO	SMETAL	Hg	0.02		mg/kg
SD011	06/24/88	01	5010	SO	SMETAL	Pb	14.00		mg/kg
SD011	06/24/88	01	5010	SO	SMETAL	Cu	6.00		mg/kg
SD011	06/24/88	01	5010	SO	SMETAL	Cr	4.00		mg/kg
SD011	06/24/88	01	5010	SO	SMETAL	Be	0.30		mg/kg
SD011	06/24/88	01	5010	SO	SMETAL	As	5.00		mg/kg
SD011	06/24/88	01	5010	SO	SSEMI	bis(2-ethylhexyl)phthalate	3000.00	B	ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
SD011	06/24/88	01	5010	SO	SSEMI	n-nitrosodiphenylamine	800.00	JB	ug/kg
SD011	06/24/88	01	5010	SO	SSEMI	phenanthrene	380.00	J	ug/kg
SD011	06/24/88	01	5010	SO	SSEMI	fluoranthene	880.00	J	ug/kg
SD011	06/24/88	01	5010	SO	SSEMI	pyrene	840.00	J	ug/kg
SD011	06/24/88	01	5010	SO	SSEMI	benzo(a)anthracene	260.00	J	ug/kg
SD011	06/24/88	01	5010	SO	SSEMI	chrysene	480.00	J	ug/kg
SD011	06/24/88	01	5010	SO	SSEMI	benzo(b)fluoranthene	340.00	J	ug/kg
SD011	06/24/88	01	5010	SO	SSEMI	benzo(k)fluoranthene	440.00	J	ug/kg
SD011	06/24/88	01	5010	SO	SVOLS	methylene chloride	22.00		ug/kg
SD011	06/24/88	01	5010	SO	SVOLS	acetone	24.00		ug/kg
SD012	06/24/88	01	5012	SO	SMETAL	Zn	18.50		mg/kg
SD012	06/24/88	01	5012	SO	SMETAL	Ni	20.00		mg/kg
SD012	06/24/88	01	5012	SO	SMETAL	Pb	37.00		mg/kg
SD012	06/24/88	01	5012	SO	SMETAL	Cu	7.00		mg/kg
SD012	06/24/88	01	5012	SO	SMETAL	Cr	5.00		mg/kg
SD012	06/24/88	01	5012	SO	SMETAL	Be	0.70		mg/kg
SD012	06/24/88	01	5012	SO	SMETAL	As	5.30		mg/kg
SD012	06/24/88	01	5012	SO	SSEMI	bis(2-ethylhexyl)phthalate	1300.00	B	ug/kg
SD012	06/24/88	01	5012	SO	SSEMI	n-nitrosodiphenylamine	270.00	JB	ug/kg
SD012	06/24/88	01	5012	SO	SVOLS	methylene chloride	25.00		ug/kg
SD012	06/24/88	01	5012	SO	SVOLS	acetone	15.00		ug/kg
SD013	10/02/88	01	5247	SO	SMETAL	As	2.90		mg/kg
SD013	10/02/88	01	5247	SO	SMETAL	Be	0.50		mg/kg
SD013	10/02/88	01	5247	SO	SMETAL	Cd	1.20		mg/kg
SD013	10/02/88	01	5247	SO	SMETAL	Cr	15.00		mg/kg
SD013	10/02/88	01	5247	SO	SMETAL	Cu	8.00		mg/kg
SD013	10/02/88	01	5247	SO	SMETAL	Pb	184.00		mg/kg
SD013	10/02/88	01	5247	SO	SMETAL	Hg	0.06		mg/kg
SD013	10/02/88	01	5247	SO	SMETAL	Ni	8.00		mg/kg
SD013	10/02/88	01	5247	SO	SMETAL	Zn	158.00		mg/kg
SD013	10/02/88	01	5247	SO	SSEMI	n-nitrosodiphenylamine	420.00	J	ug/kg
SD013	10/02/88	01	5247	SO	SSEMI	bis(2-ethylhexyl)phthalate	860.00	BJ	ug/kg
SD013	10/02/88	01	5247	SO	SVOLS	methylene chloride	26.00	B	ug/kg
SD013	10/02/88	01	5247	SO	SVOLS	acetone	18.00	B	ug/kg
SD014	10/02/88	01	5248	SO	SMETAL	As	5.80		mg/kg
SD014	10/02/88	01	5248	SO	SMETAL	Be	0.70		mg/kg
SD014	10/02/88	01	5248	SO	SMETAL	Cd	1.40		mg/kg
SD014	10/02/88	01	5248	SO	SMETAL	Cr	14.00		mg/kg
SD014	10/02/88	01	5248	SO	SMETAL	Cu	8.00		mg/kg
SD014	10/02/88	01	5248	SO	SMETAL	Pb	98.00		mg/kg
SD014	10/02/88	01	5248	SO	SMETAL	Hg	0.05		mg/kg
SD014	10/02/88	01	5248	SO	SMETAL	Ni	12.00		mg/kg
SD014	10/02/88	01	5248	SO	SMETAL	Zn	140.00		mg/kg
SD014	10/02/88	01	5248	SO	SSEMI	n-nitrosodiphenylamine	650.00	J	ug/kg
SD014	10/02/88	01	5248	SO	SSEMI	pyrene	190.00	J	ug/kg
SD014	10/02/88	01	5248	SO	SSEMI	bis(2-ethylhexyl)phthalate	520.00	BJ	ug/kg
SD014	10/02/88	01	5248	SO	SVOLS	methylene chloride	25.00	B	ug/kg
SD014	10/02/88	01	5248	SO	SVOLS	acetone	60.00	B	ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
SD014	10/02/88	01	5248	SO	SVOLS	toluene	1.00	J	ug/kg
SD015	10/02/88	01	5249	SO	SMETAL	As	5.80		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Be	0.80		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Cd	1.30		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Cr	17.00		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Cu	12.00		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Pb	102.00		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Pb	102.00		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Hg	0.05		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Ni	12.00		mg/kg
SD015	10/02/88	01	5249	SO	SMETAL	Zn	150.00		mg/kg
SD015	10/02/88	01	5249	SO	SSEMI	n-nitrosodiphenylamine	91.00	J	ug/kg
SD015	10/02/88	01	5249	SO	SSEMI	butylbenzylphthalate	110.00	J	ug/kg
SD015	10/02/88	01	5249	SO	SSEMI	bis(2-ethylhexyl)phthalate	540.00	BJ	ug/kg
SD015	10/02/88	01	5249	SO	SVOLS	methylene chloride	32.00	B	ug/kg
SD015	10/02/88	01	5249	SO	SVOLS	acetone	68.00	B	ug/kg
SD016	10/02/88	01	5250	SO	SMETAL	As	7.10		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Be	1.00		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Cd	1.40		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Cr	15.00		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Cu	9.00		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Pb	38.00		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Hg	0.04		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Ni	18.00		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Ti	0.40		mg/kg
SD016	10/02/88	01	5250	SO	SMETAL	Zn	118.00		mg/kg
SD016	10/02/88	01	5250	SO	SSEMI	n-nitrosodiphenylamine	150.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	phenanthrene	690.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	anthracene	87.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	di-n-butylphthalate	150.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	fluoranthene	1300.00		ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	pyrene	1100.00		ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	benzo(a)anthracene	230.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	chrysene	530.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	benzo(b)fluoranthene	540.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	benzo(k)fluoranthene	240.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	benzo(a)pyrene	190.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	indeno(1,2,3-cd)pyrene	190.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	dibenzo(a,h)anthracene	86.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	benzo(g,h,i)perylene	220.00	J	ug/kg
SD016	10/02/88	01	5250	SO	SSEMI	bis(2-ethylhexyl)phthalate	390.00	BJ	ug/kg
SD016	10/02/88	01	5250	SO	SVOLS	methylene chloride	27.00	B	ug/kg
SD016	10/02/88	01	5250	SO	SVOLS	acetone	30.00	B	ug/kg
WS001	09/28/88	01	5234	WT	VOLS	1,2-dichloroethene (total)	15.00		ug/L
WS001	09/28/88	01	5234	WT	VOLS	trichloroethene	2.00	J	ug/L
WS001	11/18/88	01	5304	WT	VOLS	vinyl chloride	4.00	J	ug/L
WS001	11/18/88	01	5304	WT	VOLS	acetone	13.00		ug/L
WS001	11/18/88	01	5304	WT	VOLS	1,2-dichloroethene (total)	31.00		ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 6

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
WS001	11/18/88	01	5304	WT	VOLS	trichloroethene	3.00	J	ug/L
WS001	11/18/88	01	5304	WT	VOLS	chlorobenzene	9.00		ug/L
WS003	09/28/88	01	5236	WT	VOLS	hydrocarbon #1	7.00	JB	ug/L
WS003	09/28/88	01	5236	WT	VOLS	hydrocarbon #2	6.00	JB	ug/L
WS003	09/28/88	01	5236	WT	VOLS	hydrocarbon #3	4.00	JP	ug/L
WS003	09/28/88	01	5236	WT	VOLS	acetone	4.00	J	ug/L
WS004	11/18/88	01	5305	WT	VOLS	vinyl chloride	7.00	J	ug/L
WS004	11/18/88	01	5305	WT	VOLS	methylene chloride	1.00	J	ug/L
WS004	11/18/88	01	5305	WT	VOLS	acetone	15.00		ug/L
WS004	11/18/88	01	5305	WT	VOLS	1,2-dichloroethene (total)	46.00		ug/L
WS004	11/18/88	01	5305	WT	VOLS	trichloroethene	5.00		ug/L
WS005	11/18/88	01	5306	WT	VOLS	acetone	11.00		ug/L
WS005	11/18/88	01	5306	WT	VOLS	1,2-dichloroethene (total)	2.00	J	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 7

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW005	06/16/88	03	5033	SO	SVOLS	methylene chloride	13.00		ug/kg
MW005	06/16/88	03	5033	SO	SVOLS	acetone	390.00	EB	ug/kg
MW005	06/16/88	03	5033	SO	SVOLS	2-butanone	23.00		ug/kg
MW005	06/16/88	03	5033	SO	SVOLS	1,1,1-trichloroethane	2.00	J	ug/kg
MW005	06/16/88	06	5034	SO	SVOLS	acetone	200.00	B	ug/kg
MW005	06/16/88	06	5034	SO	SVOLS	methylene chloride	6.00		ug/kg
MW005	06/16/88	06	5034	SO	SVOLS	2-butanone	8.00	J	ug/kg
MW005	06/16/88	09	5035	SO	SVOLS	acetone	93.00	B	ug/kg
MW005	06/16/88	09	5035	SO	SVOLS	methylene chloride	10.00		ug/kg
MW005	06/16/88	12	5036	SO	SVOLS	methylene chloride	23.00		ug/kg
MW005	06/16/88	12	5036	SO	SVOLS	acetone	79.00	B	ug/kg
MW005	07/08/88	01	5176	GW	ANIONS	Cl	7.80		mg/L
MW005	07/08/88	01	5176	GW	ANIONS	F	1.80		mg/L
MW005	07/08/88	01	5176	GW	ANIONS	SO4	200.00		mg/L
MW005	07/08/88	01	5176	GW	METALS	As	0.01		mg/L
MW005	07/08/88	01	5176	GW	METALS	Pb	0.01		mg/L
MW005	07/08/88	01	5176	GW	VOLS	acetone	4.00	J	ug/L
MW006	06/16/88	03	5037	SO	SVOLS	methylene chloride	12.00		ug/kg
MW006	06/16/88	03	5037	SO	SVOLS	acetone	310.00	EB	ug/kg
MW006	06/16/88	03	5037	SO	SVOLS	2-butanone	28.00		ug/kg
MW006	06/16/88	06	5038	SO	SVOLS	acetone	450.00	E	ug/kg
MW006	06/16/88	06	5038	SO	SVOLS	2-butanone	20.00		ug/kg
MW006	06/16/88	06	5038	SO	SVOLS	methylene chloride	12.00		ug/kg
MW006	06/16/88	06	5039	SR	SVOLS	acetone	400.00	E	ug/kg
MW006	06/16/88	06	5039	SR	SVOLS	2-butanone	19.00		ug/kg
MW006	06/16/88	06	5039	SR	SVOLS	methylene chloride	7.00		ug/kg
MW006	06/16/88	09	5040	SO	SVOLS	methylene chloride	19.00	B	ug/kg
MW006	06/16/88	09	5040	SO	SVOLS	acetone	100.00		ug/kg
MW006	06/16/88	12	5041	SO	SVOLS	methylene chloride	6.00		ug/kg
MW006	06/16/88	12	5041	SO	SVOLS	acetone	52.00		ug/kg
MW006	07/13/88	01	5220	GW	ANIONS	Cl	7.60		mg/L
MW006	07/13/88	01	5220	GW	ANIONS	F	2.50		mg/L
MW006	07/13/88	01	5220	GW	ANIONS	SO4	230.00		mg/L
MW006	07/13/88	01	5220	GW	METALS	Pb	0.00		mg/L
MW006	07/13/88	01	5220	GW	METALS	Zn	0.01		mg/L
MW006	07/13/88	01	5220	GW	PHCS	petroleum hydrocarbons	11.00	JB	ug/L
MW006	07/13/88	01	5220	GW	VOLS	acetone	5.00	J	ug/L
MW006	07/13/88	02	5221	WR	ANIONS	Cl	7.50		mg/L
MW006	07/13/88	02	5221	WR	ANIONS	F	2.60		mg/L
MW006	07/13/88	02	5221	WR	ANIONS	SO4	240.00		mg/L
MW006	07/13/88	02	5221	WR	PHCS	petroleum hydrocarbons	82.00	B	ug/L
MW006	07/13/88	03	5222	WR	ANIONS	Cl	7.00		mg/L
MW006	07/13/88	03	5222	WR	ANIONS	SO4	230.00		mg/L
MW006	07/13/88	03	5222	WR	ANIONS	F	2.60		mg/L
MW006	07/13/88	03	5222	WR	METALS	Zn	0.01		mg/L
MW006	07/13/88	03	5222	WR	PHCS	petroleum hydrocarbons	2.00	JB	ug/L
MW006	10/04/88	01	5269	GW	VOLS	acetone	4.00	J	ug/L
MW008	06/17/88	03	5048	SO	SVOLS	acetone	110.00		ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 7

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW008	06/17/88	03	5048	SO	SVOLS	methylene chloride	19.00	B	ug/kg
MW008	06/17/88	06	5049	SO	SVOLS	methylene chloride	24.00	B	ug/kg
MW008	06/17/88	06	5049	SO	SVOLS	acetone	16.00	B	ug/kg
MW008	06/17/88	09	5050	SO	SVOLS	methylene chloride	29.00	B	ug/kg
MW008	06/17/88	09	5050	SO	SVOLS	acetone	30.00	B	ug/kg
MW008	06/17/88	09	5051	SR	SVOLS	methylene chloride	15.00	B	ug/kg
MW008	06/17/88	09	5051	SR	SVOLS	acetone	16.00	B	ug/kg
MW008	07/11/88	01	5187	GW	VOLS	acetone	5.00	J	ug/L
MW008	07/13/88	01	5224	GW	ANIONS	Cl	13.00		mg/L
MW008	07/13/88	01	5224	GW	ANIONS	F	0.80		mg/L
MW008	07/13/88	01	5224	GW	ANIONS	SO4	110.00		mg/L
MW008	07/13/88	01	5224	GW	METALS	Zn	0.02		mg/L
MW008	07/13/88	01	5224	GW	METALS	Pb	0.02		mg/L
MW008	07/13/88	01	5224	GW	MET/LS	Cd	0.01		mg/L
MW008	10/05/88	01	5292	GW	VOLS	methylene chloride	1.00	JB	ug/L
MW008	10/05/88	01	5292	GW	VOLS	acetone	21.00	B	ug/L
MW008	10/05/88	01	5292	GW	VOLS	2-butanone	1.00	JB	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 8

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW011	06/17/88	03	5058	SO	SVOLS	acetone	74.00	B	ug/kg
MW011	06/17/88	03	5058	SO	SVOLS	methylene chloride	12.00		ug/kg
MW011	06/17/88	03	5058	SO	SVOLS	2-butanone	6.00	J	ug/kg
MW011	06/17/88	06	5059	SO	SVOLS	methylene chloride	12.00		ug/kg
MW011	06/17/88	06	5059	SO	SVOLS	acetone	220.00	B	ug/kg
MW011	06/17/88	06	5059	SO	SVOLS	2-butanone	29.00		ug/kg
MW011	06/17/88	09	5060	SO	SVOLS	methylene chloride	14.00		ug/kg
MW011	06/17/88	09	5060	SO	SVOLS	acetone	220.00	B	ug/kg
MW011	06/17/88	09	5060	SO	SVOLS	2-butanone	26.00		ug/kg
MW011	06/17/88	09	5060	SO	SVOLS	toluene	1.00	J	ug/kg
MW011	06/17/88	09	5061	SR	SVOLS	methylene chloride	11.00		ug/kg
MW011	06/17/88	09	5061	SR	SVOLS	acetone	260.00	B	ug/kg
MW011	06/17/88	09	5061	SR	SVOLS	2-butanone	25.00		ug/kg
MW011	06/17/88	12	5062	SO	SVOLS	acetone	100.00	B	ug/kg
MW011	06/17/88	12	5062	SO	SVOLS	methylene chloride	10.00		ug/kg
MW011	06/17/88	12	5062	SO	SVOLS	2-butanone	7.00	J	ug/kg
MW011	06/17/88	15	5063	SO	SVOLS	acetone	22.00	B	ug/kg
MW011	06/17/88	15	5063	SO	SVOLS	methylene chloride	10.00		ug/kg
MW011	07/10/88	01	5179	GW	ANIONS	Cl	10.00		mg/L
MW011	07/10/88	01	5179	GW	ANIONS	F	4.70		mg/L
MW011	07/10/88	01	5179	GW	ANIONS	SO4	2700.00		mg/L
MW011	07/10/88	01	5179	GW	METALS	Zn	0.02		mg/L
MW011	07/10/88	01	5179	GW	VOLS	acetone	5.00	J	ug/L
MW011	07/10/88	02	5180	WR	ANIONS	Cl	10.00		mg/L
MW011	07/10/88	02	5180	WR	ANIONS	F	4.70		mg/L
MW011	07/10/88	02	5180	WR	ANIONS	SO4	2700.00		mg/L
MW011	07/10/88	02	5180	WR	METALS	Zn	0.02		mg/L
MW011	07/10/88	03	5181	WR	ANIONS	Cl	10.00		mg/L
MW011	07/10/88	03	5181	WR	ANIONS	F	4.70		mg/L
MW011	07/10/88	03	5181	WR	ANIONS	SO4	2700.00		mg/L
MW011	07/10/88	03	5181	WR	METALS	Zn	0.02		mg/L
MW011	10/04/88	01	5271	GW	VOLS	acetone	4.00	J	ug/L
MW015	06/19/88	03	5081	SO	SVOLS	methylene chloride	12.00		ug/kg
MW015	06/19/88	03	5081	SO	SVOLS	acetone	12.00		ug/kg
MW015	06/19/88	06	5082	SO	SVOLS	acetone	36.00		ug/kg
MW015	06/19/88	06	5082	SO	SVOLS	methylene chloride	8.00		ug/kg
MW015	06/19/88	09	5083	SO	SVOLS	methylene chloride	10.00		ug/kg
MW015	06/19/88	09	5083	SO	SVOLS	acetone	78.00		ug/kg
MW015	06/19/88	09	5083	SO	SVOLS	2-butanone	3.00	J	ug/kg
MW015	06/19/88	12	5084	SO	SVOLS	methylene chloride	8.00		ug/kg
MW015	06/19/88	12	5084	SO	SVOLS	acetone	28.00		ug/kg
MW015	07/12/88	01	5198	GW	ANIONS	Cl	26.00		mg/L
MW015	07/12/88	01	5198	GW	ANIONS	F	1.40		mg/L
MW015	07/12/88	01	5198	GW	ANIONS	SO4	160.00		mg/L
MW015	07/12/88	01	5198	GW	ANIONS	Cl	25.90		mg/L
MW015	07/12/88	01	5198	GW	ANIONS	F	1.40		mg/L
MW015	07/12/88	01	5198	GW	ANIONS	SO4	156.00		mg/L
MW015	07/12/88	01	5198	GW	METALS	Zn	0.11		mg/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 8

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW015	07/12/88	01	5198	GW	METALS	Cu	0.06		mg/L
MW015	07/12/88	01	5198	GW	VOLS	acetone	2.00	JB	ug/L
MW015	10/04/88	01	5275	GW	VOLS	acetone	4.00	J	ug/L
MW016	06/19/88	03	5086	SO	SVOLS	methylene chloride	9.00		ug/kg
MW016	06/19/88	03	5086	SO	SVOLS	acetone	24.00		ug/kg
MW016	06/19/88	03	5086	SO	SVOLS	toluene	1.00	J	ug/kg
MW016	06/19/88	06	5087	SO	SVOLS	methylene chloride	8.00		ug/kg
MW016	06/19/88	06	5087	SO	SVOLS	acetone	78.00		ug/kg
MW016	06/19/88	06	5087	SO	SVOLS	2-butanone	5.00	J	ug/kg
MW016	06/19/88	09	5088	SO	SVOLS	methylene chloride	26.00		ug/kg
MW016	06/19/88	09	5088	SO	SVOLS	acetone	100.00		ug/kg
MW016	06/19/88	09	5088	SO	SVOLS	2-butanone	10.00	J	ug/kg
MW016	06/19/88	12	5089	SO	SVOLS	methylene chloride	10.00	B	ug/kg
MW016	06/19/88	12	5089	SO	SVOLS	acetone	59.00	B	ug/kg
MW016	06/19/88	15	5090	SO	SVOLS	methylene chloride	11.00	B	ug/kg
MW016	06/19/88	15	5090	SO	SVOLS	acetone	51.00	B	ug/kg
MW016	07/12/88	01	5195	GW	ANIONS	Cl	25.00		mg/L
MW016	07/12/88	01	5195	GW	ANIONS	F	2.40		mg/L
MW016	07/12/88	01	5195	GW	ANIONS	SO4	350.00		mg/L
MW016	07/12/88	01	5195	GW	METALS	Zn	0.01		mg/L
MW016	07/12/88	01	5195	GW	VOLS	acetone	2.00	JB	ug/L
MW016	10/04/88	01	5273	GW	VOLS	acetone	4.00	J	ug/L
SW003	03/11/88	01	0015	GW	VOLS	hexane	11.00		ug/L
SW003	03/11/88	01	0015	GW	VOLS	acetone	7.00	BJ	ug/L
SW003	03/11/88	01	0015	GW	VOLS	4-methyl-2-pentanone	2.00	J	ug/L
SW003	10/05/88	01	5290	GW	VOLS	methylene chloride	2.00	JB	ug/L
SW003	10/05/88	01	5290	GW	VOLS	acetone	8.00	JB	ug/L
SW004	03/11/88	01	0016	GW	PHCS	petroleum hydrocarbons	190.00		ug/L
SW004	03/11/88	01	0016	GW	VOLS	hexane	24.00		ug/L
SW004	03/11/88	01	0016	GW	VOLS	1-pentene, 2-methyl-	15.00		ug/L
SW004	03/11/88	01	0016	GW	VOLS	acetone	5.00	J	ug/L
SW004	10/05/88	01	5291	GW	PHCS	toluene	1.00		ug/L
SW004	10/05/88	01	5291	GW	VOLS	methylene chloride	2.00	JB	ug/L
SW004	10/05/88	01	5291	GW	VOLS	acetone	15.00	B	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 9

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW012	06/18/88	03	5065	SO	SVOLS	methylene chloride	10.00	B	ug/kg
MW012	06/18/88	03	5065	SO	SVOLS	acetone	51.00	B	ug/kg
MW012	06/18/88	06	5066	SO	SVOLS	methylene chloride	9.00	B	ug/kg
MW012	06/18/88	06	5066	SO	SVOLS	acetone	410.00	EE	ug/kg
MW012	06/18/88	06	5066	SO	SVOLS	2-butanone	58.00		ug/kg
MW012	06/18/88	09	5067	SO	SVOLS	methylene chloride	7.00	B	ug/kg
MW012	06/18/88	09	5067	SO	SVOLS	acetone	130.00	B	ug/kg
MW012	06/18/88	09	5067	SO	SVOLS	2-butanone	12.00		ug/kg
MW012	06/18/88	12	5068	SO	SVOLS	methylene chloride	2.00	J	ug/kg
MW012	06/18/88	12	5068	SO	SVOLS	acetone	160.00	B	ug/kg
MW012	06/18/88	12	5068	SO	SVOLS	2-butanone	30.00		ug/kg
MW012	06/18/88	15	5069	SO	SVOLS	methylene chloride	3.00	J	ug/kg
MW012	06/18/88	15	5069	SO	SVOLS	acetone	20.00	B	ug/kg
MW012	06/18/88	18	5070	SO	SVOLS	acetone	12.00	B	ug/kg
MW012	07/09/88	01	5177	GW	ANIONS	Cl	3.80		mg/L
MW012	07/09/88	01	5177	GW	ANIONS	F	1.90		mg/L
MW012	07/09/88	01	5177	GW	ANIONS	SO4	770.00		mg/L
MW012	07/09/88	01	5177	GW	VOLS	acetone	22.00		ug/L
MW012	07/09/88	01	5177	GW	VOLS	2-butanone	3.00	J	ug/L
MW013	06/18/88	03	5071	SO	SVOLS	methylene chloride	2.00	J	ug/kg
MW013	06/18/88	03	5071	SO	SVOLS	acetone	11.00	JB	ug/kg
MW013	06/18/88	06	5072	SO	SVOLS	methylene chloride	2.00	J	ug/kg
MW013	06/18/88	06	5072	SO	SVOLS	acetone	150.00	B	ug/kg
MW013	06/18/88	06	5072	SO	SVOLS	2-butanone	35.00		ug/kg
MW013	06/18/88	09	5073	SO	SVOLS	methylene chloride	2.00	J	ug/kg
MW013	06/18/88	09	5073	SO	SVOLS	acetone	45.00	B	ug/kg
MW013	06/18/88	09	5073	SO	SVOLS	2-butanone	19.00		ug/kg
MW013	06/18/88	12	5074	SO	SVOLS	methylene chloride	28.00		ug/kg
MW013	06/18/88	12	5074	SO	SVOLS	acetone	140.00		ug/kg
MW013	06/18/88	12	5074	SO	SVOLS	2-butanone	14.00		ug/kg
MW013	06/18/88	12	5074	SO	SVOLS	4-methyl-2-pentanone	2.00	J	ug/kg
MW013	06/18/88	12	5074	SO	SVOLS	toluene	3.00	J	ug/kg
MW013	07/08/88	01	5175	GW	ANIONS	Cl	20.00		mg/L
MW013	07/08/88	01	5175	GW	ANIONS	F	3.20		mg/L
MW013	07/08/88	01	5175	GW	ANIONS	SO4	140.00		mg/L
MW013	07/08/88	01	5175	GW	METALS	Zn	0.02		mg/L
MW013	07/08/88	01	5175	GW	VOLS	acetone	4.00	J	ug/L
MW017	06/19/88	03	5091	SO	SVOLS	methylene chloride	10.00	B	ug/kg
MW017	06/19/88	03	5091	SO	SVOLS	acetone	24.00	B	ug/kg
MW017	06/19/88	06	5092	SO	SVOLS	acetone	34.00	B	ug/kg
MW017	06/19/88	09	5093	SO	SVOLS	methylene chloride	18.00	B	ug/kg
MW017	06/19/88	09	5093	SO	SVOLS	acetone	6.00	JB	ug/kg
MW017	06/19/88	09	5093	SO	SVOLS	toluene	6.00	B	ug/kg
MW017	06/19/88	12	5094	SO	SVOLS	methylene chloride	17.00	B	ug/kg
MW017	06/19/88	12	5094	SO	SVOLS	acetone	9.00	JB	ug/kg
MW017	06/19/88	12	5094	SO	SVOLS	toluene	9.00	B	ug/kg
MW017	06/19/88	15	5095	SO	SVOLS	methylene chloride	17.00	B	ug/kg
MW017	06/19/88	15	5095	SO	SVOLS	acetone	32.00	B	ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SITE 9

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW017	06/19/88	15	5095	SO	SVOLS	toluene	7.00	B	ug/kg
MW017	07/13/88	01	5215	GW	ANIONS	Cl	34.00		mg/L
MW017	07/13/88	01	5215	GW	ANIONS	F	2.90		mg/L
MW017	07/13/88	01	5215	GW	ANIONS	SO4	620.00		mg/L
MW017	07/13/88	01	5215	GW	METALS	Zn	0.02		mg/L
MW017	07/13/88	01	5215	GW	VOLS	acetone	6.00	J	ug/L
MW017	10/04/88	01	5272	GW	VOLS	acetone	6.00	J	ug/L
SW002	03/11/88	01	0014	GW	VOLS	acetone	7.00	BJ	ug/L
SW002	10/05/88	01	5289	GW	PHCS	toluene	2.00		ug/L
SW002	10/05/88	01	5289	GW	VOLS	methylene chloride	2.00	JB	ug/L
SW002	10/05/88	01	5289	GW	VOLS	acetone	7.00	JB	ug/L
SW002	10/05/88	01	5289	GW	VOLS	carbon disulfide	4.00	J	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SE CORNER

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW003	06/15/88	03	5022	SO	SVOLS	acetone	88.00		ug/kg
MW003	06/15/88	03	5022	SO	SVOLS	acetone	31.00	B	ug/kg
MW003	06/15/88	03	5022	SO	SVOLS	methylene chloride	26.00	JB	ug/kg
MW003	06/15/88	03	5022	SO	SVOLS	methylene chloride	5.00	J	ug/kg
MW003	06/15/88	06	5023	SO	SVOLS	methylene chloride	4.00	JB	ug/kg
MW003	06/15/88	06	5023	SO	SVOLS	acetone	4.00	JB	ug/kg
MW003	06/15/88	06	5023	SO	SVOLS	chloroform	3.00	JB	ug/kg
MW003	06/15/88	09	5024	SO	SVOLS	methylene chloride	8.00	B	ug/kg
MW003	06/15/88	09	5024	SO	SVOLS	acetone	4.00	JB	ug/kg
MW003	06/15/88	09	5024	SO	SVOLS	chloroform	2.00	JB	ug/kg
MW003	06/15/88	12	5025	SO	SVOLS	methylene chloride	100.00	B	ug/kg
MW003	06/15/88	12	5025	SO	SVOLS	acetone	12.00	B	ug/kg
MW003	06/15/88	12	5025	SO	SVOLS	chloroform	2.00	JB	ug/kg
MW003	06/15/88	15	5027	SO	SVOLS	methylene chloride	3.00	JB	ug/kg
MW003	06/15/88	15	5027	SO	SVOLS	acetone	10.00	J	ug/kg
MW003	06/15/88	15	5027	SO	SVOLS	chloroform	2.00	JB	ug/kg
MW003	07/12/88	01	5197	WR	ANIONS	Cl	4.00		mg/L
MW003	07/12/88	01	5197	WR	ANIONS	F	0.40		mg/L
MW003	07/12/88	01	5197	WR	ANIONS	NO3	0.70		mg/L
MW003	07/12/88	01	5197	WR	ANIONS	SO4	72.00		mg/L
MW003	07/12/88	01	5197	WR	METALS	Ba	0.07		mg/L
MW003	07/12/88	01	5197	WR	METALS	Zn	0.03		mg/L
MW003	07/12/88	01	5197	WR	METALS	Na	110.00		mg/L
MW003	07/12/88	01	5197	WR	METALS	K	3.00		mg/L
MW003	07/12/88	01	5197	WR	METALS	Ca	53.00		mg/L
MW003	07/12/88	01	5197	WR	METALS	Mg	13.00		mg/L
MW003	07/12/88	01	5197	WR	SEMI	diacetone alcohol	50.00	JA	ug/L
MW003	07/12/88	01	5197	WR	SEMI	unknown #1	4.00	JB	ug/L
MW003	07/12/88	01	5197	WR	SEMI	possible ketone	9.00	J	ug/L
MW003	07/12/88	01	5197	WR	SEMI	unknown #2	5.00	J	ug/L
MW003	07/12/88	01	5197	WR	SEMI	poss alkoxy/hydroxy/alkene	17.00	JB	ug/L
MW003	07/12/88	01	5197	WR	VOLS	hexamethylcyclotrisiloxane	9.00	JP	ug/L
MW003	07/12/88	01	5197	WR	VOLS	hydrocarbon #1	21.00	JB	ug/L
MW003	07/12/88	01	5197	WR	VOLS	hydrocarbon #2	6.00	JB	ug/L
MW003	07/12/88	01	5197	WR	VOLS	hydrocarbon #3	4.00	JP	ug/L
MW003	07/12/88	01	5197	WR	VOLS	hydrocarbon #4	5.00	JP	ug/L
MW003	07/13/88	01	5214	GW	ANIONS	Cl	3.80		mg/L
MW003	07/13/88	01	5214	GW	ANIONS	F	1.40		mg/L
MW003	07/13/88	01	5214	GW	ANIONS	SO4	62.00		mg/L
MW003	07/13/88	01	5214	GW	METALS	Zn	0.02		mg/L
MW003	07/13/88	01	5214	GW	SEMI	bis(2-ethylhexyl)phthalate	14.00		ug/L
MW003	07/13/88	01	5214	GW	SEMI	di-n-butylphthalate	110.00		ug/L
MW003	07/13/88	01	5214	GW	SEMI	bis(2-ethylhexyl)phthalate	14.00		ug/L
MW003	07/13/88	01	5214	GW	VOLS	acetone	6.00	J	ug/L
MW003	10/04/88	01	5279	GW	VOLS	acetone	4.00	J	ug/L
MW004	06/15/88	03	5028	SO	SVOLS	methylene chloride	2.00	JB	ug/kg
MW004	06/15/88	03	5028	SO	SVOLS	acetone	10.00	J	ug/kg
MW004	06/15/88	03	5028	SO	SVOLS	chloroform	2.00	JB	ug/kg

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM SE CORNER

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW004	06/15/88	06	5029	SO	SVOLS	methylene chloride	3.00	JB	ug/kg
MW004	06/15/88	06	5029	SO	SVOLS	chloroform	2.00	JB	ug/kg
MW004	06/15/88	09	5030	SO	SVOLS	methylene chloride	2.00	JB	ug/kg
MW004	06/15/88	15	5032	SO	SVOLS	methylene chloride	6.00	B	ug/kg
MW007	06/16/88	03	5042	SO	SVOLS	acetone	250.00	E	ug/kg
MW007	06/16/88	03	5042	SO	SVOLS	2-butanone	14.00		ug/kg
MW007	06/16/88	03	5042	SO	SVOLS	methylene chloride	8.00	B	ug/kg
MW007	06/16/88	06	5043	SO	SVOLS	acetone	97.00		ug/kg
MW007	06/16/88	06	5043	SO	SVOLS	methylene chloride	9.00	B	ug/kg
MW007	06/16/88	06	5043	SO	SVOLS	2-butanone	3.00	J	ug/kg
MW007	06/16/88	06	5044	SR	SVOLS	acetone	120.00		ug/kg
MW007	06/16/88	06	5044	SR	SVOLS	methylene chloride	11.00	B	ug/kg
MW007	06/16/88	09	5045	SO	SVOLS	acetone	190.00		ug/kg
MW007	06/16/88	09	5045	SO	SVOLS	methylene chloride	15.00	B	ug/kg
MW007	06/16/88	12	5046	SO	SVOLS	acetone	45.00		ug/kg
MW007	06/16/88	12	5046	SO	SVOLS	methylene chloride	8.00	B	ug/kg
MW007	06/16/88	12	5047	SR	SVOLS	acetone	180.00		ug/kg
MW007	06/16/88	12	5047	SR	SVOLS	methylene chloride	9.00	B	ug/kg
MW007	07/10/88	01	5182	GW	ANIONS	Cl	14.00		mg/L
MW007	07/10/88	01	5182	GW	ANIONS	F	3.10		mg/L
MW007	07/10/88	01	5182	GW	ANIONS	SO4	520.00		mg/L
MW007	07/10/88	01	5182	GW	VOLS	acetone	4.00	J	ug/L
MW007	10/04/88	01	5270	GW	VOLS	acetone	4.00	J	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM UPGRADE

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW024	06/21/88	09	5140	SO	SVOLS	methylene chloride	14.00		ug/kg
MW024	06/21/88	09	5140	SO	SVOLS	acetone	26.00		ug/kg
MW024	06/21/88	09	5141	SO	STCLP	acetone	36.00		ug/L
MW024	06/21/88	09	5141	SO	STCLP	4-methyl-2-pentanone	20.00		ug/L
MW024	06/21/88	09	5141	SO	SVOLS	methylene chloride	2.00	J	ug/kg
MW024	06/21/88	18	5145	SO	SVOLS	methylene chloride	14.00		ug/kg
MW024	06/21/88	18	5145	SO	SVOLS	acetone	15.00		ug/kg
MW024	06/21/88	27	5148	SO	SVOLS	methylene chloride	17.00		ug/kg
MW024	06/21/88	27	5148	SO	SVOLS	acetone	22.00		ug/kg
MW024	06/21/88	36	5151	SO	SVOLS	methylene chloride	16.00		ug/kg
MW024	06/21/88	36	5151	SO	SVOLS	acetone	11.00	J	ug/kg
MW024	07/11/88	01	5188	GW	ANIONS	Cl	35.00		mg/L
MW024	07/11/88	01	5188	GW	ANIONS	F	1.60		mg/L
MW024	07/11/88	01	5188	GW	ANIONS	SO4	190.00		mg/L
MW024	07/11/88	01	5188	GW	METALS	Pb	0.01		mg/L
MW024	07/11/88	01	5188	GW	METALS	Zn	0.04		mg/L
MW024	07/11/88	01	5188	GW	VOLS	acetone	5.00	J	ug/L
MW024	07/11/88	01	5188	GW	VOLS	chloroform	2.00	J	ug/L
MW024	07/11/88	01	5188	GW	VOLS	trichloroethene	2.00	J	ug/L
MW024	10/03/88	01	5252	GW	VOLS	trichloroethene	2.00	J	ug/L
MW027	06/23/88	09	5162	SO	SVOLS	methylene chloride	10.00	B	ug/kg
MW027	06/23/88	09	5162	SO	SVOLS	acetone	7.00	JB	ug/kg
MW027	06/23/88	09	5162	SO	SVOLS	2-butanone	6.00	J	ug/kg
MW027	06/23/88	18	5163	SO	SVOLS	methylene chloride	12.00	B	ug/kg
MW027	06/23/88	18	5163	SO	SVOLS	acetone	17.00	B	ug/kg
MW027	06/23/88	18	5163	SO	SVOLS	2-butanone	24.00		ug/kg
MW027	07/10/88	01	5186	GW	ANIONS	Cl	17.00		mg/L
MW027	07/10/88	01	5186	GW	ANIONS	F	1.20		mg/L
MW027	07/10/88	01	5186	GW	ANIONS	SO4	390.00		mg/L
MW027	07/10/88	01	5186	GW	VOLS	acetone	7.00	JB	ug/L
MW027	10/03/88	01	5253	GW	VOLS	acetone	6.00	JB	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM BEDROCK

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
CH001	07/11/88	01	5194	GW	ANIONS	Cl	27.00		mg/L
CH001	07/11/88	01	5194	GW	ANIONS	F	3.00		mg/L
CH001	07/11/88	01	5194	GW	ANIONS	SO ₄	990.00		mg/L
CH001	07/11/88	01	5194	GW	METALS	Zn	0.01		mg/L
CH001	07/11/88	01	5194	GW	VOLS	methylene chloride	1.00	J	ug/L
CH001	07/11/88	01	5194	GW	VOLS	acetone	5.00	J	ug/L
CH001	10/03/88	01	5258	GW	VOLS	acetone	8.00	J	ug/L
CH002	07/14/88	01	5227	GW	ANIONS	Cl	190.00		mg/L
CH002	07/14/88	01	5227	GW	ANIONS	F	2.50		mg/L
CH002	07/14/88	01	5227	GW	ANIONS	SO ₄	180.00		mg/L
CH002	07/14/88	01	5227	GW	METALS	Cu	0.03		mg/L
CH002	07/14/88	01	5227	GW	METALS	Pb	0.00		mg/L
CH002	07/14/88	01	5227	GW	SEMI	phenol	5.00	J	ug/L
CH002	07/14/88	01	5227	GW	SEMI	benzoic acid	48.00	J	ug/L
CH002	07/14/88	01	5227	GW	SEMI	bis(2-ethylhexyl)phthalate	20.00	J	ug/L
CH002	07/14/88	01	5227	GW	SEMI	di-n-butylphthalate	2.00	J	ug/L
CH002	07/14/88	01	5227	GW	VOLS	acetone	93.00		ug/L
CH002	07/14/88	01	5227	GW	VOLS	2-butanone	13.00		ug/L
CH002	07/14/88	01	5227	GW	VOLS	methylene chloride	2.00	J	ug/L
CH002	07/14/88	02	5229	WR	ANIONS	Cl	222.00		mg/L
CH002	07/14/88	02	5229	WR	ANIONS	F	2.70		mg/L
CH002	07/14/88	02	5229	WR	ANIONS	SO ₄	172.00		mg/L
CH002	07/14/88	02	5229	WR	METALS	Cu	0.03		mg/L
CH002	07/14/88	02	5229	WR	METALS	Na	460.00		mg/L
CH002	07/14/88	02	5229	WR	METALS	K	32.00		mg/L
CH002	07/14/88	02	5229	WR	METALS	Ca	26.00		mg/L
CH002	07/14/88	02	5229	WR	METALS	Mg	0.00		mg/L
CH002	07/14/88	02	5229	WR	VOLS	chloroethane	89.00		ug/L
CH002	07/14/88	02	5229	WR	VOLS	acetone	78.00		ug/L
CH002	07/14/88	02	5229	WR	VOLS	carbon disulfide	5.00		ug/L
CH002	07/14/88	02	5229	WR	VOLS	ethylbenzene	1.00	J	ug/L
CH002	07/14/88	02	5229	WR	VOLS	hydrocarbon #1	7.00	JB	ug/L
CH002	07/14/88	02	5229	WR	VOLS	hydrocarbon #2	5.00	JB	ug/L
CH002	07/14/88	02	5229	WR	VOLS	methylene chloride	2.00	J	ug/L
CH002	07/14/88	02	5229	WR	VOLS	toluene	1.00	JB	ug/L
CH002	10/05/88	01	5282	GW	VOLS	methylene chloride	1.00	J	ug/L
CH002	10/05/88	01	5282	GW	VOLS	acetone	61.00		ug/L
CH002	10/05/88	01	5282	GW	VOLS	2-butanone	5.00	J	ug/L
CH003	07/14/88	01	5230	GW	ANIONS	Cl	120.00		mg/L
CH003	07/14/88	01	5230	GW	ANIONS	F	3.50		mg/L
CH003	07/14/88	01	5230	GW	ANIONS	SO ₄	590.00		mg/L
CH003	07/14/88	01	5230	GW	METALS	Pb	0.00		mg/L
CH003	07/14/88	01	5230	GW	PHCS	toluene	1.00		ug/L
CH003	07/14/88	01	5230	GW	VOLS	methylene chloride	2.00	J	ug/L
CH003	07/14/88	01	5230	GW	VOLS	acetone	5.00	J	ug/L
CH003	07/14/88	01	5230	GW	VOLS	carbon disulfide	3.00	J	ug/L
CH003	07/14/88	02	5231	WR	ANIONS	Cl	130.00		mg/L
CH003	07/14/88	02	5231	WR	ANIONS	F	3.70		mg/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM BEDROCK

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
CH003	07/14/88	02	5231	WR	ANIONS	SO ₄	640.00		mg/L
CH003	07/14/88	02	5231	WR	METALS	Zn	0.03		mg/L
CH003	07/14/88	02	5231	WR	VOLS	methylene chloride	2.00	J	ug/L
CH003	07/14/88	02	5231	WR	VOLS	acetone	6.00	J	ug/L
CH003	07/14/88	02	5231	WR	VOLS	carbon disulfide	4.00	J	ug/L
CH003	07/14/88	03	5232	WR	ANIONS	Cl	150.00		mg/L
CH003	07/14/88	03	5232	WR	ANIONS	F	3.50		mg/L
CH003	07/14/88	03	5232	WR	ANIONS	SO ₄	300.00		mg/L
CH003	07/14/88	03	5232	WR	METALS	Zn	0.02		mg/L
CH003	07/14/88	03	5232	WR	VOLS	methylene chloride	2.00	J	ug/L
CH003	07/14/88	03	5232	WR	VOLS	acetone	6.00	J	ug/L
CH003	07/14/88	04	5233	WR	ANIONS	Cl	145.00		mg/L
CH003	07/14/88	04	5233	WR	ANIONS	F	1.40		mg/L
CH003	07/14/88	04	5233	WR	ANIONS	SO ₄	694.00		mg/L
CH003	07/14/88	04	5233	WR	METALS	Ba	0.03		mg/L
CH003	07/14/88	04	5233	WR	METALS	Na	350.00		mg/L
CH003	07/14/88	04	5233	WR	METALS	K	9.50		mg/L
CH003	07/14/88	04	5233	WR	METALS	Ca	62.00		mg/L
CH003	07/14/88	04	5233	WR	METALS	Mg	23.00		mg/L
CH003	07/14/88	04	5233	WR	VOLS	methylene chloride	2.00	J	ug/L
CH003	07/14/88	04	5233	WR	VOLS	carbon disulfide	2.00	J	ug/L
CH003	07/14/88	04	5233	WR	VOLS	vinyl acetate	4.00	J	ug/L
CH003	07/14/88	04	5233	WR	VOLS	toluene	1.00	JB	ug/L
CH003	07/14/88	04	5233	WR	VOLS	ethylbenzene	1.00	J	ug/L
CH003	07/14/88	04	5233	WR	VOLS	hydrocarbon #1	8.00	JB	ug/L
CH003	07/14/88	04	5233	WR	VOLS	hydrocarbon #2	6.00	JB	ug/L
CH003	10/03/88	01	5251	GW	VOLS	acetone	5.00	J	ug/L

05/24/89

Table E.1. (continued)

SIGNIFICANT CHEMICAL DATA FROM LATERAL 6, HYDRAN

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
MW023	06/22/88	03	5153	SO	SPHCS	petroleum hydrocarbons	16000.00		ug/kg
MW023	06/22/88	03	5153	SO	SVOLS	methylene chloride	7.00		ug/kg
MW023	06/22/88	03	5153	SO	SVOLS	acetone	160.00		ug/kg
MW023	06/22/88	03	5153	SO	SVOLS	2-butanone	52.00		ug/kg
MW023	06/22/88	03	5153	SO	SVOLS	toluene	6.00		ug/kg
MW023	06/22/88	06	5154	SO	SVOLS	methylene chloride	19.00		ug/kg
MW023	06/22/88	06	5154	SO	SVOLS	acetone	310.00	E	ug/kg
MW023	06/22/88	06	5154	SO	SVOLS	2-butanone	93.00		ug/kg
MW023	06/22/88	06	5154	SO	SVOLS	toluene	22.00		ug/kg
MW023	06/22/88	06	5154	SO	SVOLS	trichloroethene	4.00	J	ug/kg
MW023	06/22/88	06	5155	SR	SVOLS	methylene chloride	17.00		ug/kg
MW023	06/22/88	06	5155	SR	SVOLS	acetone	220.00		ug/kg
MW023	06/22/88	06	5155	SR	SVOLS	toluene	6.00		ug/kg
MW023	06/22/88	06	5155	SR	SVOLS	2-butanone	43.00		ug/kg
MW023	06/22/88	09	5156	SO	SVOLS	methylene chloride	12.00	B	ug/kg
MW023	06/22/88	09	5156	SO	SVOLS	acetone	47.00	B	ug/kg
MW023	06/22/88	09	5156	SO	SVOLS	2-butanone	63.00		ug/kg
MW023	06/22/88	12	5157	SO	SVOLS	methylene chloride	14.00	B	ug/kg
MW023	06/22/88	12	5157	SO	SVOLS	acetone	20.00	B	ug/kg
MW023	06/22/88	12	5157	SO	SVOLS	2-butanone	16.00		ug/kg
MW023	07/10/88	01	5183	GW	ANIONS	Cl	10.00		mg/L
MW023	07/10/88	01	5183	GW	ANIONS	F	2.90		mg/L
MW023	07/10/88	01	5183	GW	ANIONS	SO4	270.00		mg/L
MW023	07/10/88	01	5183	GW	METALS	Zn	0.02		mg/L
MW023	09/30/88	01	5244	GW	PHCS	toluene	3.00		ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM N/A

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
DW001	03/09/88	02	0002	GW	PHCS	petroleum hydrocarbons	680.00		ug/L
DW001	03/09/88	02	0002	GW	PHCS	petroleum hydrocarbons	120.00		ug/L
DW001	03/09/88	02	0002	GW	VOLS	cyclopentane,methyl-	160.00		ug/L
DW001	03/09/88	02	0002	GW	VOLS	pentane,3-methyl-	10.00		ug/L
DW001	03/09/88	02	0002	GW	VOLS	hexane	320.00		ug/L
DW002	03/09/88	01	0003	GW	PHCS	petroleum hydrocarbons	100.00		ug/L
DW002	03/09/88	01	0003	GW	VOLS	acetone	92.00		ug/L
DW002	03/09/88	01	0003	GW	VOLS	1-pentene,2-methyl-	14.00		ug/L
DW002	03/09/88	01	0003	GW	VOLS	hexane	41.00		ug/L
DW002	03/09/88	01	0003	GW	VOLS	1,2 dichloroethene	1.00	J	ug/L
DW002	03/09/88	02	0004	GW	VOLS	1,2-dichloroethene (total)	27.00		ug/L
DW003	03/10/88	01	0009	GW	VOLS	hexane	12.00		ug/L
DW003	03/10/88	01	0009	GW	VOLS	acetone	7.00	JB	ug/L
DW003	03/10/88	01	0009	GW	VOLS	4-methyl-2-pentanone	2.00	JB	ug/L
DW004	03/08/88	01	0005	GW	VOLS	acetone	4.00	J	ug/L
DW004	03/09/88	02	0006	GW	PHCS	petroleum hydrocarbons	100.00		ug/L
DW004	03/09/88	02	0006	GW	VOLS	hexane	38.00		ug/L
DW004	03/09/88	02	0006	GW	VOLS	1-pentene,2-methyl-	25.00		ug/L
DW004	03/09/88	02	0006	GW	VOLS	acetone	5.00	J	ug/L
DW005	03/09/88	01	0007	GW	PHCS	petroleum hydrocarbons	70.00		ug/L
DW005	03/09/88	01	0007	GW	VOLS	acetone	5.00	J	ug/L
DW005	03/09/88	01	0007	GW	VOLS	1-pentene, 2-methyl	7.00		ug/L
DW005	03/09/88	01	0007	GW	VOLS	hexane	19.00		ug/L
DW005	03/11/88	02	0019	GW	VOLS	acetone	2.00	J	ug/L
SW001	03/11/88	01	0013	GW	PHCS	xylenes(total)	1.00		ug/L
SW001	03/11/88	01	0013	GW	PHCS	petroleum hydrocarbons	120.00		mg/L
SW001	03/11/88	01	0013	GW	VOLS	hexane	110.00		ug/L
SW001	03/11/88	01	0013	GW	VOLS	cyclopentane,methyl-	50.00		ug/L
SW001	03/11/88	01	0013	GW	VOLS	acetone	40.00	B	ug/L
SW001	10/05/88	01	5283	GW	VOLS	acetone	11.00		ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM WATER TRUCK

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
OT000	06/20/88	01	5133	SW	ANIONS	Cl	160.00		mg/L
OT000	06/20/88	01	5133	SW	ANIONS	F	1.90		mg/L
OT000	06/20/88	01	5133	SW	ANIONS	SO4	150.00		mg/L
OT000	06/20/88	01	5133	SW	METALS	Pb	0.00		mg/L
OT000	06/20/88	01	5133	SW	VOLS	acetone	10.00		ug/L
OT000	06/20/88	01	5133	SW	VOLS	chloroform	46.00		ug/L
OT000	06/20/88	01	5133	SW	VOLS	bromodichloromethane	26.00		ug/L
OT000	06/20/88	01	5133	SW	VOLS	dibromochloromethane	17.00		ug/L
OT000	06/20/88	01	5133	SW	VOLS	4-methyl-2-pentanone	8.00	J	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM FIRE HYDRANT

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
OT000	06/20/88	02	5134	SW	ANIONS	Cl	170.00		mg/L
OT000	06/20/88	02	5134	SW	ANIONS	F	1.90		mg/L
OT000	06/20/88	02	5134	SW	ANIONS	SO4	150.00		mg/L
OT000	06/20/88	02	5134	SW	VOLS	chloroform	55.00		ug/L
OT000	06/20/88	02	5134	SW	VOLS	bromodichloromethane	28.00		ug/L
OT000	06/20/88	02	5134	SW	VOLS	dibromochloromethane	17.00		ug/L
OT000	06/20/88	02	5134	SW	VOLS	4-methyl-2-pentanone	4.00	J	ug/L
OT000	06/20/88	02	5134	SW	VOLS	4-methyl-2-pentanone	5.00	J	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM EQUIPMENT RINSE

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
ER002	07/14/88	01	5228	RI	PHCS	toluene	1.00		ug/L
ER002	07/14/88	01	5228	RI	VOLS	carbon disulfide	4.00	J	ug/L
ER002	07/14/88	01	5228	RI	VOLS	toluene	1.00	J	ug/L
ER005	03/10/88	01	0011	RI	VOLS	chloroform	10.00		ug/L
ER005	03/10/88	01	0011	RI	VOLS	hexane	7.00		ug/L
ER005	03/10/88	01	0011	RI	VOLS	unknown	12.00		ug/L
ER005	09/30/88	01	5239	RI	VOLS	toluene	1.00	J	ug/L
ER009	06/17/88	08	5055	RI	PHCS	petroleum hydrocarbons	52.00		ug/L
ER009	10/05/88	01	5288	RI	VOLS	acetone	8.00	J	ug/L
ER011	06/17/88	16	5064	RI	VOLS	methylene chloride	3.00	J	ug/L
ER011	06/17/88	16	5064	RI	VOLS	acetone	4.00	JB	ug/L
ER014	06/18/88	12	5080	RI	VOLS	acetone	21.00	B	ug/L
ER015	06/19/88	12	5085	RI	VOLS	acetone	12.00	B	ug/L
ER015	06/19/88	12	5085	RI	VOLS	carbon disulfide	9.00		ug/L
ER016	10/04/88	01	5274	RI	VOLS	acetone	5.00	J	ug/L
ER017	07/13/88	01	5216	RI	PHCS	petroleum hydrocarbons	2.00	JB	ug/L
ER017	07/13/88	01	5216	RI	VOLS	toluene	1.00	J	ug/L
ER019	06/20/88	09	5124	RI	VOLS	acetone	8.00	J	ug/L
ER019	06/20/88	09	5124	RI	VOLS	carbon disulfide	3.00	J	ug/L
ER019	07/07/88	01	5167	RI	PHCS	toluene	1.00		ug/L
ER021	07/08/88	01	5171	RI	PHCS	toluene	2.00		ug/L
ER021	07/08/88	01	5171	RI	VOLS	acetone	3.00	J	ug/L
ER021	07/08/88	01	5171	RI	VOLS	toluene	2.00	J	ug/L
ER021	10/04/88	01	5265	RI	VOLS	methylene chloride	1.00	JB	ug/L
ER021	10/04/88	01	5265	RI	VOLS	acetone	5.00	JB	ug/L
ER023	06/22/88	12	5158	RI	VOLS	acetone	6.00	J	ug/L
ER023	07/10/88	01	5184	RI	PHCS	toluene	2.00		ug/L
ER023	07/10/88	01	5184	RI	VOLS	acetone	6.00	JB	ug/L
ER023	07/10/88	01	5184	RI	VOLS	toluene	2.00	J	ug/L
ER024	06/21/88	36	5152	RI	VOLS	carbon disulfide	2.00	J	ug/L
ER026	06/23/88	09	5161	RI	PHCS	petroleum hydrocarbons	130.00		ug/L
ER026	06/23/88	09	5161	RI	VOLS	acetone	7.00	J	ug/L
ER028	11/01/88	08	5298	RI	PHCS	benzene	2.80		ug/L
ER028	11/01/88	08	5298	RI	VOLS	acetone	6.00	J	ug/L
ER028	11/01/88	08	5298	RI	VOLS	carbon disulfide	33.00		ug/L
ER028	11/18/88	01	5302	RI	VOLS	acetone	11.00		ug/L
ER028	12/15/88	01	5309	RI	VOLS	methylene chloride	1.00	J	ug/L
ER028	12/15/88	01	5309	RI	VOLS	acetone	11.00		ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM FIELD BLANK

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
FB005	03/11/88	01	0022	DI	VOLS	chloroform	8.00		ug/L
FB005	09/30/88	01	5240	DI	PHCS	toluene	1.00		ug/L
FB005	09/30/88	01	5240	DI	VOLS	acetone	7.00	J	ug/L
FB005	09/30/88	01	5240	DI	VOLS	toluene	1.00	J	ug/L
FB021	07/08/88	01	5172	DI	PHCS	toluene	2.00		ug/L
FB021	07/08/88	01	5172	DI	VOLS	acetone	5.00	J	ug/L
FB021	07/08/88	01	5172	DI	VOLS	toluene	2.00	J	ug/L
FB028	11/01/88	01	5299	DI	PHCS	benzene	3.30		ug/L
FB028	11/01/88	01	5299	DI	VOLS	acetone	5.00	J	ug/L
FB028	11/18/88	01	5303	DI	VOLS	acetone	11.00		ug/L
FB028	12/15/88	01	5310	DI	VOLS	acetone	15.00		ug/L
FB028	12/15/88	01	5310	DI	VOLS	benzene	3.00	J	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM TRIP BLANK

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
TB000	03/04/88	01	0008	DI	VOLS	chloroform	5.00		ug/L
TB000	03/04/88	02	0012	DI	VOLS	acetone	4.00	JB	ug/L
TB000	03/04/88	02	0012	DI	VOLS	chloroform	5.00		ug/L
TB000	03/04/88	02	0012	DI	VOLS	4-methyl-2-pentanone	3.00	JB	ug/L
TB000	03/04/88	02	0012	DI	VOLS	unknown	7.00		ug/L
TB000	03/04/88	02	0012	DI	VOLS	unknown	7.00		ug/L
TB000	06/15/88	01	5101	DI	VOLS	methylene chloride	1.00	J	ug/L
TB000	06/15/88	01	5101	DI	VOLS	acetone	6.00	JB	ug/L
TB000	06/15/88	02	5102	DI	VOLS	methylene chloride	8.00	JB	ug/L
TB000	06/16/88	03	5103	DI	VOLS	methylene chloride	3.00	J	ug/L
TB000	06/17/88	04	5104	DI	VOLS	methylene chloride	2.00	J	ug/L
TB000	06/17/88	04	5104	DI	VOLS	acetone	7.00	JB	ug/L
TB000	06/15/88	05	5105	DI	VOLS	methylene chloride	4.00	J	ug/L
TB000	06/15/88	05	5105	DI	VOLS	acetone	14.00	B	ug/L
TB000	06/15/88	06	5106	DI	VOLS	methylene chloride	3.00	JB	ug/L
TB000	06/15/88	06	5106	DI	VOLS	acetone	6.00	JB	ug/L
TB000	06/15/88	07	5107	DI	VOLS	methylene chloride	2.00	JB	ug/L
TB000	06/15/88	07	5107	DI	VOLS	acetone	7.00	JB	ug/L
TB000	06/15/88	08	5108	DI	VOLS	methylene chloride	1.00	J	ug/L
TB000	06/15/88	09	5109	DI	VOLS	methylene chloride	1.00	J	ug/L
TB000	06/15/88	10	5110	DI	VOLS	methylene chloride	1.00	J	ug/L
TB000	06/15/88	11	5111	DI	VOLS	methylene chloride	2.00	J	ug/L
TB000	06/15/88	12	5112	DI	VOLS	methylene chloride	2.00	J	ug/L
TB000	06/15/88	12	5112	DI	VOLS	acetone	3.00	J	ug/L
TB000	07/07/88	01	5113	DI	VOLS	methylene chloride	1.00	JB	ug/L
TB000	07/07/88	01	5113	DI	VOLS	acetone	7.00	J	ug/L
TB000	07/07/88	01	5113	DI	VOLS	4-methyl-2-pentanone	2.00	JB	ug/L
TB000	07/07/88	02	5114	DI	VOLS	benzene	8.00		ug/L
TB000	07/07/88	02	5114	DI	VOLS	toluene	7.00	B	ug/L
TB000	07/07/88	02	5114	DI	VOLS	ethylbenzene	3.00	J	ug/L
TB000	07/07/88	02	5114	DI	VOLS	xylene(s)(total)	1.00	J	ug/L
TB000	07/07/88	02	5114	DI	VOLS	hydrocarbon #1	6.00	JB	ug/L
TB000	07/07/88	02	5114	DI	VOLS	hydrocarbon #2	4.00	JB	ug/L
TB000	07/07/88	03	5115	DI	VOLS	methylene chloride	1.00	JB	ug/L
TB000	07/07/88	03	5115	DI	VOLS	acetone	4.00	J	ug/L
TB000	07/07/88	03	5115	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	05	5117	DI	VOLS	acetone	3.00	J	ug/L
TB000	07/07/88	05	5117	DI	VOLS	2-butanone	1.00	J	ug/L
TB000	07/07/88	05	5117	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	06	5118	DI	VOLS	acetone	3.00	J	ug/L
TB000	07/07/88	06	5118	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	07	5119	DI	VOLS	acetone	4.00	J	ug/L
TB000	07/07/88	07	5119	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	08	5120	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	09	5199	DI	VOLS	acetone	5.00	JB	ug/L
TB000	07/07/88	09	5199	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	11	5225	DI	VOLS	acetone	12.00		ug/L
TB000	07/07/88	11	5225	DI	VOLS	methylene chloride	2.00	J	ug/L

Table E.1. (continued)

05/24/89

SIGNIFICANT CHEMICAL DATA FROM TRIP BLANK

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
TB000	07/07/88	11	5225	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	12	5226	DI	VOLS	acetone	29.00		ug/L
TB000	07/07/88	12	5226	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	13	5234	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	14	5235	DI	VOLS	toluene	2.00	J	ug/L
TB000	07/07/88	14	5236	DI	VOLS	toluene	3.00	J	ug/L
TB000	09/23/88	01	5245	DI	VOLS	acetone	63.00		ug/L
TB000	09/23/88	02	5246	DI	VOLS	acetone	130.00		ug/L
TB000	09/23/88	04	5280	DI	VOLS	acetone	19.00		ug/L
TB000	09/23/88	05	5294	DI	VOLS	acetone	33.00	B	ug/L
TB000	11/01/88	01	5300	DI	VOLS	acetone	29.00		ug/L
TB000	11/18/88	01	5308	DI	VOLS	acetone	9.00	J	ug/L
TB000	12/15/88	01	5312	DI	VOLS	acetone	17.00		ug/L
TB000	09/23/88	03	5315	DI	VOLS	acetone	66.00		ug/L

Table E.2. Target compound list

Volatile organic compounds	<u>Detection limits (dilution factor = 1)</u>	
	Soil ($\mu\text{g/Kg dry weight}$)	Water ($\mu\text{g/L}$)
chloromethane	14	10
bromomethane	14	10
vinyl chloride	14	10
chloroethane	14	10
methylene chloride	7	5
acetone	14	10
carbon disulfide	7	5
1,1-dichloroethene	7	5
1,1-dichloroethane	7	5
1,2-dichloroethene (total)	7	5
chloroform	7	5
1,2-dichloroethane	7	5
2-butanone	14	10
1,1,1-trichloroethane	7	5
carbon tetrachloride	7	5
vinyl acetate	14	10
bromodichloromethane	7	5
1,2-dichloropropane	7	5
cis-1,3-dichloropropene	7	5
trichloroethene	7	5
dibromochloromethane	7	5
1,1,2-trichloroethane	7	5
benzene	7	5
trans-1,3-dichloropropene	7	5
bromoform	7	5
4-methyl-2-pentanone	14	10
2-hexanone	14	10
tetrachloroethene	7	5
1,1,2,2-tetrachloroethane	7	5
toluene	7	5
chlorobenzene	7	5

Table E.2. (continued)

<u>Volatile organic compounds (continued)</u>	<u>Detection limits (dilution factor = 1)</u>	
	<u>Soil</u> <u>($\mu\text{g/Kg dry weight}$)</u>	<u>Water</u> <u>($\mu\text{g/L}$)</u>
ethylbenzene	7	5
styrene	7	5
total xylenes	7	5
Analytical method	8240	624

<u>JP-4 components</u>	<u>Detection limits (dilution factor = 1)</u>	
	<u>Soil</u> <u>($\mu\text{g/kg dry weight}$)</u>	<u>Water</u> <u>($\mu\text{g/L}$)</u>
Total petroleum hydrocarbons	5000	50
Analytical method	8015	8015, 418.1
Benzene	50	0.5
Toluene	100	1
Ethyl Benzene	400	4
Xylenes (total)	400	4

<u>Base/neutral and acid extractable Semi-volatile organics (BNA)</u>	<u>Detection limits (dilution factor = 1)</u>	
	<u>Soil</u> <u>($\mu\text{g/kg dry weight}$)</u>	<u>Water</u> <u>($\mu\text{g/L}$)</u>
phenol	330	10
bis (2-chloroethyl)ether	330	10
2-chlorophenol	330	10
1,3-dichlorobenzene	330	10

Table E.2. (continued)

Base/neutral and acid extractable <u>Semi-volatile organics (BNA)</u>	<u>Detection limits (dilution factor = 1)</u>	
	Soil <u>($\mu\text{g/kg dry weight}$)</u>	Water <u>($\mu\text{g/L}$)</u>
1,4-dichlorobenzene	330	10
benzyl alcohol	330	10
1,2-dichlorobenzene	330	10
2-methylphenol	330	10
bis(2-chloroisopropyl)ether	330	10
4-methylphenol	330	10
n-nitroso-di-n-propylamine	330	10
hexachloroethane	330	10
nitrobenzene	330	10
isophorone	330	10
2-nitrophenol	330	10
2,4-dimethylphenol	330	10
benzoic acid	1,600	50
bis(2-chloroethoxy)methane	330	10
2,4-dichlorophenol	330	10
1,2,4-trichlorobenzene	330	10
naphthalene	330	10
4-chloroaniline	330	10
hexachlorobutadiene	330	10
4-chloro-3-methylphenol	330	10
2-methylnaphthalene	330	10
hexachlorocyclopentadiene	330	10
2,4,6-trichlorophenol	330	10
2,4,5-trichlorophenol	1,600	50
2-chloronaphthalene	330	10
2-nitroaniline	1,600	50
dimethyl phthalate	330	10
acenaphthylene	330	10
2,6-dinitrotoluene	330	10
3-nitroaniline	1,600	50
acenaphthene	330	10
2,4-dinitrophenol	1,600	50

Table E.2. (continued)

Base/neutral and acid extractable Semi-volatile organics (BNA)	<u>Detection limits (dilution factor = 1)</u>	
	Soil ($\mu\text{g/kg dry weight}$)	Water ($\mu\text{g/L}$)
4-nitrophenol	1,600	50
dibenzofuran	330	10
2,4-dinitrotoluene	330	10
diethylphthalate	330	10
4-chlorophenyl-phenylether	330	10
fluorene	330	10
4-nitroaniline	1,600	50
4,6-dinitro-2-methylphenol	1,600	50
n-nitrosodiphenylamine ¹	330	10
4-bromophenyl-phenylether	330	10
hexachlorobenzene	330	10
pentachlorophenol	1,600	50
phenanthrene	330	10
anthracene	330	10
di-n-butylphthalate	330	10
fluoranthene	330	10
pyrene	330	10
butylbenzylphthalate	330	10
3,3'-dichlorobenzidine	660	20
benzo(a)anthracene	330	10
chrysene	330	10
bis(2-ethylhexyl)phthalate	250	10
di-n-octylphthalate	330	10
benzo(b)fluoranthene	330	10
benzo(k)fluoranthene	330	10
benzo(a)pyrene	330	10
indeno(1,2,3-cd)pyrene	330	10
dibenzo(a,h)anthracene	330	10
benzo(g,h,i)perylene	330	10
Analytical method	8270	625

¹Detected as diphenylamine

Table E.2. (continued)

<u>Pesticides and PCBs</u>	<u>Detection limits (dilution factor = 1)</u>	
	<u>Soil</u> <u>($\mu\text{g/kg dry weight}$)</u>	<u>Water</u> <u>($\mu\text{g/L}$)</u>
α -BHC	8.0	0.050
β -BHC	8.0	0.050
δ -BHC	8.0	0.050
γ -BHC (lindane)	8.0	0.050
heptachlor	8.0	0.050
aldrin	8.0	0.050
heptachlor epoxide	8.0	0.050
endosulfan I	8.0	0.050
dieldrin	16	0.10
4,4'-DDE	16	0.10
endrin	16	0.10
endosulfan II	16	0.10
4,4'-DDD	16	0.10
endosulfan sulfate	16	0.10
4,4'-DDT	16	0.10
methoxychlor	80	0.50
endrin ketone	16	0.10
α -chlordane	80	0.50
γ -chlordane	80	0.50
toxaphene	160	1.0
Aroclor 1016	80	0.50
Aroclor 1221	80	0.50
Aroclor 1232	80	0.50
Aroclor 1242	80	0.50
Aroclor 1248	80	0.50
Aroclor 1254	160	1.0
Aroclor 1260	160	1.0
Analytical method	8080	608

Table E.2. (continued)

<u>Priority pollutant metals</u>	<u>Detection limits (dilution factor = 1)</u>	
	<u>Soil</u> <u>($\mu\text{g/kg dry weight}$)</u>	<u>Water</u> <u>($\mu\text{g/L}$)</u>
antimony	3	0.03
arsenic	0.3	0.002
beryllium	0.1	0.001
cadmium	0.5	0.005
chromium	1	0.01
copper	1	0.01
lead	3	0.002
mercury	0.02	0.001
nickel	2	0.02
selenium	0.2	0.002
silver	0.5	0.005
thallium	0.2	0.002
zinc	0.5	0.005

Analytical method

SW846, including Cold Vapor Atomic Absorption Spectroscopy - mercury; Graphite Furnace Atomic Absorption Spectroscopy - arsenic, selenium, lead, thallium; the remaining metals were analyzed by Inductively Coupled Argon Plasma Spectroscopy.

APPENDIX F

EVALUATION OF QUALITY ASSURANCE/QUALITY CONTROL

Evaluation of Quality Assurance/Quality Control

I. LABORATORY QA/QC

The following tables, F.1 through F.6, summarize the results of method blanks, surrogate spike recoveries, holding time compliance, duplicate sample agreement, and matrix spike/matrix spike duplicate recoveries.

Tables F.1 and F.2 summarize the frequency and distribution of contaminants found in the method blanks. Although the majority of blanks (61%) had contamination of some kind, the compounds were generally below reporting levels. The preponderance of acetone and methylene chloride is not surprising, as both are common lab solvents. Similarly, the blank results with other common solvents, 2-hexanone, 4-methyl-2-pentanone, and chloroform, are also due to the laboratory. Since site data shows mostly jet fuel contamination with traces of chlorinated solvents, these blank results do not affect the sample data.

Table F.3 lists the surrogate spike recoveries which are outside CLP limits. Due to the small number of samples in this category, including two lab blanks and three samples from sites of known contamination, the overall surrogate results do not affect the review of sample data. The high bromofluorobenzene and nitrobenzene surrogate recoveries on samples 5000 and 5053, and the high dibutylchlorendate recoveries on samples 5170 and 5234-5236 suggest a high bias in the analytical results for these categories. Fortunately, only traces of benzene were found in a few of these samples. Thus, even with a high bias the data could be used. The low surrogate recoveries for the semi-volatiles phenol D-5 and 2-fluorophenol in samples 5168 and 5170, and the low dibutylchlorendate recoveries in samples 5217 and 5219 indicate a low bias for these compounds. Since the volatile and petroleum hydrocarbon analyses of these samples were unaffected, the results are acceptable for evaluating JP-4 constituents.

Table F.4 lists the samples which exceeded holding times. Analyses or extractions beyond the contractual time limits were 1 day for the volatiles listed, 5 days for BNAs and PCB/pesticides, and varied from 1 to 4 days for the petroleum hydrocarbons. Recent studies by ORNL suggest that holding times may be extended in certain cases without sample loss (Maskarinec, et al. 1988). For example, volatiles preserved with HCl were found to be stable for at least 56 days in water. Semi-volatile compounds in the study

Table F.1. Method blanks

	Total number of method blanks (both soil & water)	Total number of blanks with contamination	Total number of blanks with contamination greater than reporting levels
Volatiles	82	50	15
Semi-volatiles	18	4	2
Petroleum hydrocarbons	61	4	0

Table F.2. Blank contaminants listed in descending order of frequency

Contamination	Limit of detection water/soil (ug/L / ug/kg)	Reporting level water/soil (ug/L / ug/kg)	Maximum concentration found in blank water/soil (ug/L/ug/L)	Number of blanks with contamination <RL water/soil	Number of blanks with contamination >RL water/soil
<u>Volatiles</u>					
acetone	1/1	10/10	17/22	10/16	5/5
methylene chloride	1/1	5/5	2/8	19/12	0/2
2-hexanone	1/1	10/10	2/2	2/6	0/0
4-methyl-2-pentanone	1/1	10/10	24/1	3/1	1/0
chloroform	1/1	5/5	1/2	1/2	0/0
bromoform	1/1	5/5	4/-	2/0	0/0
1,1,2,2-tetrachloroethane	1/1	5/5	8/-	0/0	2/0
toluene	1/1	5/5	-/4	0/2	0/0
total xylenes	1/1	5/5	-/1	0/2	0/0
2,2-dimethyl-1-propanol (TIC)	1/1	5/5	6/-	0/0	1/0
ethylbenzene	1/1	5/5	1/-	1/0	0/0
styrene	1/1	5/5	-/1	0/1	0/0
carbon disulfide	1/1	5/5	-/1	0/1	0/0
2-butanone	1/1	10/10	-/4	0/1	0/0
<u>Semi-volatiles</u>					
bis(2-ethylhexyl)phthalate	unknown	10/330	25/400	0/2	1/1
n-nitrosodiphenylamine	unknown	10/330	-/91	0/1	0/0
<u>Petroleum hydrocarbons</u>	unknown	50/5000	18/-	4/0	0/0

RL - reporting level

Table F.3. Surrogate spike recoveries outside CIP limits

Sample field number	Volatile bromofluorobenzene (74-121%)	nitrobenzene (23-120%)	Semi volatile phenol D-5 (10-94%)	2-fluorophenol (21-100%)	Pesticide dibutylchloroendate (24-154%)
5000	142	241			
5000 MSD		139			
5053	455				
5168					
5170			8	15	
5217			6	12	182
5219					3
5234-5236					1
(method blank)					193

Table F.4. Samples exceeding holding times

Sample	Analysis	<u>Allowable holding time (days)</u>		<u>Actual holding time (days)</u>	
		Collection to extraction or analysis	Extraction to analysis	Collection to extraction or analysis	Extraction to analysis
5022, 5027-5032, 5141, 5196, 5197, 5200, 5229, 5233, 5236	VOA	14	-	15	-
5196, 5197, 5200, 5229, 5233, 5236	PCB/PEST	5	40	<5	45
5196, 5197, 5200, 5229, 5233, 5236 5113, 5115, 5165, 5165MS, 5165MSD,	BVA	5	40	<5	45
5165 duplicate, 5167-5170	PHC	14	40 (water)	19	<40
5191, 5193, 5194	PHC			15	<40
5214-5222	PHC			19	<40

appeared to be stable indefinitely in the extraction solvent. Maintaining semi-volatile sample integrity is dependent on meeting the holding time from sample collection to extraction, thus minimizing degradation due to photochemical and microbial processes. In view of the ORNL study, and the fact that the samples in Table F.4 were analyzed close to contractual deadlines, there appears to be no reason to reject the data. Also, these analytical results were used only for screening and trend evaluation, and not for regulatory compliance.

Tables F.5 and F.6 show the degree of precision in the duplicate and triplicate analyses submitted to the lab. Replicate agreement was generally good, with the exception of sediments SD009 and SD010 (samples 5008 and 5009, Table F.6), which were collected next to each other from the drainage ditch at the northwest corner of the base. In order to avoid releasing volatile compounds during collection, the samples were not homogenized and subsampled. As a result, one sample contained pesticides but no petroleum hydrocarbons, while the other contained petroleum hydrocarbons but no pesticides. Both samples contained polynuclear aromatics in excellent agreement. Both the pesticides and petroleum hydrocarbons were present in trace quantities; the discrepancy probably indicates an erratic distribution of these compounds along the ditch.

Table F.7 contains the matrix spike/matrix spike duplicate (MS/MSD) recoveries outside contract laboratory program (CLP) limits. Overall, MS/MSD results are acceptable, with the exception of the six samples noted in the table. Arsenic and selenium data in samples 5179-5181 were rejected due to no recovery on the spikes. The 1,1-dichloroethene data is not considered to be a problem since one sample was an equipment rinse (5161) and two were soil samples (5032 and 5125). None of the soil samples at the base showed significant chlorinated solvents and since the water in the wells from which these soil samples were taken also showed no chlorinated solvents, the poor recoveries do not affect the data interpretation.

Table F.5. Duplicate sample agreement

	Acetone	Methylene chloride	2-Butanone	Toluene	TCE	PKCs	1,1,2-TCA	Benzene	Cl	F	S0 4	Ba	Zn	Carbon	Ethylbenzene	Vinyl acetate
5038	450E	12	20													
5039	400E	7	19													
5043	97	98	3J													
5044	120	118	.													
5046	45	88														
5047	180	98														
5050	308	298														
5051	168	158														
5060	2208	14	26	1J												
5061	2608	11	25	-												
5076	24	13		3J												
5077	11	6J		2J												
5097		198		98												
5098		5JB		5JB												
5154	310E	19	93	22	45											
5155	220	17	43	6												
5165	6J	1JB		1		83	-									
5166							5	0.5J								
5220	5J					11JB			7.6	2.5	230		0.01			
5221						828			7.5	2.6	240					
5222						2JB			7.0	2.6	230		0.01			
5230	5J	2J		1					120	3.5	590			3		
5231	6J	2J							130	3.7	640			4		
5232	6J	2J							150	3.5	300			-		
5233*		2J		1JB					145	1.4	694	0.03		2J	1J	4J

* duplicate of 5230-5232 analyzed at K-25.

J - indicates an estimated value less than the detection limit

S - analyte was found in the blank as well as the sample

E - value exceeded CLP calibration range, but was within the instrument linear range

D - value reported from 1:100 dilution

Table F.6. Duplicate sample agreement, field numbers 5008 and 5009

Compound	5008	5009
4,4' -DDE	30	
4,4' -DDT	65	
arenaphthene	240J	
acetone	14	37
anthracene	520	330J
as	2.6	4.5
be	0.5	0.4
benzo(a)anthracene	1400J	1500J
benzo(a)pyrene	1200J	1400J
benzo(b)fluoranthene	1600J	1800J
benzo (g,h,i)perlyene	1400J	1400J
benzo(k)fluoranthene	1700J	1700J
bis(2-ethylhexyl)phthalate	2700B	2500B
chrysene	1500J	1700J
cr	4	5
cu	8	8
dieldrin	47D	
fluoranthene	3400	3400
fluorene	270J	
hg	0.05	0.15
methylene chloride	2J	19
n-nitrosodiphenylamine	1400JB	2200B
naphthalene	190J	
ni	8	7
pb	19	31
petroleum hydrocarbons		6000
phenanthrene	2300	1700
pyrene	3100	3000
zn	44	56

Table F.7. Matrix spike/matrix spike duplicate recoveries outside CIP limits

Sample	Spike	Conc. spike added	Sample conc.	MS conc.	MS % rec	Conc. spike added	MSD conc.	MSD % Rec	RPD*
5032	1,1-Dichloroethene	62	6U	66	106	62	50	81	27
5125	1,1-Dichloroethene	68	7U	36	53	68	36	53	0
5161	1,1-Dichloroethene	50	5U	23	46	50	22	44	4
5000	Zn	50	425	523	196		446	42	129
5179-5181	As	0.044	0.03U	0.03U	NR		0.03U	NR	-
	Se	0.011	0.3U	0.3U	NR		0.03U	NR	-
5250	Sb	42	3U	9	21		14	33	-44
	As	4.0	7.1	9.4	58		11	88	-41
	Se	1.0	1.0U	0.8	80		0.5	50	46

* RPD = relative percent difference, calculated as:

$$RPD = \frac{D1 - D2}{1/2 (D1 + D2)} \times 100$$

NR = no recovery

U = compound was analyzed for, but not detected. The number is the detection limit for the sample.

II. FIELD QA/QC

Samples collected for field QA/QC include equipment rinsates, field blanks, and trip blanks. Significant analytical results for these samples can be found in Tables F.8, F.9, and F.10, respectively.

Equipment Rinsates

Petroleum hydrocarbons (TPHCs) were found in rinsate blank samples 5055, 5161, and 5216, at concentrations of 52, 130, and 2 $\mu\text{g/L}$, respectively. Sample 5216 also had TPHCs in the associated method blank. Sample 5055 was collected by running deionized water through the 5-ft continuous sampler. In this case, prior to decontamination, the sampler had penetrated a zone of JP-4 contamination during the drilling of MW009. It is quite likely that residual TPHCs were transferred to the equipment rinsate blank during collection. Sample 5161 (130 $\mu\text{g/L}$ TPHCs) was taken after drilling to 9 ft at MW026. The presence of TPHCs in this rinsate is unexplained, as MW026 is not associated with any contamination. The last sample from the previous well at which the sampler was used, MW023, is also clean. Fortunately, the sample collected after each of the rinsate blanks containing TPHCs showed no detectable TPHCs. Thus, the three high rinsate blanks did not affect data quality.

Field Blanks

Six field blanks were taken during the program. Three of the field blanks had traces of contamination. The analytes detected were chloroform (8 $\mu\text{g/L}$), acetone (up to 15 $\mu\text{g/L}$), benzene (up to 3.3 $\mu\text{g/L}$), and toluene (up to 2 $\mu\text{g/L}$). Based on the site history and the results from the groundwater and soil samples, the acetone and chloroform are believed to be due to laboratory contamination and may be disregarded: the laboratory reported that toluene was frequently present in laboratory method blanks. Toluene and benzene, however, were also found throughout the site and TPHCs were found in some of the equipment rinsates. Thus, contamination in the field from toluene and benzene cannot be ruled out without further review. Fortunately, a review of samples collected subsequent to the field blanks shows that even if the field blanks were contaminated in the field, the contamination did not carry over to subsequent samples. The samples

Table F.8. Significant analytical results from equipment rinsates.

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
ER002	07/14/88	01	5228	RI	PHCS	toluene	1.00		ug/L
ER002	07/14/88	01	5228	RI	VOLS	carbon disulfide	4.00	J	ug/L
ER002	07/14/88	01	5228	RI	VOLS	toluene	1.00	J	ug/L
ER005	03/10/88	01	0011	RI	VOLS	chloroform	10.00		ug/L
ER005	03/10/88	01	0011	RI	VOLS	hexane	7.00		ug/L
ER005	03/10/88	01	0011	RI	VOLS	unknown	12.00		ug/L
ER005	09/30/88	01	5239	RI	VOLS	toluene	1.00	J	ug/L
ER009	06/17/88	08	5055	RI	PHCS	petroleum hydrocarbons	52.00		ug/L
ER009	10/05/88	01	5288	RI	VOLS	acetone	8.00	J	ug/L
ER011	06/17/88	16	5064	RI	VOLS	methylene chloride	3.00	J	ug/L
ER011	06/17/88	16	5064	RI	VOLS	acetone	4.00	JB	ug/L
ER014	06/18/88	12	5080	RI	VOLS	acetone	21.00	B	ug/L
ER015	06/19/88	12	5085	RI	VOLS	acetone	12.00	B	ug/L
ER015	06/19/88	12	5085	RI	VOLS	carbon disulfide	9.00		ug/L
ER016	10/04/88	01	5274	RI	VOLS	acetone	5.00	J	ug/L
ER017	07/13/88	01	5216	RI	PHCS	petroleum hydrocarbons	2.00	JB	ug/L
ER017	07/13/88	01	5216	RI	VOLS	toluene	1.00	J	ug/L
ER019	06/20/88	09	5124	RI	VOLS	acetone	8.00	J	ug/L
ER019	06/20/88	09	5124	RI	VOLS	carbon disulfide	3.00	J	ug/L
ER019	07/07/88	01	5167	RI	PHCS	toluene	1.00		ug/L
ER021	07/08/88	01	5171	RI	PHCS	toluene	2.00		ug/L
ER021	07/08/88	01	5171	RI	VOLS	acetone	3.00	J	ug/L
ER021	07/08/88	01	5171	RI	VOLS	toluene	2.00	J	ug/L
ER021	10/04/88	01	5265	RI	VOLS	methylene chloride	1.00	JB	ug/L
ER021	10/04/88	01	5265	RI	VOLS	acetone	5.00	JB	ug/L
ER023	06/22/88	12	5158	RI	VOLS	acetone	6.00	J	ug/L
ER023	07/10/88	01	5184	RI	PHCS	toluene	2.00		ug/L
ER023	07/10/88	01	5184	RI	VOLS	acetone	6.00	JB	ug/L
ER023	07/10/88	01	5184	RI	VOLS	toluene	2.00	J	ug/L
ER024	06/21/88	36	5152	RI	VOLS	carbon disulfide	2.00	J	ug/L
ER026	06/23/88	09	5161	RI	PHCS	petroleum hydrocarbons	130.00		ug/L
ER026	06/23/88	09	5161	RI	VOLS	acetone	7.00	J	ug/L
ER028	11/01/88	08	5298	RI	PHCS	benzene	2.80		ug/L
ER028	11/01/88	08	5298	RI	VOLS	acetone	6.00	J	ug/L
ER028	11/01/88	08	5298	RI	VOLS	carbon disulfide	33.00		ug/L
ER028	11/18/88	01	5302	RI	VOLS	acetone	11.00		ug/L
ER028	12/15/88	01	5309	RI	VOLS	methylene chloride	1.00	J	ug/L
ER028	12/15/88	01	5309	RI	VOLS	acetone	11.00		ug/L

Table F.9. Significant analytical results from field blanks.

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
FB005	03/11/88	01	0022	DI	VOLS	chloroform	8.00		ug/L
FB005	09/30/88	01	5240	DI	PHCS	toluene	1.00		ug/L
FB005	09/30/88	01	5240	DI	VOLS	acetone	7.00	J	ug/L
FB005	09/30/88	01	5240	DI	VOLS	toluene	1.00	J	ug/L
FB021	07/08/88	01	5172	DI	PHCS	toluene	2.00		ug/L
FB021	07/08/88	01	5172	DI	VOLS	acetone	5.00	J	ug/L
FB021	07/08/88	01	5172	DI	VOLS	toluene	2.00	J	ug/L
FB028	11/01/88	01	5299	DI	PHCS	benzene	3.30		ug/L
FB028	11/01/88	01	5299	DI	VOLS	acetone	5.00	J	ug/L
FB028	11/18/88	01	5303	DI	VOLS	acetone	11.00		ug/L
FB028	12/15/88	01	5310	DI	VOLS	acetone	15.00		ug/L
FB028	12/15/88	01	5310	DI	VOL	benzene	3.00	J	ug/L

Table F.10. Significant analytical results from trip blanks.

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
T8000	03/04/88	01	0008	DI	VOLS	chloroform	5.00		ug/L
T8000	03/04/88	02	0012	DI	VOLS	acetone	4.00	J8	ug/L
T8000	03/04/88	02	0012	DI	VOLS	chloroform	5.00		ug/L
T8000	03/04/88	02	0012	DI	VOLS	4-methyl-2-pentanone	3.00	J8	ug/L
T8000	03/04/88	02	0012	DI	VOLS	unknown	7.00		ug/L
T8000	03/04/88	02	0012	DI	VOLS	unknown	7.00		ug/L
T8000	06/15/88	01	5101	DI	VOLS	methylene chloride	1.00	J	ug/L
T8000	06/15/88	01	5101	DI	VOLS	acetone	6.00	J8	ug/L
T8000	06/15/88	02	5102	DI	VOLS	methylene chloride	8.00	J8	ug/L
T8000	06/16/88	03	5103	DI	VOLS	methylene chloride	3.00	J	ug/L
T8000	06/17/88	04	5104	DI	VOLS	methylene chloride	2.00	J	ug/L
T8000	06/17/88	04	5104	DI	VOLS	acetone	7.00	J8	ug/L
T8000	06/15/88	05	5105	DI	VOLS	methylene chloride	4.00	J	ug/L
T8000	06/15/88	05	5105	DI	VOLS	acetone	14.00	B	ug/L
T8000	06/15/88	06	5106	DI	VOLS	methylene chloride	3.00	J8	ug/L
T8000	06/15/88	06	5106	DI	VOLS	acetone	6.00	J8	ug/L
T8000	06/15/88	07	5107	DI	VOLS	methylene chloride	2.00	J8	ug/L
T8000	06/15/88	07	5107	DI	VOLS	acetone	7.00	J8	ug/L
T8000	06/15/88	08	5108	DI	VOLS	methylene chloride	1.00	J	ug/L
T8000	06/15/88	09	5109	DI	VOLS	methylene chloride	1.00	J	ug/L
T8000	06/15/88	10	5110	DI	VOLS	methylene chloride	1.00	J	ug/L
T8000	06/15/88	11	5111	DI	VOLS	methylene chloride	2.00	J	ug/L
T8000	06/15/88	12	5112	DI	VOLS	methylene chloride	2.00	J	ug/L
T8000	06/15/88	12	5112	DI	VOLS	acetone	3.00	J	ug/L
T8000	07/07/88	01	5113	DI	VOLS	methylene chloride	1.00	J8	ug/L
T8000	07/07/88	01	5113	DI	VOLS	acetone	7.00	J	ug/L
T8000	07/07/88	01	5113	DI	VOLS	4-methyl-2-pentanone	2.00	J8	ug/L
T8000	07/07/88	02	5114	DI	VOLS	benzene	8.00		ug/L
T8000	07/07/88	02	5114	DI	VOLS	toluene	7.00	B	ug/L
T8000	07/07/88	02	5114	DI	VOLS	ethylbenzene	3.00	J	ug/L
T8000	07/07/88	02	5114	DI	VOLS	xylenes(total)	1.00	J	ug/L
T8000	07/07/88	02	5114	DI	VOLS	hydrocarbon #1	6.00	J8	ug/L
T8000	07/07/88	02	5114	DI	VOLS	hydrocarbon #2	4.00	J8	ug/L
T8000	07/07/88	03	5115	DI	VOLS	methylene chloride	1.00	J8	ug/L
T8000	07/07/88	03	5115	DI	VOLS	acetone	4.00	J	ug/L
T8000	07/07/88	03	5115	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	05	5117	DI	VOLS	acetone	3.00	J	ug/L
T8000	07/07/88	05	5117	DI	VOLS	2-butanone	1.00	J	ug/L
T8000	07/07/88	05	5117	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	06	5118	DI	VOLS	acetone	3.00	J	ug/L
T8000	07/07/88	06	5118	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	07	5119	DI	VOLS	acetone	4.00	J	ug/L
T8000	07/07/88	07	5119	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	08	5120	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	09	5199	DI	VOLS	acetone	5.00	J8	ug/L
T8000	07/07/88	09	5199	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	11	5225	DI	VOLS	acetone	12.00		ug/L
T8000	07/07/88	11	5225	DI	VOLS	methylene chloride	2.00	J	ug/L

Table F.10. (continued)

SAMPLE LOCATION	SAMPLE DATE	SAMPLE INTERVAL	FIELD NUMBER	SAMPLE MATRIX	ANALYTICAL METHOD	ANALYTE	RESULT	CODE	UNITS
T8000	07/07/88	11	5225	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	12	5226	DI	VOLS	acetone	29.00		ug/L
T8000	07/07/88	12	5226	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	13	5234	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	14	5235	DI	VOLS	toluene	2.00	J	ug/L
T8000	07/07/88	14	5236	DI	VOLS	toluene	3.00	J	ug/L
T8000	09/23/88	01	5245	DI	VOLS	acetone	63.00		ug/L
T8000	09/23/88	02	5246	DI	VOLS	acetone	130.00		ug/L
T8000	09/23/88	04	5280	DI	VOLS	acetone	19.00		ug/L
T8000	09/23/88	05	5294	DI	VOLS	acetone	33.00	B	ug/L
T8000	11/01/88	01	5300	DI	VOLS	acetone	29.00		ug/L
T8000	11/18/88	01	5308	DI	VOLS	acetone	9.00	J	ug/L
T8000	12/15/88	01	5312	DI	VOLS	acetone	17.00		ug/L
T8000	09/23/88	03	5315	DI	VOLS	acetone	66.00		ug/L

collected subsequent to the field blank with field numbers 5240 and 5172 (which contained toluene) did not contain any toluene. The sample subsequent to field blank 5299 (which contained benzene) did not contain any benzene. The sample subsequent to field blank 5310, which had 3.3 $\mu\text{g/L}$ benzene, had 270 $\mu\text{g/L}$ of TPHCs, a value much higher than any of the blanks. Thus, it may be concluded that the traces of contamination reported in the field blanks have had no impact on the interpretation of data from the site.

Trip Blanks

There were 37 trip blanks submitted during the program. Many of the trip blanks had traces of the same solvents mentioned previously. Chloroform, 4-methyl-2-pentanone, acetone, and methylene chloride are all believed to be due to laboratory contamination. Traces of toluene (up to 2 $\mu\text{g/L}$), benzene (8 $\mu\text{g/L}$), ethylbenzene (3 $\mu\text{g/L}$), and xylenes (1 $\mu\text{g/L}$) were also detected. Of these last four analytes, all but the benzene were listed as estimated values. This result indicates that values under 10 $\mu\text{g/L}$ should be interpreted with caution. Thus, no decisions were made as to whether a site was definitely contaminated at low levels unless the data were verified with repeat samples.

Finally, as shown below, acetone and methylene chloride were present in many of the samples collected during the sampling program:

% of samples in which compound was detected

Compound	Maximum concentration in samples water ($\mu\text{g/L}$)/soil ($\mu\text{g/kg}$)	All samples collected including water, soil, and blanks	Trip blanks	Equipment rinses	Field blanks
Acetone	250/600	66	55	52	50
Methylene chloride	13/220	47	39	4	0

Both compounds are common laboratory solvents; since neither are markers of JP-4, they have been attributed to contamination during sample preparation at the laboratory. Although acetone is found in the exhaust gases of

gasoline and diesel engines, it was reasoned that other volatile exhaust products should have been detected as well. Contamination in storage in Grand Junction, Colorado has been ruled out since the sample bottles were purchased sealed and pre-cleaned from I-Chem, Inc. Acetone is not used in the cleaning procedures, and the bottles are oven-dried prior to being capped. Neither solvent is used or stored by ORNL/CAT in Grand Junction, Colorado.

Contamination in storage at the base has also been ruled out. A HAZWRAP QA/QC specialist audited the field work in June 1988. An observation from that audit was that sampling equipment and bottles were stored in a room which contained various chemical compounds for use at the base. The location and quantities of all equipment and chemicals in the room were listed. The sample bottles were in unopened, sealed boxes and all sampling equipment was decontaminated before use (Pickering 1988). All equipment was subsequently moved to a "clean" conference room for storage. Total time in the storage room with the various chemicals was four days. Contamination from the storage room has also been ruled out because several cases of sample bottles were never unloaded into this storage room but were kept in the sampling vehicle for immediate use. The acetone and methylene chloride were detected beginning with the first sample collected in June 1988 (5013).

III. ANALYTICAL RESULTS FROM LABORATORY QA/QC SAMPLES

Table A.11 lists all samples collected at the base and the associated method blank, surrogate, and matrix spike which applies to that sample. The table of contents for this table lists each sample collected at the base and the page number of the analytical report for the respective QA/QC sample.

TABLE F.11. Analytical reports from laboratory QA/QC samples

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FODW001GW0308801	0001	VOA	31,32	173	226
FODW001GW0309802	0002	VOA	29,30	173	
FODW002GW0309801	0003	VOA	31,32	173	
FODW002GW0309802	0004	VOA	31,32	173	
FODW004GW0308801	0005	VOA	31,32	173	
FODW004GW0309802	0006	VOA	31,32	173	
FODW005GW0309801	0007	VOA	31,32	173	
FOTB000RI0304801	0008	VOA	31,32	173	
FODW003GW0310801	0009	VOA	33,34	174	227
FOSW005GW0310801	0010	VOA	33,34	174	
FOER005RI0310801	0011	VOA	33,34	174	
FOTB000RI0304802	0012	VOA	33,34	174	
FOSW001GW0311801	0013	VOA	39,40	174	
FOSW002GW0311801	0014	VOA	39,40	174	
FOSW003GW0311801	0015	VOA	39,40	174	
FOSW004GW0311801	0016	VOA	37,38	174	
FOSW005GW0311802	0017	VOA	35,36	174	
FOSW005WR0311803	0018	VOA	35,36	174	
FODW005GW0311802	0019	VOA	35,36	174	
FODW005GW0311803	0020	VOA	37,38	174	
FODW006GW0311801	0021	VOA	35,36	174	
		PHC			264,265
FOFB005RI0311801	0022	VOA	37,38	174	
FOTE000RI0304803	0023	VOA	37,38	174	
FOSD001S00614801	5000	VOA	100,101	201	240
		BNA	132,133	216	251
		PHC	151,152,155		266
		PEST\PCB	169	225	275
		METALS			279
FOSD002S00623801	5001	VOA	105		
		BNA	134,135	214	
		PHC	157,158		
		PEST\PCB	170	223	
FOSD003S00623801	5002	VOA	105		
		BNA	134,135	214	
		PHC	153,156		
		PEST\PCB	170	223	
FOSD004S00623801	5003	VOA	106		
		BNA	134,135	214	
		PHC	157,158		
		PEST\PCB	170	223	
FOSD005S00623801	5004	VOA	106		
		BNA	134,135	214	
		PHC	157,158		
		PEST\PCB	170	223	
FOSD006S00623801	5005	VOA	106		
		BNA	134,135	214	
		PHC	153,156		
		PEST\PCB	170	223	

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOSD007S00623801	5006	VOA	106		
		BNA	134,135	214	
		PHC	157,158		
		PEST\PCB	170	223	
FOSD008S00623801	5007	VCA	106		
		BNA	134,135	214	
		PHC	157,158		
		PEST\PCB	170	223	
FOSD009S00623801	5008	VOA	106		
		BNA	134,135	214	
		PHC	157,158		
		PEST\PCB	170	223	
FOSD010SR0623801	5009	VOA	107		
		BNA	134,135	214	
		PHC	153,156		
		PEST\PCB	170	223	
FOSD011S00624801	5010	VOA	107		
		BNA	134,135	214	
		PHC	157,158		
		PEST\PCB	170	223	
FOSD012S00624801	5012	VOA	107		
		BNA	134,135	214	
		PHC	157,158		
		PEST\PCB	170	223	
FOMW001S000614803	5013	VOA	100	201	
		PHC	151,152,155		
			157,158		
FOMW001S00614806	5014	VOA	100	201	
		PHC	151,152,155		
FOMW001S00614809	5015	VOA	101	201	
		PHC	151,152,155		
FOMW001S00614812	5016	VOA	101	201	
		PHC	151,152,155		
FOER001RI0614812	5018	VOA	44,45	178	228
		PHC			253
FOMW002S00614803	5019	VOA	101	201	
		PHC	151,152,155		
FOMW002S00614806	5020	VOA	102	201	
		PHC	155		
FOMW002S00614809	5021	VOA	102	201	
		PHC	155		
FOMW003S00615803	5022	VOA	103,104	201	
		PHC	155		
FOMW003S00615806	5023	VOA	102	201	
		PHC	151,152,155		
FOMW003S00615809	5024	VOA	102	201	
		PHC	155		
FOMW003S00615812	5025	VOA	102	201	
		PHC	155		
FOMW003RI0615813	5027	VOA	103	201	
		PHC	155		

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOMW004S00615803	5028	VOA	103	201	
		PHC	151,152,155		
FOMW004S00615806	5029	VOA	103	201	
		PHC	151,152,155		
FOMW004S00615809	5030	VOA	103	201	
		PHC	155		
FOMW004S00615812	5031	VOA	103	201	
		PHC	155		
FOMW004S00615815	5032	VOA	103	201	241
		PHC	155		
FOMW005S00616803	5033	VOA	81	196	
FOMW005S00616806	5034	VOA	88	196	
		PHC	155		
FOMW005S00616809	5035	VOA	88	196	
		PHC	155		
FOMW005S00616812	5036	VOA	88	196	242
		PHC	155		267
FOMW006S00616803	5037	VOA	88	196	
		PHC	155		
FOMW006S00616806	5038	VOA	89	196	
		PHC	155		
FOMW006SR0616806	5039	VOA	89	196	
		PHC	155		
FOMW006S00616809	5040	VOA	90	196	
		PHC	155		
FOMW006S00616812	5041	VOA	89	196	
FOMW007S00616803	5042	VOA	90	196	
FOMW007S00616806	5043	VOA	90	196	
FOMW007SR0616806	5044	VOA	90	196	
FOMW007S00616809	5045	VOA	90	196	
FOMW007S00616812	5046	VOA	90	196	
FOMW007SR0616812	5047	VOA	90	196	
FOMW008S00617803	5048	VOA	90	196	
FOMW008S00617806	5049	VOA	91	197	
FOMW008S00617809	5050	VOA	91	197	
FOMW008SR0617809	5051	VOA	91	197	
FOMW009S00617803	5052	VOA	92	197	
FOMW009S00617806	5053	VOA	92,93	197	
FOMW009S00617806	5054	TCCLP	117	206	250
FOER009RI0617808	5055	VOA	41	175	
FOMW010S00617803	5056	VOA	93	197	
FOMW010S00617806	5057	VOA	93	197	
FOMW011S00617803	5058	VOA	93	197	
FOMW011S00617806	5059	VOA	93	197	
FOMW011S00617809	5060	VOA	93	197	
FOMW011SR0617809	5061	VOA	93	197	
FOMW011S00617812	5062	VOA	93	197	
FOMW011S00617815	5063	VOA	93	197	243
		PHC			268
FOER011RI0617816	5064	VOA	41	175	

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOMW012S00618803	5065	VOA	94	198	
		PHC	152		
FOMW012S00618806	5066	VOA	94	198	
		PHC	152		
FOMW012S00618809	5067	VOA	94	198	
		PHC	152		
FOMW012S00618812	5068	VOA	95	198	
		PHC	152		
FOMW012S00618815	5069	VOA	95	198	
		PHC	152		
FOMW012S00618818	5070	VOA	95	198	
		PHC	152		
FOMW013S00618803	5071	VOA	95	198	
		PHC	152		
FOMW013S00618806	5072	VOA	95	198	
		PHC	152		
FOMW013S00618809	5073	VOA	95	198	
		PHC	152		
FOMW013S00618812	5074	VOA	96	198	
		PHC	152		
FOMW014S00618803	5075	VOA	96	198	
		PHC	153, 156		
FOMW014S00618806	5076	VOA	96	198	
		PHC	152		
FOMW014SR0618806	5077	VOA		198	
		PHC	152		
FOMW014S00618809	5078	VOA		198	244
		PHC	152		269
FOMW014S00618812	5079	VOA		198	
		PHC	152		
FOER014RI0618812	5080	VOA	42	176, 198	
FOMW015S00619803	5081	PHC	153		
FOMW015S00619806	5082	VOA	97	199	
		PHC	153		
FOMW015S00619809	5083	VOA	97	199	
		PHC	153		
FOMW015S00619812	5084	VOA	97	199	
		PHC	153		
FOER015RI0619812	5085	VOA	42	176	
FOMW016S00619803	5086	VOA	97	199	
		PHC	153		
FOMW016S00619806	5087	VOA	97	199	
		PHC	153		
FOMW016S00619809	5088	VOA	97	199	
		PHC	153		
FOMW016S00619812	5089	VOA	98	199	
		PHC	153		
FOMW016S00619815	5090	VOA	98	199	
		PHC	153, 156		

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOMW017S00619803	5091	VOA	98	199	
		PHC	153,156		
FOMW017S00619806	5092	VOA	98	199	
		PHC	153,156		
FOMW017S00619809	5093	VOA	110	202	
		PHC	157,158		
FOMW017S00619812	5094	VOA	110	202	
		PHC	157,158		
FOMW017S00619815	5095	VOA	109	202	
		PHC	154,157,158		
			159		
FOMW018S00620803	5096	VOA	110	202	
		PHC	154,157,158		
			159		
FOMW018S00620806	5097	VOA	109	202	245
		PHC	154,157,158		
			159		
FOMW018SR0620806	5098	VOA	110	202	
		PHC	154,157,158		
			159		
FOMW018S00620809	5099	TCLP	119	186	
FOMW018S00620812	5100	VOA	110	202	
		PHC	159		
FOTB000RI0615801	5101	VOA	45	178	
FOTB000RI0615802	5102	VOA	45	178	
FOTB000RI0616803	5103	VOA	41	175	
FOTB000RI0617804	5104	VOA	41	175	
FOTB000RI0615805	5105	VOA	41	175	
FOTB000RI0615806	5106	VOA	42	176	
FOTB000RI0615807	5107	VOA	42	176	
FOTB000RI0615808	5108	VOA	63	185	
FOTB000RI0615809	5109	VOA	63	185	
FOTB000RI0615810	5110	VOA	43	177	
FOTB000RI0615811	5111	VOA	46	179	
FOTB000RI0615812	5112	VOA		179	
FOTB000RI0707801	5113	VOA	49	180	
FOTB000RI0707802	5114	VOA	47,48		
FOTB000RI0707803	5115	VOA	49	180	
FOTB000RI0707805	5117	VOA	52	179	
FOTB000RI0707806	5118	VOA	52	179	
FOTB000RI0707807	5119	VOA	54	182	
FOTB000RI0707808	5120	VOA	54	182	
FOMW019S00620803	5121	VOA	109	202	
		PHC	154,157,158		
			159		
FOMW019S00620806	5122	VOA	111	203	
		PHC	154,157,158		
			159		
FOMW019S00620809	5123	VOA	112	203	
		PHC	154,157,158		
			159		

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOERO19RI0620809	5124	VOA	63	185	
FOMW020SO0620803	5125	VOA	111	175	246
		PHC	154,157,158 159		270
FOMW020SO0620806	5126	VOA	111	203	
		PHC	159		
FOMW020SO0620809	5127	VOA	111	203	
		PHC	159		
FOMW020SO0620812	5128	VOA	111	203	
		PHC	159		
FOMW020SO0620803	5129	VOA	111	203	
		PHC	159		
FOMW021SO0620806	5130	VOA	113	203	
		PHC	159		
FOMW021SO0620809	5131	VOA	112	203	
		PHC	159		
FOMW021SO0620806	5132	TCLP		186	
FOOT000SW0620801	5133	VOA	63	185	
		BNA	126,127	211	
		PEST\PCB	165	220	
		ANIONS	172		
FOOT000SW0626802	5134	VOA	64,65	185	
		BNA	126,127	211	
		PEST\PCB	165	220	
		ANIONS	172		283
FOMW022SO0621803	5135	VOA	99	200	
		PHC	154		
FOMW022SO0621806	5136	VOA	99	200	
		PHC	154		
FOMW024SO0621809	5140	VOA	99	200	
		PHC	154		
FOMW024SO0621809	5141	TCLP	118	207	
FOMW024SO0621818	5145	VOA	99	200	
		PHC	154		
FOMW024SO0621827	5148	VOA	99	200	
		PHC	154		
FOMW024SO0621836	5151	VOA	99	200	
		PHC	154		271
FOERO24RI0621836	5152	VOA	43	173	
FOMW023SO0622803	5153	VOA	107		
FOMW023SO0622806	5154	VOA	107		
		PHC	153,156		
FOMW023SR0622806	5155	VOA	107		
		PHC	156		
FOMW023SO0622809	5156	VOA	108		
		PHC	156		
FOMW023SO0622812	5157	VOA	108		
		PHC	156		
FOERO23RI0622812	5158	VOA		179	
		PHC	138		

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOMW026S00623803	5159	VOA	108		
		PHC	156		
FOMW026S00623806	5160	VOA	108		
		PHC	154,157,158		
			159		
FOER026RI0623809	5161	VOA	46	179	229
		PHC	138		
FOMW027S00623809	5162	VOA	108		
		PHC	156		
FOMW027S00623818	5163	VOA	108		247
		PHC	156		272
FOMW019GW0707801	5165	VOA	49	180	
		PHC	139		255
		ANIONS			284
FOER019RI0707801	5167	VOA	50	180	
		PHC	138,139		
FOMW001GW0707801	5168	VOA	50	180	
		BNA	120,121	208	
		PHC	138,139		
		PEST\PCB	162	217	
FOMW020GW0708801	5169	VOA	50	200	
		PHC	138,139		
FOMW021GW0708801	5170	VOA	50	200	
		BNA	120,121	208	
		PHC	138,139		
		PEST\PCB	162	217	
FOER021RI0708801	5171	VOA	40	180	
		PHC	138,139		
FOFB021RI0708801	5172	VOA	51	180	
		PHC	138,139		
FOMW026GW0708801	5173	VOA	51	180	
		PHC	138,139		
FOMW018GW0709801	5174	VOA	52	181	
		PHC	140		
FOMW013GW0708801	5175	VOA	51	180	
		PHC	139		
FOMW005GW0708801	5176	VOA	51	180	
		PHC	139		
FOMW012GW0709801	7177	VOA	52	181	
		PHC	140		
FOMW011GW0710801	5179	VOA	52	181	230
		PHC	140,141,143		
		METALS			277,278
FOMW011WR0710802	5180	VOA	52	181	230
		PHC	140,141,143		
		METALS			277,278
FOMW011WR0710803	5181	VOA	52	181	230
		PHC	140,141,143		
		METALS			277,278
FOMW007GW0710801	5182	VOA	52	181	
		PHC	140,141,143		

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOMW023GW0710801	5183	VOA	53	181	
		PHC	140,142		
FOER023RI0710801	5184	VOA	52	181	
		PHC	140,142		
FOMW002GW0710801	5185	VOA	53	181	
		PHC	140,142		
FOMW027GW0710801	5186	VOA	53	181	
		PHC	140,142		
FOMW008GW0711801	5187	VOA	54	182	
		PHC	141		
FOMW024GW0711801	5188	VOA	55	182	
		PHC	141		
FOMW027GW0711801	5189	BNA	122,123	209	
		PEST\PCB	163	218	
FOMW014GW0711801	5190	VOA	55	182	
		PHC	141		256
FOMW010GW0711801	5191	VOA	55	182	
		PHC	141,143		
FOMW009GW0711801	5192	VOA	55	182	
		PHC	140,141,142		
			143		
FOER009RI0711801	5193	VOA	55	182	
		PHC	141,143		
FOCH001GW0711801	5194	VOA	55	182	
		PHC	141,143		
FOMW016GW0712801	5195	VOA	56	183	
		PHC	141		
FOMW025WR0712801	5196	VOA	47,66		
FOMW003WR0712801	5197	VOA	47,66		
FOMW015GW0712801	5198	VOA	56,57	183	231
		PHC	141		
		ANIONS			285
FOTB000RI0707809	5199	VOA	57	183	
FOTB000RI0707810	5200	VOA	47,48		232
FOMW003GW0713801	5214	VOA	58	184	
		BNA	124,125	210	
		PHC	140,142		
		PEST\PCB	164	219	
FOMW017GW0713801	5215	VOA	58	184	
		PHC	140,142		
FOER017RI0713801	5216	VOA	59	184	
		PHC	141,142		
FOMW025GW0713801	5217	VOA	60	184	
		BNA	124,125	210	
		PHC	141,142		
		PEST\PCB	164	219	
FOMW025WR0713802	5218	VOA	59	184	
		BNA	124,125	210	
		PHC	141,142		
		PEST\PCB	164	219	

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOMW25WR0713803	5219	VOA	59	184	
		BNA	124,125	210	
		PHC	141,142		
		PEST\PCB	164	219	
FOMW006GW0173801	5220	VOA	59	184	
		PHC	142		
FOMW006WR0713802	5221	VOA	59	184	
		PHC	142		
FOMW006WR0713803	5222	VOA	60	184	
		PHC	142		
FOTB000RI0707811	5225	VOA	60	184	
FOTB000RI0707812	5226	VOA	60	184	
FOCH002GW0714801	5227	VOA	61	187	
		BNA	128,129	212	
		PHC	141,143		
		PEST\PCB	166	221	
FOER002RI0714801	5228	VOA	61	187	
		PHC	141,143		
FOCH002WR0714802	5229	VOA	47,48		
FOCH003GW0714801	5230	VOA	61	187	
		BNA	128,129	212	
		PHC	140,141,143		
		PEST\PCB	166	221	
FOCH003WR0714702	5231	VOA	61	187	
		BNA	128,129	212	
		PHC	140,141,143		
		PEST\PCB	166	221	
FOCH003WR0714803	5232	VOA	61	187	
		BNA	128,129	212	
		PHC	140,141,143		257
		PEST\PCB	166	221	
FOWS001WT0928801	5234	VOA	62,68	187,188	
		BNA	130,131	213	
		PHC	144		
		PEST\PCB	167	222	
FOWS002WT0928801	5235	VOA	62,68	187,188	
		BNA	130,131	213	
		PHC	144		
		PEST\PCB	167,168	222	
FOWS003WT0928801	5236	VOA	68	188	
		BNA	130,131	213	
		PHC	144		
		PEST\PCB	167	222	
FOMW014GW0930801	5237	VOA	68	188	
		PHC	134		
FOSW005GW0930801	5238	VOA	70	188	
		PHC	144,147		
FOER005RI0930801	5239	VOA	69	188	
		PHC	144,147		
FOFB005RI0930801	5240	VOA	69	188	
		PHC	144,147		

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOMW018GW0930801	5241	VOA	69	188	
		PHC	144		
FOMW026GW0930801	5242	VOA	69	188	
		PHC	144		
FOMW010GW0930801	5243	VOA	69	188	
		PHC	144,147		
FOMW023GW0930801	5244	VOA	69	188	233
		PHC	144,147		254
FOTB000RI0923801	5245	VOA	70	188	
FOTB000RI0923802	5246	VOA	70	188	
FOSD013SO1002801	5247	VOA	114	204	
		BNA	130,137	215	
		PHC	160		
		PEST\PCB	171	224	
FOSD014SO1002801	5248	VOA	115	204	
		BNA	136,137	215	
		PHC	160		
		PEST\PCB	171	224	
FOSD015SO1002801	5249	VOA	115	204	
		BNA	136,137	215	
		PHC	160		
		PEST\PCB	171	224	
FOSD016SO1002801	5250	VOA	115	204	248
		BNA	136,137	213	252
		PHC	160		273
		PEST\PCB	171	221	276
		METALS			280,281,282
FOCH003GW1003801	5251	VOA	77	192	
		PHC	144,147		
FOMW024GW1003801	5252	VOA	79	192	
		PHC	144,147		
FOMW027GW1003801	5253	VOA	78	192	
		PHC	144,147		
FOMW005GW1003801	5254	VOA	79	192	
		PHC	144,147		
FOMW012GW1003801	5255	VOA	79	192	
		PHC	144,147		
FOMW013GW1003801	5256	VOA	79	192	
		PHC	144,147		
FOMW014GW1003801	5257	VOA	79	192	
		PHC	144,147		
FOCH001GW1003801	5258	VOA	79	192	
		PHC	144,147		
FOMW001GW1003801	5259	VOA	79	192	
		PHC	144,147		
FOMW025GW1003801	5260	VOA	80	192	
		PHC	144,147		
FOMW023GW1003801	5261	VOA	79	192	234
		PHC	145,147		258
FOMW020GW1004801	5262	VOA	71	189	
		PHC	145,147		

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOMW019GW1004801	5263	VOA	72	189	
		PHC	145,147		
FOMW021GW1004801	5264	VOA	72	189	
		PHC	145,146,147		
FOER021RI1004801	5265	VOA	72	189	
		PHC	145,147		
FOMW018GW1004801	5266	VOA	72	189	235
		PHC	145,147		259
FOMW018WR1004802	5267	VOA	72	189	235
		PHC	145,147		259
FOMW018WR1004803	5268	VOA	72	189	235
		PHC	145,147		259
FOMW006GW1004801	5269	VOA	75	191	
		PHC	145		
FOMW007GW1004801	5270	VOA	73	190	
		PHC	145		
FOMW011GW1004801	5271	VOA	73	190	
		PHC	145		
FOMW017GW1004801	5272	VOA	73	190	
		PHC	145		
FOMW016GW1004801	5273	VOA	75	191	
		PHC	145		
FOER016RI1004801	5274	VOA	75	191	
		PHC	145		
FOMW015GW1004801	5275	VOA	75	191	
		PHC	145		
FOMW002GW1004801	5276	VOA	74	190	236
		PHC	146		260
FOMW002WR1004802	5277	VOA	74	190	236
		PHC	146		260
FOMW002WR1004803	5278	VOA	74	190	236
		PHC	146		260
FOMW003GW1004801	5279	VOA	75	191	
		PHC	145		
FOTB000RI0923804	5280	VOA	75	191	
FOMW026GW1005801	5281	VOA	75	191	
		PHC	146		
FOCH002GW1005801	5282	VOA	75	191	
		PHC	146		
FOSW001GW1005801	5283	VOA	75	191	
		PHC	146		
FOMW010GW1005801	5284	VOA	74	190	237
		PHC	146		261
FOMW010WR1005802	5285	VOA	74	190	237
		PHC	146		261
FOMW010WR1005803	5286	VOA	74	190	237
		PHC	146		261
FOMW009GW1005801	5287	VOA	74	190	
		PHC	146		
FOER009RI1005801	5288	VOA	74	190	
		PHC	146		

TABLE F.11. (continued)

SAMPLE ID #	FIELD #	ANALYTE	METHOD BLANK	SURROGATE	MATRIX SPIKE
FOSW002GW1005801	5289	VOA	76	191	
		PHC	146		
FOSW003GW1005801	5290	VOA	76	191	
		PHC	146		
FOSW004GW1005801	5291	VOA	75	191	
		PHC	146		
FOMW008GW1005801	5292	VOA	76	191	
		PHC	146		
FOSW005GW1005801	5293	VOA	76	191	
		PHC	146		
FOTB000RI0923805	5294	VOA	76	191	
FOMW028SO1101803	5295	VOA	116	205	249
		PHC	161		284
FOMW028SO1101807	5296	VOA	116	205	
		PHC	161		
FOMW028SO1101809	5297	VOA	116	205	
		PHC	161		
FOER028RI1101808	5298	VOA	81	193	
		PHC	148		
FOFB028RI1101801	5299	VOA	81	193	
		PHC	148		
FOTB000RI1101801	5300	VOA	81	193	
FOMW028GW1118801	5301	VOA	82	194	
		PHC	149		
FOER028RI1118801	5302	VOA	82	194	
		PHC	149		
FOFB028RI1118801	5303	VOA	82	194	
		PHC	149		
FOWS001WT1118801	5304	VOA	83	194	
		PHC	149		
FOWS004WT1118801	5305	VOA	83	194	
		PHC	149		
FOWS005WT1118801	5306	VOA	84	194	
		PHC	154		262
FOMW028GW1118802	5307	VOA	84	194	238
		PHC	149		
FOTB000RI1118801	5308	VOA	84	194	
FOER028RI1215801	5309	VOA	84	195	239
		PHC	150		263
FOFB028RI1215801	5310	VOA	86	195	
		PHC	140		
FOMW028GW1215801	5311	VOA	86	195	
		PHC	150		
FOTB000RI1215801	5312	VOA	86	195	
FOTB000RI0923803	5315	VOA	80	192	



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40893
ORDER NUMBER: 118-02242-DL-292
PAGE 18 OF 22

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/liter}$)	<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/liter}$)
chloromethane	10. U	1,2-dichloropropane	5 U
bromomethane	10. U	cis-1,3-dichloropropene	5 U
vinyl chloride	10. U	trichloroethene	5 U
chloroethane	10. U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10. U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10. U
1,2-dichloroethene (total)	5 U	2-hexanone	10. U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10. U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10. U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

B - Analyte was found in the blank as well as the sample.

Date Analyzed: 03/15/88

Dilution Factor: 1

This method blank applies to the following sample: F00W01GW0309-8-02. Field No. 0002

Alyce R. Moore

Approved by

Laboratory Manager

Title



Accredited by the American Association for Laboratory Accreditation in the chemical field. This accreditation is based on the current AALA Survey of Accredited Laboratories.

93-9-45



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ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40893
ORDER NUMBER: 118-02242-DL-292
PAGE 19 OF 22

Sample Description: VBLK1 (Water)

TENTATIVELY IDENTIFIED COMPOUNDS

<u>Tentative Identification (1)</u>	<u>CAS Number</u>	<u>Concentration (2) (ug/liter)</u>
None detected		

Remarks: (1) Identification is based on computer search of N.B.S. Library.
(2) Concentration is based on a response factor of 1.00 relative to the internal standard.

Alyce R. Moore
Approved by Laboratory Manager

Title



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ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40893
ORDER NUMBER: 118-02242-DL-292
PAGE 20 OF 22

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration ($\mu\text{g/liter}$)	Compound	Concentration ($\mu\text{g/liter}$)
chloromethane	10. U	1,2-dichloropropane	5 U
bromomethane	10. U	cis-1,3-dichloropropene	5 U
vinyl chloride	10. U	trichloroethene	5 U
chloroethane	10. U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10. U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10. U
1,2-dichloroethene (total)	5 U	2-hexanone	10. U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10. U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10. U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

B - Analyte was found in the blank as well as the sample.

Date Analyzed: 03/16/88

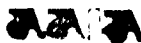
Dilution Factor: 1

This method blank applies to the following samples: FODW01GW0308-8-01, FODW01GW0308-8-01 MS, FODW01GW0308-8-01 MSD, FODW02GW0309-8-01, FODW02GW0309-8-02, FODW04GW0308-8-01, FODW04GW0309-8-02, FODW05GW0309-8-01, FOTB00RI0304-8-01.

Alyce L. Moore
Approved ☒ Laboratory Manager

Title

P-31



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92.4



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ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831


DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40893
ORDER NUMBER: 118-02242-DL-292
PAGE 21 OF 22

Sample Description: VBLK2 (Water)

TENTATIVELY IDENTIFIED COMPOUNDS

<u>Tentative Identification (1)</u>	<u>CAS Number</u>	<u>Concentration (?) (ug/liter)</u>
None detected		

- Remarks: (1) Identification is based on computer search of N.B.S. Library.
- (2) Concentration is based on a response factor of 1.00 relative to the internal standard.


Approved by _____
Laboratory Manager
Title _____



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ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 11B-02242-DL-293
PAGE 32 OF 40

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10. U	1,2-dichloropropane	5 U
bromomethane	10. U	cis-1,3-dichloropropene	5 U
vinyl chloride	10. U	trichloroethene	5 U
chloroethane	10. U	dibromochloromethane	5 U
methylene chloride	3 J	1,1,2-trichloroethane	5 U
acetone	10.	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	4 J
1,2-dichloroethene (total)	5 U	2-hexanone	10. U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10. U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10. U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for sample.

J - Indicates an estimated value less than the detection limit.

B - Analyte was found in the blank as well as the sample.

Date Analyzed: 03/16/88

Dilution Factor: 1

This method blank applies to the following samples: FODW03GW0310-8-01,
FOSW05GW0310-8-01, FOER05RI0310-8-01, FOTB00RI0310-8-02.

Alice L. Moser
Approved by _____
Laboratory Manager

Title _____



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

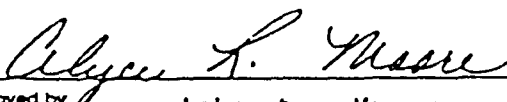
DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-DL-293
PAGE 33 OF 40

Sample Description: VBLK1 (Water)

TENTATIVELY IDENTIFIED COMPOUNDS

<u>Tentative Identification (1)</u>	<u>CAS Number</u>	<u>Concentration (%) (μg/liter)</u>
1-propanol,2,2-dimethyl	75-84-3	6

Remarks: (1) Identification is based on computer search of N.B.S. Library.
(2) Concentration is based on a response factor of 1.00 relative to the internal standard.


Approved by _____
Laboratory Manager

Title

P-34



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P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-DL-293
PAGE 34 OF 40

Sample Description: VBLK1A (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10. U	1,2-dichloropropane	5 U
bromomethane	10. U	cis-1,3-dichloropropene	5 U
vinyl chloride	10. U	trichloroethene	5 U
chloroethane	10. U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10. U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10. U
1,2-dichloroethene (total)	5 U	2-hexanone	10. U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10. U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10. U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

B - Analyte was found in the blank as well as the sample.

Date Analyzed: 03/16/88

Dilution Factor: 1

This method blank applies to the following samples: F0DW06GW0311-8-01, F0DW06GW0311-8-01 MS, F0DW06GW0311-8-01 MSD, F0SW05GW0311-8-02, F0SW05GW0311-8-03, F0DW05GW0311-8-02.


Approved by Laboratory Manager

Title



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ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-OL-293
PAGE 35 OF 40

Sample Description: VBLK1A (Water)

TENTATIVELY IDENTIFIED COMPOUNDS

<u>Tentative Identification (1)</u>	<u>CAS Number</u>	<u>Concentration () (ug/liter)</u>
None detected		

- Remarks: (1) Identification is based on computer search of N.B.S. Library.
- (2) Concentration is based on a response factor of 1.00 relative to the internal standard.

Alyce R. Moore
Approved by Laboratory Manager

Title

EE-36



Accredited by the American Association for Laboratory Accreditation in the chemical
field of testing as listed in the current AALA Directory of Accredited Laboratories


CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-DL-293
PAGE 36 OF 40

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10. U	1,2-dichloropropane	5 U
bromomethane	10. U	cis-1,3-dichloropropene	5 U
vinyl chloride	10. U	trichloroethene	5 U
chloroethane	10. U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10. U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10. U
1,2-dichloroethene (total)	5 U	2-hexanone	10. U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10. U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10. U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

B - Analyte was found in the blank as well as the sample.

Date Analyzed: 03/17/88

Dilution Factor: 1

This method blank applies to the following samples: FOFB05R10311-8-01,
FOTB00R10304-8-03, FODW05GW0311-8-03, FOSW04GW0311-8-01.

Allyce R. Moore
Approved by: Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-DL-293
PAGE 37 OF 40

Sample Description: VBLK2 (Water)

TENTATIVELY IDENTIFIED COMPOUNDS

<u>Tentative Identification (1)</u>	<u>CAS Number</u>	<u>Concentration () (ug/liter)</u>
None detected		

Remarks: (1) Identification is based on computer search of N.B.S. Library.
(2) Concentration is based on a response factor of 1.00 relative to the internal standard.

Alyce L. Moore
Approved by _____
Laboratory Manager

Title

P-33



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-OL-293
PAGE 38 OF 40

Sample Description: VBLKF2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (μg/liter)</u>	<u>Compound</u>	<u>Concentration (μg/liter)</u>
chloromethane	10. U	1,2-dichloropropane	5 U
bromomethane	10. U	cis-1,3-dichloropropene	5 U
vinyl chloride	10. U	trichloroethene	5 U
chloroethane	10. U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	12	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10. U
1,2-dichloroethene (total)	5 U	2-hexanone	10. U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10. U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10. U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

B - Analyte was found in the blank as well as the sample.

Date Analyzed: 03/17/88
Dilution Factor: 1

This method blank applies to the following samples: FOSW01GW0311-8-01,
FOSW02GW0311-8-01, FOSW03GW0311-8-01.

Allyce L. Moore
Approved by _____
Laboratory Manager

Title



ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-DL-293
PAGE 39 OF 40

Sample Description: VBLKF2 (Water)

TENTATIVELY IDENTIFIED COMPOUNDS

<u>Tentative Identification (1)</u>	<u>CAS Number</u>	<u>Concentration (2 (ug/liter)</u>
None detected		

- Remarks: (1) Identification is based on computer search of N.B.S. Library.
(2) Concentration is based on a response factor of 1.00 relative to the internal standard.


Approved by _____
Laboratory Manager

Title _____

P-40



Accredited by the American Association for Laboratory Accreditation in the chemical field of testing utilized in the current AAA Directory of Accredited Laboratories

93 15



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ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 1 OF 61

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	15	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/23/88
Dilution Factor: 1

This method blank applies to the following samples: 5055, 5064, 5103, 5104, 5105.

R. M. Wagner
Operations Manager

Approved by

Title



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11-9-88



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 118-02242-HM519 & HM524
PAGE 1 OF 56

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	2 J	1,1,2-trichloroethane	5 U
acetone	5 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/24/88

Dilution Factor: 1

This method blank applies to the following samples: 5107, 5106, 5085, 5080.

Approved by

Roger M. Wagner
Operations Manager

Title



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41539
ORDER NUMBER: 118-02242-HM530
PAGE 1 OF 21

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

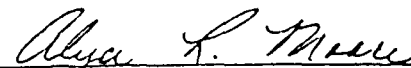
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/30/88

Dilution Factor: 1

This method blank applies to the following samples: 5152, 5110.


Approved By Laboratory Manager

Title



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 118-02242-HM515
PAGE 1 OF 56

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

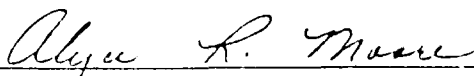
<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/22/88
Dilution Factor: 1

This method blank applies to the following samples: 5018, 5018 MS.


Approved by _____ Laboratory Manager

Title _____



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 4 OF 56

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (<u>ug/liter</u>)	<u>Compound</u>	<u>Concentration</u> (<u>ug/liter</u>)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	7 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

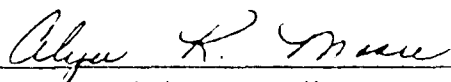
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/23/88

Dilution Factor: 1

This method blank applies to the following samples: 5018 MSD, 5101, 5102.


Approved by Laboratory Manager

1109

E-45



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 1 OF 83

Sample Description: VBLK3 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/liter}$)	<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/liter}$)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/05/88

Dilution Factor: 1

This method blank applies to the following samples: 5111, 5161, 5161 MS, 5161 MSD, 5112, 5158.


Approved by Laboratory Manager

Title

E-46



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011

Oak Ridge Gaseous Diffusion Plant
Analytical Chemistry Department

VGA (TCL) ORGANICS ANALYSIS DATA SHEETS
TENTATIVELY IDENTIFIED COMPOUNDS

AnalIS ID: 880811-044
Laboratory: Organic Mass Spectroscopy Laboratory
Sample Matrix: WATER
Level: (low/med): LOW
Dilution Factor: 1.0
% Moisture: not dec.

Customer Sample ID: VBK 1617
Customer: HERRON
File ID: > 01617
Date Received: 11-AUG-1988
Date Analyzed: 11-AUG-1988

Number TICs found: 2

Concentration Units
(ug/L or ug/Kg): ug/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	PROBABLE HYDROCARBON #1	17.45	8	J
2.	PROBABLE HYDROCARBON #2	20.26	5	J
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				
26.				
27.				
28.				
29.				
30.				

Data Reporting Qualifiers:

- U - Compound was analyzed for but not detected. The number is the attainable detection limit for the sample.
- B - Analyte was found in the reagent blank as well as the sample.
- J - Indicates an estimated value.
- ND - Not detected.
- A - Aldol condensation product.
- D - Secondary dilution.
- E - Exceeds initial calibration range.
- P - Probable Identification.

ANALYSIS DATA REPORT

Page 1 of 1

Analysis ID: 380812-081
 Laboratory: Organic Mass Spectroscopy Laboratory
 File ID: > 01630
 Instrument ID: HP5970-1
 Authorized By: D. C. Canada

Customer Sample ID: VBLK_01630
 Customer: FORBES FIELD
 Sample Matrix: WATER
 Requisition Number:
 Date Sample Received: 12-AUG-1988

VOA - Volatile Organic Compounds (TCL)

Date Extracted/Prepared:
 Preparation Procedure Number: PURGE & TRAP
 Percent Moisture:
 Percent Moisture (decanted):
 Associated Blank: 880812-081

Date Analyzed: 12-AUG-1988
 Analysis Procedure Number: EPA-624
 Dilution Factor: 1.0
 Analyst: GJ PARDUE JR

CAS		ug/L	CAS		ug/L
74-37-3	Chloromethane	10U	79-00-5	1,1,2-Trichloroethane	SU
74-33-9	Bromomethane	10U	71-43-2	Benzene	SU
75-01-4	Vinyl Chloride	10U	10061-02-6	trans-1,3-Dichloropropene	SU
75-00-3	Chloroethane	10U	110-75-3	2-Chloroethylvinyl ether	10U
75-09-2	Methylene Chloride	SU	75-25-2	Bromoform	4 J
67-64-1	Acetone	17	108-10-1	4-Methyl-2-pentanone	4 J
75-15-0	Carbon Disulfide	SU	591-78-6	2-Hexanone	10U
75-35-4	1,1-Dichloroethene	SU	127-18-4	Tetrachloroethene	SU
75-34-3	1,1-Dichloroethane	SU	79-34-5	1,1,2,2-Tetrachloroethane	3
156-60-5	trans-1,2-Dichloroethene	SU	108-98-3	Toluene	SU
67-66-3	Chloroform	SU	108-90-7	Chlorobenzene	SU
107-06-2	1,2-Dichloroethane	SU	100-41-4	Ethyl benzene	SU
78-33-3	2-Butanone	10U	100-42-5	Styrene	SU
71-55-6	1,1,1-Trichloroethane	SU	1330-20-7	Xylene (total)	SU
56-23-5	Carbon Tetrachloride	SU			
108-05-4	Vinyl Acetate	10U			
75-27-4	Bromodichloromethane	SU			
78-37-5	1,2-Dichloropropane	SU			
10061-01-5	cis-1,3-Dichloropropene	SU			
79-01-6	Trichloroethene	SU			
124-48-1	Dibromochloromethane	SU			

Data Reporting Qualifiers:

- U - Compound was analyzed for but not detected. The number is the attainable detection limit for the sample.
- B - Analyte was found in the reagent blank as well as the sample.
- J - Indicates an estimated value.
- ND - Not detected.
- A - Aldol condensation product.
- D - Secondary dilution.
- E - Exceeds initial calibration range.

Surrogate Compound	Amount Spiked	Amount Recovered	Percent Recovered
TOLUENE-08	50	51.0	102.0
BROMOFLUOROBENZENE	50	52.0	104.0
1,2-DICHLOROETHANE-04	50	48.0	96.0

Oak Ridge Gaseous Diffusion Plant
Analytical Chemistry Department

VGA (TCL) ORGANICS ANALYSIS DATA SHEETS
TENTATIVELY IDENTIFIED COMPOUNDS

Analysis ID: 980812-081
Laboratory: Organic Mass Spectroscopy Laboratory
Sample Matrix: WATER
Level: (low/med): LOW
Dilution Factor: 1.0
% Moisture: not dec.

Customer Sample ID: VBK 01630
Customer: FORBES FIELD
File ID: > 01630
Date Received: 12-AUG-1988
Date Analyzed: 12-AUG-1988

Number TICs found: 2

Concentration Units
(ug/L or ug/Kg): ug/L

CAS NUMBER	COMPOUND NAME	RT	EST. CONC.	Q
1.	hydrocarbon #1	17.34	5	JP
2.	hydrocarbon #2	20.13	5	JP
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
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25.				
26.				
27.				
28.				
29.				
30.				

Data Reporting Qualifiers:

- U - Compound was analyzed for but not detected. The number is the attainable detection limit for the sample.
- B - Analyte was found in the reagent blank as well as the sample.
- J - Indicates an estimated value.
- ND - Not detected.
- A - Aldol condensation product.
- D - Secondary dilution.
- E - Exceeds initial calibration range.
- P - Probable identification.



INTERNATIONAL
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ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 11B-02242-HM537
PAGE 1 OF 38

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	2 J
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/11/88

Dilution Factor: 1

This method blank applies to the following samples: 5115, 5113, 5165.

Alfred L. Moore
Approved by: _____
Laboratory Manager

Title



Accredited by the American Association of Environmental Chemists and Technicians (AAECT) for the analysis of volatile organic compounds in water.

11-1-88



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 118-02242-HM537
PAGE 5 OF 38

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST


<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/12/88
Dilution Factor: 1

This method blank applies to the following samples: 5167, 5168, 5169, 5170, 5171.


Approved by _____
Laboratory Manager

Title _____



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 11B-02242-HM537
PAGE 11 OF 38

Sample Description: VBLK3 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (ug/liter)	<u>Compound</u>	<u>Concentration</u> (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

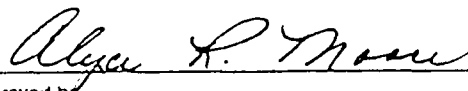
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/12/88

Dilution Factor: 1

This method blank applies to the following samples: 5172, 5173, 5175, 5176.


Approved by _____
Laboratory Manager
Title _____

F-52



Accredited by the American Association for Laboratory Accreditation in the chemical field. It means you are in the current AALAC Directory of Accredited Laboratories.

33-1



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41616
ORDER NUMBER: 11B-02242-HM538
PAGE 1 OF 24

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

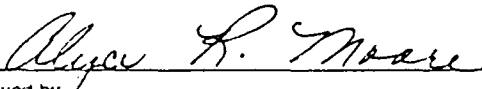
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/13/88

Dilution Factor: 1

This method blank applies to the following samples: 5117, 5118, 5174, 5177, 5179, 5180 MS, 5181 MSD, 5182.


Approved by _____
Laboratory Manager

Title _____

P-53



Accredited by the American Association of Laboratory Accreditation, a non-profit organization, to perform the following tests: Volatile Organic Compounds (VOCs) in water.

11-1-88



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CERTIFICATE OF ANALYSIS

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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41616
ORDER NUMBER: 11B-02242-HM538
PAGE 9 OF 24

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	3 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U


U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/13/88

Dilution Factor: 1

This method blank applies to the following samples: 5183, 5184, 5185, 5186.


Approved by _____
Laboratory Manager

Title

P-54



Accredited by the American Association for Laboratory Accreditation in the chemical and physical testing listed in the current AALA Directory of Accredited Laboratories

93-9-1



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 11B-02242-HM540
PAGE 1 OF 28

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST


Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/13/88
Dilution Factor: 1

This method blank applies to the following samples: 5119, 5120, 5187.


Approved by _____
Laboratory Manager

Tab

Page 1





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CERTIFICATE OF ANALYSIS

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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 118-02242-HM540
PAGE 5 OF 28

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

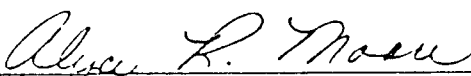
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/14/88

Dilution Factor: 1

This method blank applies to the following samples: 5188, 5190, 5191, 5192, 5193, 5194.


Approved by: _____
Laboratory Manager

Title





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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 19, 1988
PROJECT CODE: MMOK 41637
ORDER NUMBER: 11B-02242-HM541
PAGE 1 OF 12

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	3 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/14/88
Dilution Factor: 1

This method blank applies to the following samples: 5195, 5198, 5198 MS.

Allyce R. Moore
Approved by _____
Laboratory Manager

Tip



CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 19, 1988
PROJECT CODE: MMOK 41637
ORDER NUMBER: 11B-02242-HM541
PAGE 5 OF 12

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	2 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/15/88

Dilution Factor: 1

This method blank applies to the following samples: 5198 MSD, 5199.

Alfred R. Moore

Approved by Laboratory Manager

Date



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 11B-02242-HM544
PAGE 1 OF 41

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

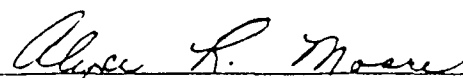
<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/15/88
Dilution Factor: 1

This method blank applies to the following samples: 5214, 5215.


Approved by _____
Laboratory Manager

Date



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 118-02242-HM544
PAGE 4 OF 41

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

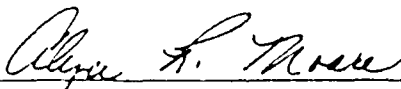
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/16/88

Dilution Factor: 1

This method blank applies to the following samples: 5216, 5217, 5218, 5219, 5220, 5221.


Approved by _____
Laboratory Manager

TSB



Accredited by the American Association of Environmental Engineers and Technicians, Inc. (AAEET) for the purpose of environmental testing and analysis.

11-11



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 11B-02242-HM544
PAGE 11 OF 41

Sample Description: VBLK3 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/liter}$)	<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/liter}$)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/17/88
Dilution Factor: 1

This method blank applies to the following samples: 5222, 5225, 5226.

Alger L. Moore
Approved by: Laboratory Manager

Title





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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 11B-02242-HM545
PAGE 1 OF 33

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U


U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/18/88

Dilution Factor: 1

This method blank applies to the following samples: 5227, 5228, 5230, 5231, 5232.


Approved by _____
Laboratory Manager
Title _____

E-62



Accredited by the American Association of Laboratory Accreditation in the Chemical
Field. This accreditation is shown in the current data. The laboratory is accredited to the following

11-1-88



CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 118-02242-HM545
PAGE 7 OF 33

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

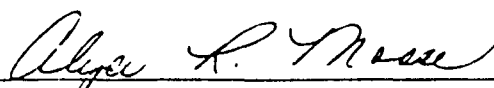
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/19/88

Dilution Factor: 1

This method blank applies to the following samples: 5234, 5235.


Approved by _____
Laboratory Manager
Title _____



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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 1 OF 62

Sample Description: VBLK3 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U


U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/02/88

Dilution Factor: 1

This method blank applies to the following samples: 5108, 5109, 5124, 5133.


Approved by Laboratory Manager





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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 6 OF 62

Sample Description: VBLK4 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

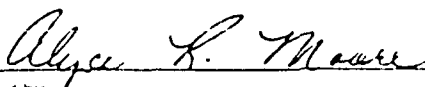
<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	2 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/02/88
Dilution Factor: 1

This method blank applies to the following sample: 5134.


Approved by Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 8 OF 62

Sample Description: VBLK5 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/03/88

Dilution Factor: 1

This method blank applies to the following sample: 5134.

Alice R. Moore
Approved by _____
Laboratory Manager

Title



Accredited by the American Association of Laboratory Accredited (AALA) for the detection of the chemical and physical properties of the sample. AALA is a non-profit organization that provides a standard for the detection of the chemical and physical properties of the sample.

ANALYSIS DATA REPORT

Page 1 of 1

Analysis ID: 880811-044
 Laboratory: Organic Mass Spectroscopy Laboratory
 File ID: > 01617
 Instrument ID: HP59708
 Authorized By: D. C. Canada

Customer Sample ID: VBLK_1617
 Customer: HERRON
 Sample Matrix: WATER
 Requisition Number:
 Date Sample Received: 11-AUG-1988

VOA - Volatile Organic Compounds (TCL)

Date Extracted/Prepared: 11-AUG-1988
 Preparation Procedure Number: PURGE & TRAP
 Percent Moisture:
 Percent Moisture (decanted):
 Associated Blank: BLANK

Date Analyzed: 11-AUG-1988
 Analysis Procedure Number: EPA-624
 Dilution Factor: 1.0
 Analyst: GJ PARDUE JR

CAS		ug/L	CAS		ug/L
74-87-3	Chloromethane	10U	79-00-5	1,1,2-Trichloroethane	5U
74-33-9	Bromomethane	10U	71-43-2	Benzene	5U
75-01-4	Vinyl Chloride	10U	10061-02-6	trans-1,3-Dichloropropene	5U
75-00-3	Chloroethane	10U	110-75-8	2-Chloroethylvinyl ether	10U
75-09-2	Methylene Chloride	5U	75-25-2	Bromoform	3 J
67-64-1	Acetone	10U	108-10-1	4-Methyl-2-pentanone	10U
75-15-0	Carbon Disulfide	5U	591-78-6	2-Hexanone	10U
75-35-4	1,1-Dichloroethene	5U	127-18-4	Tetrachloroethene	5U
75-34-3	1,1-Dichloroethane	5U	79-34-5	1,1,2,2-Tetrachloroethane	7
156-60-5	trans-1,2-Dichloroethene	5U	108-88-3	Toluene	5U
67-66-3	Chloroform	5U	108-90-7	Chlorobenzene	5U
107-06-2	1,2-Dichloroethane	5U	100-41-4	Ethyl benzene	1 J
78-93-3	2-Butanone	10U	100-42-5	Styrene	5U
71-55-6	1,1,1-Trichloroethane	5U	1330-20-7	Xylene (total)	5U
56-23-5	Carbon Tetrachloride	5U			
108-95-4	Vinyl Acetate	10U			
75-27-4	Bromodichloromethane	5U			
78-87-5	1,2-Dichloropropane	5U			
10061-01-5	cis-1,3-Dichloropropene	5U			
79-01-6	Trichloroethene	5U			
124-48-1	Dibromochloromethane	5U			

Data Reporting Qualifiers:

- U - Compound was analyzed for but not detected. The number is the attainable detection limit for the sample.
- B - Analyte was found in the reagent blank as well as the sample.
- J - Indicates an estimated value.
- ND - Not detected.
- A - Aldol condensation product.
- D - Secondary dilution.
- E - Exceeds initial calibration range.

Surrogate Compound	Amount Spiked	Amount Recovered	Percent Recovered
TOLUENE-08	50	51	102.0
BROMOFLUOROBENZENE	50	49	98.0
1,2-DICHLOROETHANE-04	50	48	96.0



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 1 OF 39

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

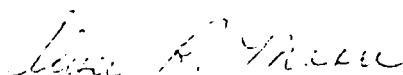
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/10/88

Dilution Factor: 1

This method blank applies to the following samples: 5234, 5235, 5236, 5237.



APPROVED BY Laboratory Manager



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 5 OF 39

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (ug/liter)	<u>Compound</u>	<u>Concentration</u> (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethen	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

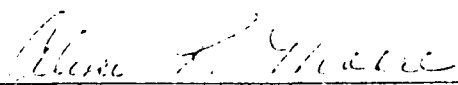
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/11/88

Dilution Factor: 1

This method blank applies to the following samples: 5244, 5244 MS, 5244 MSD, 5239, 5240, 5241, 5242, 5243.

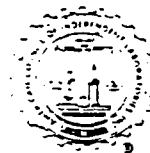

Approved by _____
Laboratory Manager



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 14 OF 39

Sample Description: VBLK3 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

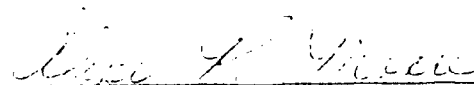
Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/12/88
Dilution Factor: 1

This method blank applies to the following samples: 5245, 5246, 5238.


Approved by: Laboratory Manager





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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 1 OF 51

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	9 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	2 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

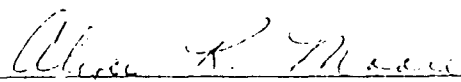
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/13/88

Dilution Factor: 1

This method blank applies to the following sample: 5262.


Approved by Laboratory Manager

**CERTIFICATE OF ANALYSIS**

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 3 OF 51

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	2 J	1,1,2-trichloroethane	5 U
acetone	4 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/13/88

Dilution Factor: 1

This method blank applies to the following samples: 5263, 5264, 5265, 5266-68, 5266-68 MS, 5266-68 MSD.


Approved by _____ Laboratory Manager

File



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 9 OF 51

Sample Description: VBLK2A (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

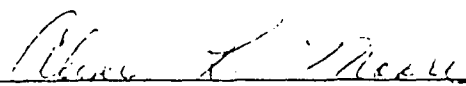
Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/13/88
Dilution Factor: 1

This method blank applies to the following samples: 5270, 5271, 5272.


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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 13 OF 51

Sample Description: VBLK3 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/14/88

Dilution Factor: 1

This method blank applies to the following samples: 5276, 5276-78 MS, 5276-78 MSD, 5284, 5284-86 MS, 5284-86 MSD, 5287, 5288.

James H. Miller

Approved by Laboratory Manager

Title





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Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 20 OF 51

Sample Description: VBLK4 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/14/88
Dilution Factor: 1

This method blank applies to the following samples: 5269, 5273, 5274, 5275, 5279, 5280, 5281, 5282, 5283.

Approved by Laboratory Manager

Title



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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 118-02242-HM647
PAGE 30 OF 51

Sample Description: VBLK5 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (μg/liter)</u>	<u>Compound</u>	<u>Concentration (μg/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	7 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	1 J	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/14/88

Dilution Factor: 1

This method blank applies to the following samples: 5294, 5293, 5292, 5291, 5290, 5289.

[Signature]
Approved by Laboratory Manager

**CERTIFICATE OF ANALYSIS**

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 1 OF 57

Sample Description: VBLK1A (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/11/88

Dilution Factor: 1

This method blank applies to the following sample: 5251.

Alyce K. Moore
Approved by Laboratory Manager

Title



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 3 OF 57

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST


<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	4 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/12/88
Dilution Factor: 1

This method blank applies to the following sample: 5253.


Approved by Laboratory Manager

Title



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P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 5 OF 57

Sample Description: VBLK2A (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

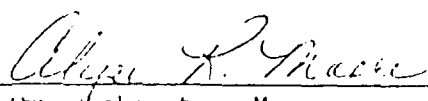
U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/13/88

Dilution Factor: 1

This method blank applies to the following samples: 5261, 5261 MS, 5261 MSD, 5252, 5254, 5255, 5256, 5257, 5258, 5259.


Approved by Laboratory Manager



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 15 OF 57

Sample Description: VBLK4 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/13/88
Dilution Factor: 1

This method blank applies to the following samples: 5260, 5315.

Elmer L. Moore
Approved by: Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED November 18, 1988
PROJECT CODE: MMOK 42231
ORDER NUMBER: 11B-02242-HM682
PAGE 1 OF 16

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 11/04/88
Dilution Factor: 1

This method blank applies to the following samples: 5298, 5299, 5300.

Alvin L. Moore
Approved by Laboratory Manager





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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED December 6, 1988
PROJECT CODE MMOK 42335
ORDER NUMBER 11B-02242-HM680
PAGE 1 OF 17

Sample Description: VBLK3 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 11/28/88

Dilution Factor: 1

This method blank applies to the following samples: 5301, 5302, 5303.

Alyce R. Moore
Approved by Laboratory Manager

Title

F-82



Approved by the American Association of Environmental Chemists in the chemical
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93-3-85

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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED December 6, 1988
PROJECT CODE: MMOK 42335
ORDER NUMBER: 118-02242-HM680
PAGE 5 OF 17

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (ug/liter)	<u>Compound</u>	<u>Concentration</u> (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	5 J
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 11/23/88

Dilution Factor: 1

This method blank applies to the following samples: 5304, 5305.

Alger S. Moore
Approved by Laboratory Manager



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED December 6, 1988
PROJECT CODE MMOK 42335
ORDER NUMBER 11B-02242-HM680
PAGE 8 OF 17

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 11/22/88
Dilution Factor: 1

This method blank applies to the following samples: 5308, 5307, 5307 MS, 5306, 5307 MSD.


Approved by Laboratory Manager



**CERTIFICATE OF ANALYSIS**

TO Martin Marietta Energy Systems, Inc.
ATTN: S. R. Rizk, K-25
P. O. Box 2003
Oak Ridge, TN 37831-7440

DATE REPORTED January 9, 1989
PROJECT CODE MMOK 42490
ORDER NUMBER 11B-02242-TU880
PAGE 1 OF 11

Sample Description: VBLK1 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 12/20/88
Dilution Factor: 1

This method blank applies to the following samples: 5309, 5309 MS, 5309 MSD.

Alvin L. Moore

Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: S. R. Rizk, K-25
P. O. Box 2003
Oak Ridge, TN 37831-7440

DATE REPORTED January 9, 1989
PROJECT CODE MMOK 42490
ORDER NUMBER 11B-02242-TU880
PAGE 4 OF 11

Sample Description: VBLK2 (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 12/21/88

Dilution Factor: 1

This method blank applies to the following samples: 5312, 5310, 5311.

Alma K. Moore

APPROVED BY

Laboratory Manager





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 8 OF 61

Sample Description: VBLK1 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	15	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/23/88
Dilution Factor: 1

This method blank applies to the following sample: 5033.

Approved by

Operations Manager

Title





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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 11B-02242-HM-514 & 518
PAGE 10 OF 61

Sample Description: VBLK2 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	2 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/24/88
Dilution Factor: 1

This method blank applies to the following samples: 5034, 5035, 5036, 5036 MS, 5036 MSD, 5037.

Approved by RL M. Wagner
Title Operations Manager



Accredited by the American Association for Laboratory Accreditation in the chemical field as being listed in the current AALA Directory of Accredited Laboratories

93-4-4



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 16 OF 61

Sample Description: VBLK3 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	2 J

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/24/88

Dilution Factor: 1

This method blank applies to the following samples: 5038, 5039, 5041.

Approved by

Ralph M. Wagner
Operations Manager

Title



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11-1-88



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 20 OF 61

Sample Description: VBLK4 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethene	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/27/88
Dilution Factor: 1

This method blank applies to the following samples: 5040, 5042, 5043, 5044, 5046, 5047, 5045, 5048.

Approved by

Robert M. Wagner
Operations Manager

Date

E-90



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11-1



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Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 29 OF 61

Sample Description: VBLK5 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

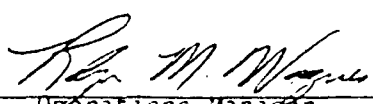
Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	8	1,1,2-trichloroethane	5 U
acetone	3 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/27/88
Dilution Factor: 1

This method blank applies to the following samples: 5049, 5050, 5051.


Approved by: Operations Manager





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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 33 OF 61

Sample Description: VBLK6 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	3 J	1,1,2-trichloroethane	5 U
acetone	4 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	1 J	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	1 J
bromodichloromethane	5 U	total xylenes	1 J

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/29/88

Dilution Factor: 1

This method blank applies to the following samples: 5052, 5053.


Approved by Operations Manager

Title



Accredited by the American Association for Laboratory Accreditation in the chemical



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 36 OF 61

Sample Description: VBLK7 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	2 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/30/88
Dilution Factor: 1

This method blank applies to the following samples: 5053 DL, 5056, 5058, 5059, 5060, 5061, 5062, 5063, 5063 MS, 5063 MSD, 5057.

DL = Dilution

Approved by

R. M. May Jr.
Operations Manager





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE 7 OF 56

Sample Description: VBLK1 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration ($\mu\text{g/kg}$ dry weight)	Compound	Concentration ($\mu\text{g/kg}$ dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	2 J	1,1,2-trichloroethane	5 U
acetone	5 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/24/88

Dilution Factor: 1

This method blank applies to the following samples: 5065, 5066, 5067.

Approved by

Robert M. Wagner
Operations Manager

Title





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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE 11 OF 56

Sample Description: VBLK2 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	4 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/25/88
Dilution Factor: 1

This method blank applies to the following samples: 5068, 5069, 5070, 5071, 5072, 5073.

Approved by

Operations Manager

File



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 116-02242-HM519 & HM524
PAGE 18 OF 56

Sample Description: VBLK3A (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/kg}$ dry weight)	<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/kg}$ dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/28/88
Dilution Factor: 1

This method blank applies to the following samples: 5074, 5075, 5076.

Approved by

Operations Manager

Title



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 118-02242-HM519 & HM524
PAGE 29 OF 56

Sample Description: VBLK5 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (<u>ug/kg dry weight</u>)	<u>Compound</u>	<u>Concentration</u> (<u>ug/kg dry weight</u>)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/29/88
Dilution Factor: 1

This method blank applies to the following samples: 5082, 5083, 5084, 5086, 5087, 5088.

Approved by

Operations Manager

Title





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 118-02242-HM519 & HM524
PAGE 35 OF 56

Sample Description: VBLK6 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	5 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	1 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/30/88
Dilution Factor: 1

This method blank applies to the following samples: 5089, 5090, 5091, 5092.

Approved by

R. M. Wagner
Operations Manager

Title



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11-1-88



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41539
ORDER NUMBER: 11B-02242-HM530
PAGE 5 OF 21

Sample Description: VBLK2 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/01/88
Dilution Factor: 1

This method blank applies to the following samples: 5135, 5136, 5140, 5145, 5151, 5148.


Approved by: _____
Laboratory Manager





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Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 8 OF 56

Sample Description: VBLK3 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration ($\mu\text{g/kg}$ dry weight)	Compound	Concentration ($\mu\text{g/kg}$ dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	2 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/23/88

Dilution Factor: 1

This method blank applies to the following samples: 5000 (1:5), 5013, 5014, 5000 MS (1:125), 5000 MSD (1:125).

Alger R. Mason
Approved by Laboratory Manager

Title

P-100



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93-9-85



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DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 13 OF 56

Sample Description: VBLK4 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/24/88
Dilution Factor: 1

This method blank applies to the following samples: 5015, 5016, 5019, 5000 (1:125) RE.

Approved by Laboratory Manager

Title



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DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 17 OF 56

Sample Description: VBLK5 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	7 J	benzene	5 U
carbon disulfide	1 J	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	2 J	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/24/88
Dilution Factor: 1

This method blank applies to the following samples: 5020, 5021, 5023, 5024, 5025.

Alger R. Mann
Approved by _____
Laboratory Manager
Title _____

F-102



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11-2-85



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DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-C2242-HM515
PAGE 23 OF 56

Sample Description: VBLK6 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	1 J	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/01/88

Dilution Factor: 1

This method blank applies to the following samples: 5027, 5028, 5029, 5030, 5031, 5032, 5022 (1:5), 5032 MS, 5032 MSD.

Alyce R. Mason
Approved by Laboratory Manager

Title

10-100





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Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 32 OF 56

Sample Description: VBLK7 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	4 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/02/88
Dilution Factor: 1

This method blank applies to the following sample: 5022 (Rerun).

Alfred L. Mason
Approved by: Laboratory Manager

Title

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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 11B-02242-HM525
PAGE 8 OF 83

Sample Description: VBLK1 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST


<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/01/88
Dilution Factor: 1

This method blank applies to the following samples: 5001, 5002.


Approved by Alyce R. Mason
Laboratory Manager
Title _____



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DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 11B-02242-HM525
PAGE 11 OF 83

Sample Description: VBLK2 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

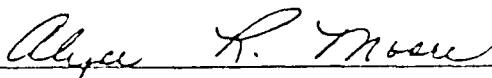
<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	2 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/04/88
Dilution Factor: 1

This method blank applies to the following samples: 5003, 5004, 5005, 5006, 5007, 5008.


Approved by _____
Laboratory Manager
Title _____



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DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 18 OF 83

Sample Description: VBLK4 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST


Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/05/88
Dilution Factor: 1

This method blank applies to the following samples: 5009, 5010, 5012, 5153, 5154, 5155.


Approved by Laboratory Manager



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DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 25 OF 83

Sample Description: VBLK5 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	2 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/05/88
Dilution Factor: 1

This method blank applies to the following samples: 5163, 5163 MS, 5163 MSD, 5162, 5160, 5159, 5157, 5156.

Alger L. Moore

Approved by Laboratory Manager

Title

0-108



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P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 11 OF 62

Sample Description: VBLK1C (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5	1,1,2-trichloroethane	5 U
acetone	6 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	4 J
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	1 J

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/01/88
Dilution Factor: 1

This method blank applies to the following samples: 5095, 5097, 5097 MS, 5097 MSD, 5121.

Alger S. Moore
Approved by Laboratory Manager



ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-568-6401



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 15 OF 62

Sample Description: VBLK1D (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST


Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	3 J	1,1,2-trichloroethane	5 U
acetone	4 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	3 J
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/02/88
Dilution Factor: 1

This method blank applies to the following samples: 5093, 5094, 5096, 5098, 5100.


Approved by: Laboratory Manager



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 113-02242-HM520
PAGE 22 OF 62

Sample Description: VBLK1B (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	6 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/01/88
Dilution Factor: 1

This method blank applies to the following samples: 5125, 5125 MS, 5125 MSD, 5122, 5127, 5129, 5126, 5128.

Alice R. Moore
Approved by _____
Laboratory Manager



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 30 OF 62

Sample Description: VBLK2 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST


Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	4 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/02/88
Dilution Factor: 1

This method blank applies to the following samples: 5123, 5131.


Approved by Laboratory Manager

Title





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Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 115-02242-HM520
PAGE 33 OF 62

Sample Description: VBLK6 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/04/88
Dilution Factor: 1

This method blank applies to the following sample: 5130.

Alyce L. Moore
Approved by Laboratory Manager

Title



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 118-02242-HM644
PAGE 19 OF 57

Sample Description: VBLK1 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	3 J	1,1,2-trichloroethane	5 U
acetone	10	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	1 J	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/06/88

Dilution Factor: 1

This method blank applies to the following sample: 5247.

Alice S. Moore
Approved by Laboratory Manager

Title



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 118-02242-HM644
PAGE 21 OF 57

Sample Description: VBLK3 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	9 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	2 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 10/13/88

Dilution Factor: 1

This method blank applies to the following samples: 5250, 5250 MS, 5250 MSD, 5248, 5249.

Alvin K. Moore

Approved by Laboratory Manager

Title


CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED November 18, 1988
PROJECT CODE: MMOK 42231
ORDER NUMBER: 11B-02242-HM682
PAGE 6 OF 16

Sample Description: VBLK2 (Soil)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	1 J	1,1,2-trichloroethane	5 U
acetone	7 J	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	1 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U


U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 11/04/88

Dilution Factor: 1

This method blank applies to the following samples: 5295 3', 5295 3' MS, 5295 3' MSD, 5296 6', 5297 9'.


Approved by Laboratory Manager


CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE 42 OF 56

Sample Description: TCLP Blank Extraction (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	11	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	1 J
1,2-dichloroethene (total)	5 U	2-hexanone	2 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	4 J	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/28/88

Dilution Factor: 1

This method blank applies to the following samples: 5054, 5054 MS, 5054 MSD.

Approved by

Robert M. Wagner
Operations Manager

Title



**CERTIFICATE OF ANALYSIS**

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41539
ORDER NUMBER: 118-02242-HM530
PAGE 13 OF 21

Sample Description: TCLP Extraction Blank (Water)

VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5 U	1,1,2-trichloroethane	5 U
acetone	10 U	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	10 U
1,2-dichloroethene (total)	5 U	2-hexanone	2 J
chloroform	5 U	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U


U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 07/28/88

Dilution Factor: 1

This method blank applies to the following sample: 5141.


Approved by _____
Laboratory Manager

Title _____

F-118



Accredited by the American Association for Laboratory Accreditation in the chemical field of testing as listed in the current AALA Directory of Accredited Laboratories

93-2



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 16, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 59 OF 62

Sample Description: TCLP Extraction Blank


VOLATILE ORGANIC TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>
chloromethane	10 U	1,2-dichloropropane	5 U
bromomethane	10 U	cis-1,3-dichloropropene	5 U
vinyl chloride	10 U	trichloroethene	5 U
chloroethane	10 U	dibromochloromethane	5 U
methylene chloride	5	1,1,2-trichloroethane	5 U
acetone	22	benzene	5 U
carbon disulfide	5 U	trans-1,3-dichloropropene	5 U
1,1-dichloroethene	5 U	bromoform	5 U
1,1-dichloroethane	5 U	4-methyl-2-pentanone	24
1,2-dichloroethene (total)	5 U	2-hexanone	10 U
chloroform	1 J	tetrachloroethene	5 U
1,2-dichloroethane	5 U	1,1,2,2-tetrachloroethane	5 U
2-butanone	10 U	toluene	5 U
1,1,1-trichloroethane	5 U	chlorobenzene	5 U
carbon tetrachloride	5 U	ethylbenzene	5 U
vinyl acetate	10 U	styrene	5 U
bromodichloromethane	5 U	total xylenes	5 U

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Date Analyzed: 06/27/88
Dilution Factor: 1


Approved by: Alexander S. Moore
Laboratory Manager

7-10



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 118-02242-HM537
PAGE 17 OF 38

Sample Description: S8LK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
phenol	10 U	bis(2-chloroethoxy)methane	10 U
bis(2-chloroethyl)ether	10 U	2,4-dichlorophenol	10 U
2-chlorophenol	10 U	1,2,4-trichlorobenzene	10 U
1,3-dichlorobenzene	10 U	naphthalene	10 U
1,4-dichlorobenzene	10 U	4-chloroaniline	10 U
benzyl alcohol	10 U	hexachlorobutadiene	10 U
1,2-dichlorobenzene	10 U	4-chloro-3-methylphenol	10 U
2-methylphenol	10 U	2-methylnaphthalene	10 U
bis(2-chloroisopropyl)ether	10 U	hexachlorocyclopentadiene	10 U
4-methylphenol	10 U	2,4,6-trichlorophenol	10 U
n-nitroso-di-n-propylamine	10 U	2,4,5-trichlorophenol	50 U
hexachloroethane	10 U	2-chloronaphthalene	10 U
nitrobenzene	10 U	2-nitroaniline	50 U
isophorone	10 U	dimethyl phthalate	10 U
2-nitrophenol	10 U	acenaphthylene	10 U
2,4-dimethylphenol	10 U	2,6-dinitrotoluene	10 U
benzoic acid	50 U		

Date Extracted: 07/12/88

Date Analyzed: 07/21/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following samples: 5168, 5170.

Allyce R. Moore

Approved by

Laboratory Manager

Title

E-120



Approved by the American Association for Laboratory Accreditation in the Chemical and Environmental fields in the current AALAC cycle for Accredited Laboratories

11-1



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CERTIFICATE OF ANALYSIS

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ATTN: Mr. Stuart Goza
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Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 11B-02242-HM537
PAGE 18 OF 38

Sample Description: SBLK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST (continued)

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
3-nitroaniline	50 U	anthracene	10 U
acenaphthene	10 U	di-n-butylphthalate	10 U
2,4-dinitrophenol	50 U	fluoranthene	10 U
4-nitrophenol	50 U	pyrene	10 U
dibenzofuran	10 U	butylbenzylphthalate	10 U
2,4-dinitrotoluene	10 U	3,3'-dichlorobenzidine	20 U
diethylphthalate	10 U	benzo(a)anthracene	10 U
4-chlorophenyl-phenylether	10 U	chrysene	10 U
fluorene	10 U	bis(2-ethylhexyl)phthalate	25
4-nitroaniline	50 U	di-n-octylphthalate	10 U
4,6-dinitro-2-methylphenol	50 U	benzo(b)fluoranthene	10 U
n-nitrosodiphenylamine ¹	10 U	benzo(k)fluoranthene	10 U
4-bromophenyl-phenylether	10 U	benzo(a)pyrene	10 U
hexachlorobenzene	10 U	indeno(1,2,3-cd)pyrene	10 U
pentachlorophenol	50 U	dibenzo(a,h)anthracene	10 U
phenanthrene	10 U	benzo(g,h,i)perylene	10 U

Date Extracted: 07/12/88
Date Analyzed: 07/21/88
Dilution Factor: 1

- U - Compound was analyzed for but not detected. The number is the detection limit for the sample.
J - Indicates an estimated value less than the detection limit.
1 - Detected as diphenylamine.

Alma L. Moore
Approved by Laboratory Manager

**CERTIFICATE OF ANALYSIS**

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 118-02242-HM540
PAGE 13 OF 29

Sample Description: S8LK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
phenol	10 U	bis(2-chloroethoxy)methane	10 U
bis(2-chloroethyl)ether	10 U	2,4-dichlorophenol	10 U
2-chlorophenol	10 U	1,2,4-trichlorobenzene	10 U
1,3-dichlorobenzene	10 U	naphthalene	10 U
1,4-dichlorobenzene	10 U	4-chloroaniline	10 U
benzyl alcohol	10 U	hexachlorobutadiene	10 U
1,2-dichlorobenzene	10 U	4-chloro-3-methylphenol	10 U
2-methylphenol	10 U	2-methylnaphthalene	10 U
bis(2-chloroisopropyl)ether	10 U	hexachlorocyclopentadiene	10 U
4-methylphenol	10 U	2,4,6-trichlorophenol	10 U
n-nitroso-di-n-propylamine	10 U	2,4,5-trichlorophenol	50 U
hexachloroethane	10 U	2-chloronaphthalene	10 U
nitrobenzene	10 U	2-nitroaniline	50 U
isophorone	10 U	dimethyl phthalate	10 U
2-nitrophenol	10 U	acenaphthylene	10 U
2,4-dimethylphenol	10 U	2,6-dinitrotoluene	10 U
benzoic acid	50 U		

Date Extracted: 07/13/88

Date Analyzed: 07/21/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following sample: 5189.


Approved by _____
Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 118-02242-HM540
PAGE 14 OF 28


Sample Description: SBLK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST (continued)

<u>Compound</u>	<u>Concentration</u> (ug/liter)	<u>Compound</u>	<u>Concentration</u> (ug/liter)
3-nitroaniline	50 U	anthracene	10 U
acenaphthene	10 U	di-n-butylphthalate	10 U
2,4-dinitrophenol	50 U	fluoranthene	10 U
4-nitrophenol	50 U	pyrene	10 U
dibenzofuran	10 U	butylbenzylphthalate	10 U
2,4-dinitrotoluene	10 U	3,3'-dichlorobenzidine	20 U
diethylphthalate	10 U	benzo(a)anthracene	10 U
4-chlorophenyl-phenylether	10 U	chrysene	10 U
fluorene	10 U	bis(2-ethylhexyl)phthalate	10 U
4-nitroaniline	50 U	di-n-octylphthalate	10 U
4,6-dinitro-2-methylphenol	50 U	benzo(b)fluoranthene	10 U
n-nitrosodiphenylamine ¹	10 U	benzo(k)fluoranthene	10 U
4-bromophenyl-phenylether	10 U	benzo(a)pyrene	10 U
hexachlorobenzene	10 U	indeno(1,2,3-cd)pyrene	10 U
pentachlorophenol	50 U	dibenzo(a,h)anthracene	10 U
phenanthrene	10 U	benzo(g,h,i)perylene	10 U

Date Extracted: 07/13/88
Date Analyzed: 07/21/88
Dilution Factor: 1

- U - Compound was analyzed for but not detected. The number is the detection limit for the sample.
J - Indicates an estimated value less than the detection limit.
1 - Detected as diphenylamine.


Approved by _____
Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 118-02242-HM544
PAGE 16 OF 41

Sample Description: S8LK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (<u>ug/liter</u>)	<u>Compound</u>	<u>Concentration</u> (<u>ug/liter</u>)
phenol	10 U	bis(2-chloroethoxy)methane	10 U
bis(2-chloroethyl)ether	10 U	2,4-dichlorophenol	10 U
2-chlorophenol	10 U	1,2,4-trichlorobenzene	10 U
1,3-dichlorobenzene	10 U	naphthalene	10 U
1,4-dichlorobenzene	10 U	4-chloroaniline	10 U
benzyl alcohol	10 U	hexachlorobutadiene	10 U
1,2-dichlorobenzene	10 U	4-chloro-3-methylphenol	10 U
2-methylphenol	10 U	2-methylnaphthalene	10 U
bis(2-chloroisopropyl)ether	10 U	hexachlorocyclopentadiene	10 U
4-methylphenol	10 U	2,4,6-trichlorophenol	10 U
n-nitroso-di-n-propylamine	10 U	2,4,5-trichlorophenol	50 U
hexachloroethane	10 U	2-chloronaphthalene	10 U
nitrobenzene	10 U	2-nitroaniline	50 U
isophorone	10 U	dimethyl phthalate	10 U
2-nitrophenol	10 U	acenaphthylene	10 U
2,4-dimethylphenol	10 U	2,6-dinitrotoluene	10 U
benzoic acid	50 U		

Date Extracted: 07/18/88

Date Analyzed: 07/21/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following samples: 5214, 5217, 5218, 5219.

Alger R. Moore
Approved by _____
Laboratory Manager

Title

E-124



Accredited by the American Association for Laboratory Accreditation in the chemical field of testing as listed in the current AALL Directory of Accredited Laboratories

93 9-



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P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 118-02242-HM544
PAGE 17 OF 41

Sample Description: SBLK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST (continued)

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
3-nitroaniline	50 U	anthracene	10 U
acenaphthene	10 U	di-n-butylphthalate	10 U
2,4-dinitrophenol	50 U	fluoranthene	10 U
4-nitrophenol	50 U	pyrene	10 U
dibenzofuran	10 U	butylbenzylphthalate	10 U
2,4-dinitrotoluene	10 U	3,3'-dichlorobenzidine	20 U
diethylphthalate	10 U	benzo(a)anthracene	10 U
4-chlorophenyl-phenylether	10 U	chrysene	10 U
fluorene	10 U	bis(2-ethylhexyl)phthalate	10 U
4-nitroaniline	50 U	di-n-octylphthalate	10 U
4,6-dinitro-2-methylphenol	50 U	benzo(b)fluoranthene	10 U
n-nitrosodiphenylamine ¹	10 U	benzo(k)fluoranthene	10 U
4-bromophenyl-phenylether	10 U	benzo(a)pyrene	10 U
hexachlorobenzene	10 U	indeno(1,2,3-cd)pyrene	10 U
pentachlorophenol	50 U	dibenzo(a,h)anthracene	10 U
phenanthrene	10 U	benzo(g,h,i)perylene	10 U

Date Extracted: 07/18/88


Date Analyzed: 07/21/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

1 - Detected as diphenylamine.


Approved by _____
Laboratory Manager

Title

E-125



Accredited by EPA as an EPA Approved Laboratory for the analysis of environmental samples. The laboratory is also a member of the American Society for Testing and Materials (ASTM).

11-1-88



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 36 OF 62

Sample Description: SBLK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (ug/liter)	<u>Compound</u>	<u>Concentration</u> (ug/liter)
phenol	10 U	bis(2-chloroethoxy)methane	10 U
bis(2-chloroethyl)ether	10 U	2,4-dichlorophenol	10 U
2-chlorophenol	10 U	1,2,4-trichlorobenzene	10 U
1,3-dichlorobenzene	10 U	naphthalene	10 U
1,4-dichlorobenzene	10 U	4-chloroaniline	10 U
benzyl alcohol	10 U	hexachlorobutadiene	10 U
1,2-dichlorobenzene	10 U	4-chloro-3-methylphenol	10 U
2-methylphenol	10 U	2-methylnaphthalene	10 U
bis(2-chloroisopropyl)ether	10 U	hexachlorocyclopentadiene	10 U
4-methylphenol	10 U	2,4,6-trichlorophenol	10 U
n-nitroso-di-n-propylamine	10 U	2,4,5-trichlorophenol	50 U
hexachloroethane	10 U	2-chloronaphthalene	10 U
nitrobenzene	10 U	2-nitroaniline	50 U
isophorone	10 U	dimethyl phthalate	10 U
2-nitrophenol	10 U	acenaphthylene	10 U
2,4-dimethylphenol	10 U	2,6-dinitrotoluene	10 U
benzoic acid	50 U		

Date Extracted: 06/24/88

Date Analyzed: 07/08/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following samples: 5133, 5134.

Allyce R. Moore
Approved by Laboratory Manager

Title

E-126



Accredited by the American Association of Laboratory Accreditation in the chemical analysis of water and wastewater.

11-2



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DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 37 OF 62

Sample Description: S8LK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST (continued)

<u>Compound</u>	<u>Concentration</u> (ug/liter)	<u>Compound</u>	<u>Concentration</u> (ug/liter)
3-nitroaniline	50 U	anthracene	10 U
acenaphthene	10 U	di-n-butylphthalate	10 U
2,4-dinitrophenol	50 U	fluoranthene	10 U
4-nitrophenol	50 U	pyrene	10 U
dibenzofuran	10 U	butylbenzylphthalate	10 U
2,4-dinitrotoluene	10 U	3,3'-dichlorobenzidine	20 U
diethylphthalate	10 U	benzo(a)anthracene	10 U
4-chlorophenyl-phenylether	10 U	chrysene	10 U
fluorene	10 U	bis(2-ethylhexyl)phthalate	10 U
4-nitroaniline	50 U	di-n-octylphthalate	10 U
4,6-dinitro-2-methylphenol	50 U	benzo(b)fluoranthene	10 U
n-nitrosodiphenylamine ¹	10 U	benzo(k)fluoranthene	10 U
4-bromophenyl-phenylether	10 U	benzo(a)pyrene	10 U
hexachlorobenzene	10 U	indeno(1,2,3-cd)pyrene	10 U
pentachlorophenol	50 U	dibenzo(a,h)anthracene	10 U
phenanthrene	10 U	benzo(g,h,i)perylene	10 U

Date Extracted: 06/24/88
Date Analyzed: 07/08/88
Dilution Factor: 1

- U - Compound was analyzed for but not detected. The number is the detection limit for the sample.
J - Indicates an estimated value less than the detection limit.
1 - Detected as diphenylamine.

Approved by

Allyce R. Moore

Laboratory Manager

Title



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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 118-02242-HM545
PAGE 11 OF 33

Sample Description: SBLK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
phenol	10 U	bis(2-chloroethoxy)methane	10 U
bis(2-chloroethyl)ether	10 U	2,4-dichlorophenol	10 U
2-chlorophenol	10 U	1,2,4-trichlorobenzene	10 U
1,3-dichlorobenzene	10 U	naphthalene	10 U
1,4-dichlorobenzene	10 U	4-chloroaniline	10 U
benzyl alcohol	10 U	hexachlorobutadiene	10 U
1,2-dichlorobenzene	10 U	4-chloro-3-methylphenol	10 U
2-methylphenol	10 U	2-methylnaphthalene	10 U
bis(2-chloroisopropyl)ether	10 U	hexachlorocyclopentadiene	10 U
4-methylphenol	10 U	2,4,6-trichlorophenol	10 U
n-nitroso-di-n-propylamine	10 U	2,4,5-trichlorophenol	50 U
hexachloroethane	10 U	2-chloronaphthalene	10 U
nitrobenzene	10 U	2-nitroaniline	50 U
isophorone	10 U	dimethyl phthalate	10 U
2-nitrophenol	10 U	acenaphthylene	10 U
2,4-dimethylphenol	10 U	2,6-dinitrotoluene	10 U
benzoic acid	50 U		

Date Extracted: 07/19/88

Date Analyzed: 07/22/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following samples: 5227, 5230, 5231, 5232.

Allyce R. Moore
Approved by Laboratory Manager

Title

F-128



Accredited by the American Association for Laboratory Accreditation in the chemical
and biological testing as listed in the current AALA Directory of Accredited Laboratories

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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 118-02242-HM545
PAGE 12 OF 33

Sample Description: SBLK1 (Water)

SEMIVOLATILE TARGET COMPOUND LIST (continued)

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
3-nitroaniline	50 U	anthracene	10 U
acenaphthene	10 U	di-n-butylphthalate	10 U
2,4-dinitrophenol	50 U	fluoranthene	10 U
4-nitrophenol	50 U	pyrene	10 U
dibenzofuran	10 U	butylbenzylphthalate	10 U
2,4-dinitrotoluene	10 U	3,3'-dichlorobenzidine	20 U
diethylphthalate	10 U	benzo(a)anthracene	10 U
4-chlorophenyl-phenylether	10 U	chrysene	10 U
fluorene	10 U	bis(2-ethylhexyl)phthalate	10 U
4-nitroaniline	50 U	di-n-octylphthalate	10 U
4,6-dinitro-2-methylphenol	50 U	benzo(b)fluoranthene	10 U
n-nitrosodiphenylamine ¹	10 U	benzo(k)fluoranthene	10 U
4-bromophenyl-phenylether	10 U	benzo(a)pyrene	10 U
hexachlorobenzene	10 U	indeno(1,2,3-cd)pyrene	10 U
pentachlorophenol	50 U	dibenzo(a,h)anthracene	10 U
phenanthrene	10 U	benzo(g,h,i)perylene	10 U

Date Extracted: 07/19/88
Date Analyzed: 07/22/88
Dilution Factor: 1

- U - Compound was analyzed for but not detected. The number is the detection limit for the sample.
J - Indicates an estimated value less than the detection limit.
1 - Detected as diphenylamine.

Alger L. Mason
Approved by Laboratory Manager

**CERTIFICATE OF ANALYSIS**

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 19 OF 39

Sample Description: SBLK1 (Water)

SEMIVOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS

<u>Compound</u>	<u>Concentration (ug/liter)</u>	<u>Compound</u>	<u>Concentration (ug/liter)</u>
phenol	10 U	bis(2-chloroethoxy)methane	10 U
bis(2-chloroethyl)ether	10 U	2,4-dichlorophenol	10 U
2-chlorophenol	10 U	1,2,4-trichlorobenzene	10 U
1,3-dichlorobenzene	10 U	naphthalene	10 U
1,4-dichlorobenzene	10 U	4-chloroaniline	10 U
benzyl alcohol	10 U	hexachlorobutadiene	10 U
1,2-dichlorobenzene	10 U	-chloro-3-methylphenol	10 U
2-methylphenol	10 U	2-methylnaphthalene	10 U
bis(2-chloroisopropyl)ether	10 U	hexachlorocyclopentadiene	10 U
4-methylphenol	10 U	2,4,6-trichlorophenol	10 U
n-nitroso-di-n-propylamine	10 U	2,4,5-trichlorophenol	50 U
hexachloroethane	10 U	2-chloronaphthalene	10 U
nitrobenzene	10 U	2-nitroaniline	50 U
isophorone	10 U	dimethyl phthalate	10 U
2-nitrophenol	10 U	acenaphthylene	10 U
2,4-dimethylphenol	10 U	2,6-dinitrotoluene	10 U
benzoic acid	50 U		

Date Extracted: 10/04/88

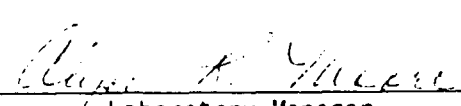
Date Analyzed: 10/11/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following samples: 5234, 5235, 5236.


Approved by ☒ Laboratory Manager

Title



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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 20 OF 39

Sample Description: SBLK1 (Water)

SEMIVOLATILE HAZARDOUS SUBSTANCE LIST COMPOUNDS (continued)

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
3-nitroaniline	50 U	anthracene	10 U
acenaphthene	10 U	di-n-butylphthalate	10 U
2,4-dinitrophenol	50 U	fluoranthene	10 U
4-nitrophenol	50 U	pyrene	10 U
dibenzofuran	10 U	butylbenzylphthalate	10 U
2,4-dinitrotoluene	10 U	3,3'-dichlorobenzidine	20 U
diethylphthalate	10 U	benzo(a)anthracene	10 U
4-chlorophenyl-phenylether	10 U	chrysene	10 U
fluorene	10 U	bis(2-ethylhexyl)phthalate	10 U
4-nitroaniline	50 U	di-n-octylphthalate	10 U
4,6-dinitro-2-methylphenol	50 U	benzo(b)fluoranthene	10 U
n-nitrosodiphenylamine ¹	10 U	benzo(k)fluoranthene	10 U
4-bromophenyl-phenylether	10 U	benzo(a)pyrene	10 U
hexachlorobenzene	10 U	indeno(1,2,3-cd)pyrene	10 U
pentachlorophenol	50 U	dibenzo(a,h)anthracene	10 U
phenanthrene	10 U	benzo(g,h,i)perylene	10 U

Date Extracted: 10/04/88

Date Analyzed: 10/11/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

1 - Detected as diphenylamine.


Approved by Laboratory Manager

720

8-1-11



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 35 OF 56

Sample Description: SBLK1 (Soil)

SEMIVOLATILE TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>
phenol	330 U	bis(2-chloroethoxy)methane	330 U
bis(2-chloroethyl)ether	330 U	2,4-dichlorophenol	330 U
2-chlorophenol	330 U	1,2,4-trichlorobenzene	330 U
1,3-dichlorobenzene	330 U	naphthalene	330 U
1,4-dichlorobenzene	330 U	4-chloroaniline	330 U
benzyl alcohol	330 U	hexachlorobutadiene	330 U
1,2-dichlorobenzene	330 U	4-chloro-3-methylphenol	330 U
2-methylphenol	330 U	2-methylnaphthalene	330 U
bis(2-chloroisopropyl)ether	330 U	hexachlorocyclopentadiene	330 U
4-methylphenol	330 U	2,4,6-trichlorophenol	330 U
n-nitroso-di-n-propylamine	330 U	2,4,5-trichlorophenol	1,600 U
hexachloroethane	330 U	2-chloronaphthalene	330 U
nitrobenzene	330 U	2-nitroaniline	1,600 U
isophorone	330 U	dimethyl phthalate	330 U
2-nitrophenol	330 U	acenaphthylene	330 U
2,4-dimethylphenol	330 U	2,6-dinitrotoluene	330 U
benzoic acid	1,600 U		

Date Extracted: 06/20/88
Date Analyzed: 07/06/88
Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for this sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following samples: 5000, 5000 MS, 5000 MSD.

Alice R. Moore

Approved by Laboratory Manager

Title



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 36 OF 56

Sample Description: SBLK1 (Soil)

SEMIVOLATILE TARGET COMPOUND LIST (continued)

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
3-nitroaniline	1,600 U	anthracene	330 U
acenaphthene	330 U	di-n-butylphthalate	330 U
2,4-dinitrophenol	1,600 U	fluoranthene	330 U
4-nitrophenol	1,600 U	pyrene	330 U
dibenzofuran	330 U	butylbenzylphthalate	330 U
2,4-dinitrotoluene	330 U	3,3'-dichlorobenzidine	660 U
diethylphthalate	330 U	benzo(a)anthracene	330 U
4-chlorophenyl-phenylether	330 U	chrysene	330 U
fluorene	330 U	bis(2-ethylhexyl)phthalate	280 J
4-nitroaniline	1,600 U	di-n-octylphthalate	330 U
4,6-dinitro-2-methylphenol	1,600 U	benzo(b)fluoranthene	330 U
n-nitrosodiphenylamine ¹	330 U	benzo(k)fluoranthene	330 U
4-bromophenyl-phenylether	330 U	benzo(a)pyrene	330 U
hexachlorobenzene	330 U	indeno(1,2,3-cd)pyrene	330 U
pentachlorophenol	1,600 U	dibenzo(a,h)anthracene	330 U
phenanthrene	330 U	benzo(g,h,i)perylene	330 U

Date Extracted: 06/20/88

Date Analyzed: 07/06/88

Dilution Factor: 1

- U - Compound was analyzed for but not detected. The number is the detection limit for the sample.
J - Indicates an estimated value less than the detection limit.
1 - Detected as diphenylamine.

Alice L. Moore
Approved by Laboratory Manager

Title



Accredited by the American Association of Environmental Chemists, Inc. (AAEC) for the analysis of semivolatile organic compounds in soil.

11-1-88



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 11B-02242-HM525
PAGE 34 OF 83

Sample Description: SBLK1 (Soil)

SEMIVOLATILE TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
phenol	330 U	bis(2-chloroethoxy)methane	330 U
bis(2-chloroethyl)ether	330 U	2,4-dichlorophenol	330 U
2-chlorophenol	330 U	1,2,4-trichlorobenzene	330 U
1,3-dichlorobenzene	330 U	naphthalene	330 U
1,4-dichlorobenzene	330 U	4-chloroaniline	330 U
benzyl alcohol	330 U	hexachlorobutadiene	330 U
1,2-dichlorobenzene	330 U	4-chloro-3-methylphenol	330 U
2-methylphenol	330 U	2-methylnaphthalene	330 U
bis(2-chloroisopropyl)ether	330 U	hexachlorocyclopentadiene	330 U
4-methylphenol	330 U	2,4,6-trichlorophenol	330 U
n-nitroso-di-n-propylamine	330 U	2,4,5-trichlorophenol	1,600 U
hexachloroethane	330 U	2-chloronaphthalene	330 U
nitrobenzene	330 U	2-nitroaniline	1,600 U
isophorone	330 U	dimethyl phthalate	330 U
2-nitrophenol	330 U	acenaphthylene	330 U
2,4-dimethylphenol	330 U	2,6-dinitrotoluene	330 U
benzoic acid	1,600 U		

Date Extracted: 06/28/88
Date Analyzed: 07/12/88
Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for this sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following samples: 5001, 5002, 5003, 5004, 5005, 5006, 5007, 5007 (1:12), 5008, 5009, 5010, 5012.

Allyce R. Moser

Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 35 OF 83

Sample Description: SBLK1 (Soil)

SEMIVOLATILE TARGET COMPOUND LIST (continued)

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
3-nitroaniline	1,600 U	anthracene	330 U
acenaphthene	330 U	di-n-butylphthalate	330 U
2,4-dinitrophenol	1,600 U	fluoranthene	330 U
4-nitrophenol	1,600 U	pyrene	330 U
dibenzofuran	330 U	butylbenzylphthalate	330 U
2,4-dinitrotoluene	330 U	3,3'-dichlorobenzidine	660 U
diethylphthalate	330 U	benzo(a)anthracene	330 U
4-chlorophenyl-phenylether	330 U	chrysene	330 U
fluorene	330 U	bis(2-ethylhexyl)phthalate	400
4-nitroaniline	1,600 U	di-n-octylphthalate	330 U
4,6-dinitro-2-methylphenol	1,600 U	benzo(b)fluoranthene	330 U
n-nitrosodiphenylamine ¹	91 J	benzo(k)fluoranthene	330 U
4-bromophenyl-phenylether	330 U	benzo(a)pyrene	330 U
hexachlorobenzene	330 U	indeno(1,2,3-cd)pyrene	330 U
pentachlorophenol	1,600 U	dibenzo(a,h)anthracene	330 U
phenanthrene	330 U	benzo(g,h,i)perylene	330 U

Date Extracted: 06/28/88

Date Analyzed: 07/12/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

1 - Detected as diphenylamine.

Allyce R. Moore
Approved by Laboratory Manager

Title

P-135



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and physical testing of soil and water samples. AAAL is an ISO 9001:1987 Accredited Laboratory.

11-2-88



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 27 OF 57

Sample Description: SBLK1 (Soil)

SEMIVOLATILE TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (<u>ug/kg dry weight</u>)	<u>Compound</u>	<u>Concentration</u> (<u>ug/kg dry weight</u>)
phenol	330 U	bis(2-chloroethoxy)methane	330 U
bis(2-chloroethyl)ether	330 U	2,4-dichlorophenol	330 U
2-chlorophenol	330 U	1,2,4-trichlorobenzene	330 U
1,3-dichlorobenzene	330 U	naphthalene	330 U
1,4-dichlorobenzene	330 U	4-chloroaniline	330 U
benzyl alcohol	330 U	hexachlorobutadiene	330 U
1,2-dichlorobenzene	330 U	4-chloro-3-methylphenol	330 U
2-methylphenol	330 U	2-methylnaphthalene	330 U
bis(2-chloroisopropyl)ether	330 U	hexachlorocyclopentadiene	330 U
4-methylphenol	330 U	2,4,6-trichlorophenol	330 U
n-nitroso-di-n-propylamine	330 U	2,4,5-trichlorophenol	1,600 U
hexachloroethane	330 U	2-chloronaphthalene	330 U
nitrobenzene	330 U	2-nitroaniline	1,600 U
isophorone	330 U	dimethyl phthalate	330 U
2-nitrophenol	330 U	acenaphthylene	330 U
2,4-dimethylphenol	330 U	2,6-dinitrotoluene	330 U
benzoic acid	1,600 U		

Date Extracted: 10/11/88
Date Analyzed: 10/14/88
Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

This method blank applies to the following samples: 5247, 5248, 5249, 5250, 5250 MS, 5250 MSD.

Allyce R. Maer
Approved by Laboratory Manager

Title


CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 28 OF 57

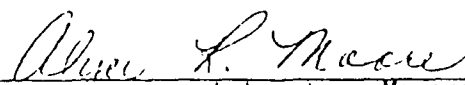
Sample Description: SBLK1 (Soil)

SEMIVOLATILE TARGET COMPOUND LIST (continued)

<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration (ug/kg dry weight)</u>
3-nitroaniline	1,600 U	anthracene	330 U
acenaphthene	330 U	di-n-butylphthalate	330 U
2,4-dinitrophenol	1,600 U	fluoranthene	330 U
4-nitrophenol	1,600 U	pyrene	330 U
dibenzofuran	330 U	butylbenzylphthalate	330 U
2,4-dinitrotoluene	330 U	3,3'-dichlorobenzidine	660 U
diethylphthalate	330 U	benzo(a)anthracene	330 U
4-chlorophenyl-phenylether	330 U	chrysene	330 U
fluorene	330 U	bis(2-ethylhexyl)phthalate	250 J
4-nitroaniline	1,600 U	di-n-octylphthalate	330 U
4,6-dinitro-2-methylphenol	1,600 U	benzo(b)fluoranthene	330 U
n-nitrosodiphenylamine ¹	330 U	benzo(k)fluoranthene	330 U
4-bromophenyl-phenylether	330 U	benzo(a)pyrene	330 U
hexachlorobenzene	330 U	indeno(1,2,3-cd)pyrene	330 U
pentachlorophenol	1,600 U	dibenzo(a,h)anthracene	330 U
phenanthrene	330 U	benzo(g,h,i)perylene	330 U

Date Extracted: 10/11/88
Date Analyzed: 10/14/88
Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.
J - Indicates an estimated value less than the detection limit.
1 - Detected as diphenylamine.


Approved by: _____ Laboratory Manager

Title

**CERTIFICATE OF ANALYSIS**

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 11B-02242-HM-514 & 518
PAGE 60 OF 61

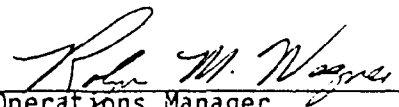
Sample Description: Method Blank Summary

Concentration units are $\mu\text{g/liter}$ (ppb)

	Method Blank <u>7/7/88</u>	Method Blank <u>7/8/88</u>	Method Blank <u>7/9/88</u>	Method Blank <u>7/11/88</u>
Benzene	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1 U	1 U	1 U	1 U
Ethyl Benzene	4 U	4 U	4 U	4 U
Xylenes (Total)	4 U	4 U	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U	50 U	50 U
Date of Analysis:	7/7/88	7/8/88	7/9/88	7/11/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by


Operations Manager

Title





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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 11B-02242-HM537
PAGE 32 OF 38

Sample Description: Method Blank Summary (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5 U	0.5 U
Toluene	1 U	1 U
Ethyl Benzene	4 U	4 U
Xylenes (total)	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U

Date of Analysis:

07/11/88

07/12/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alice R. Moore
Approved by _____
Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41616
ORDER NUMBER: 11B-02242-HM538
PAGE 17 OF 24

Sample Description: Method Blank Summary (Water)

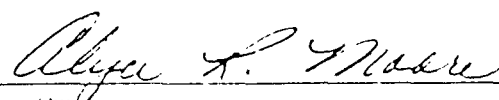
Concentration units are $\mu\text{g/liter}$ (ppb)

	07/27-28/88 Method Blank	07/28/88 Method Blank*	07/29/88 Method Blank*
Benzene	0.5 U	1 U	1 U
Toluene	1 U	1 U	1 U
Ethyl Benzene	4 U	1 U	1 U
Xylenes (total)	4 U	1 U	1 U
Total Petroleum Hydrocarbons	50 U	20 U	20 U

Date of Analysis: 07/27,28/88 07/28/88 07/29/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

*Analysis performed by gas chromatography/mass spectroscopy.


Approved by Laboratory Manager

Title





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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 118-02242-HM540
PAGE 24 OF 28

Sample Description: Method Blank Summary (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1 U	1 U	1 U	1 U
Ethyl Benzene	4 U	4 U	4 U	4 U
Xylenes (total)	4 U	4 U	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U	50 U	50 U

Date of Analysis:	07/25/88	07/26/88	07/28/88	07/30/88
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U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Allyce L. Mason
Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 11B-02242-HM544
PAGE 35 OF 41

Sample Description: Method Blank Summary (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U
Ethyl Benzene	1 U	1 U	1 U	1 U
Xylenes (total)	1 U	1 U	1 U	1 U
Total Petroleum Hydrocarbons	6 J	13 J	16 J	18 J

Date of Analysis:	7/29/88	7/30/88	8/01/88	8/02/88
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U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Analysis performed by gas chromatography/mass spectroscopy.

Allyce L. Moore

Approved by Laboratory Manager

Title

F-142



Accredited by the American Association for Laboratory Accreditation in the Chemical and Toxicology Laboratory. AALA File No. 11B-02242-HM544



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 118-02242-HM545
PAGE 31 OF 33

Sample Description: Method Blank Summary (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5 U	0.5 U
Toluene	1 U	1 U
Ethyl Benzene	4 U	4 U
Xylenes (total)	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U

Date of Analysis:	7/26/88	7/28/88
-------------------	---------	---------

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alfred R. Moore
Approved by Laboratory Manager
Title





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 39 OF 39

Sample Description: Method Blank Summary

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5 U	0.5 U	0.5 U
Toluene	1 U	1 U	1 U
Ethyl Benzene	4 U	4 U	4 U
Xylenes (total)	4 U	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U	50 U
Date of Analysis:	10/5/88	10/6/88	10/7/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Russ H. Hester
Approved by Laboratory Manager

Title

P-144



Approved by the American Association for Laboratory Accreditation, Inc. (AALA)
AALA is a non-profit organization that provides a variety of services to its members.



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

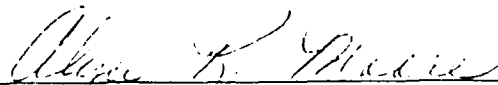
DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 118-02242-HM647
PAGE 50 OF 51

Sample Description: Method Blank Summary

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1 U	1 U	1 U	1 U
Ethyl Benzene	4 U	4 U	4 U	4 U
Xylenes (total)	4 U	4 U	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U	50 U	50 U
Date of Analysis:	10/10/88	10/11/88	10/12/88	10/13/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by: Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 51 OF 51

Sample Description: Method Blank Summary

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5 U	0.5 U
Toluene	1 U	1 U
Ethyl Benzene	4 U	4 U
Xylenes (total)	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U
Date of Analysis:	10/14/88	10/20/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Wayne K. Mearns
Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831


DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 50 OF 57

Sample Description: Method Blank Summary (Water)

Concentration units are ug/liter (ppb)

Benzene	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1 U	1 U	1 U	1 U
Ethyl Benzene	4 U	4 U	4 U	4 U
Xylenes (total)	4 U	4 U	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U	50 U	50 U
Date of Analysis:	10/06/88	10/07/88	10/10/88	10/11/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 18, 1988
PROJECT CODE: MMOK 42231
ORDER NUMBER: 11B-02242-HM682
PAGE 13 OF 16

Sample Description: Method Blank Summary (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5	U
Toluene	1	U
Ethyl Benzene	4	U
Xylenes (total)	4	U
Total Petroleum Hydrocarbons	50	U

Date of Analysis: 11/08/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by Alper K. Mader
Laboratory Manager

4. 10. 2000

p-148



A. *Interpreting the American Aesthetic: A Preliminary Address* (Lecture 1) and *Form and Content: The American Aesthetic* (Lecture 2) are the first two lectures in the series.

29. 45



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: December 6, 1988
PROJECT CODE: MMOK 42335
ORDER NUMBER: 11B-02242-HM680
PAGE 14 OF 17

Sample Description: Method Blank Summary (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5 U	0.5 U	0.5 U	0.5 U
Toluene	1 U	1 U	1 U	1 U
Ethyl Benzene	4 U	4 U	4 U	4 U
Xylenes (total)	4 U	4 U	4 U	4 U
Total Petroleum Hydrocarbons	50 U	NA	50 U	50 U

Date of Analysis: 11/21/88 11/22/88 11/23/88 12/01/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.
NA - Not analyzed.

Alyce S. Moore
Approved by Laboratory Manager

File





ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-558-6401



CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: S. R. Rizk, K-25
P. O. Box 2003
Oak Ridge, TN 37831-7440

DATE REPORTED January 9, 1989
PROJECT CODE MMOK 42490
ORDER NUMBER 11B-02242-TU880
PAGE 9 OF 11

Sample Description: Method Blank Summary (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

Benzene	0.5 U	0.5 U	0.5 U
Toluene	1 U	1 U	1 U
Ethyl Benzene	4 U	4 U	4 U
Xylenes (Total)	4 U	4 U	4 U
Total Petroleum Hydrocarbons	50 U	50 U	50 U
Date of Analysis:	12/28/88	12/23/88	12/29/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Allye L. Moore
Approved by Laboratory Manager

The





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 11B-02242-HM-514 & 518
PAGE 61 OF 61

Sample Description: Extraction Blank Summary

Concentration units are $\mu\text{g/kg}$ (ppb)

	<u>Blank A</u>	<u>Blank B</u>	<u>Blank C</u>
Benzene	50 U	50 U	50 U
Toluene	100 U	100 U	100 U
Ethyl Benzene	400 U	400 U	400 U
Xylenes (Total)	400 U	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U	5,000 U
Date of Extraction:	6/30/88	6/30/88	6/30/88
Date of Analysis:	7/6/88	7/6/88	7/6/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by

R. M. Wagner
Operations Manager

Title



E-151
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industry testing is listed in the current AALA Directory of Accredited Laboratories

92-4-41

**CERTIFICATE OF ANALYSIS**

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE 55 OF 56

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

	Extraction Blank	7/12/88 Method Blank	7/13/88 Method Blank
Benzene	50 U	50 U	50 U
Toluene	100 U	100 U	100 U
Ethyl Benzene	400 U	400 U	400 U
Xylenes (Total)	400 U	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U	5,000 U
Date of Extraction:	6/30/88	---	---
Date of Analysis:	7/06/88	7/12/88	7/13/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by



Operations Manager

Title



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 118-02242-HM519 & HM524
PAGE 50 OF 50

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

	7/14/88 Method Blank	7/29/88 Method Blank
Benzene	50 U	50 U
Toluene	100 U	100 U
Ethyl Benzene	400 U	400 U
Xylenes (Total)	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U
Date of Extraction:	---	---
Date of Analysis:	7/14/88	7/29/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by

Operations Manager

Title



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93-1-45



INTERNATIONAL
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ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831


DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41539
ORDER NUMBER: 11B-02242-HM530
PAGE 20 OF 21

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

	7/21/88 Method Blank	Extraction Blank
Benzene	50 U	50 U
Toluene	100 U	100 U
Ethyl Benzene	400 U	400 U
Xylenes (Total)	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U
Date of Extraction:	---	7/01/88
Date of Analysis:	7/21/88	8/02/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by _____
Laboratory Manager
Title _____



Accredited by the American Association for Laboratory Accreditation in the chemical
field of testing as listed in the current AALA directory of Accredited Laboratories

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 118-02242-HM515
PAGE 53 OF 56

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

	6/27/88 Method Blank	7/06/88 Method Blank	7/07/88 Method Blank	Extraction Blank
Benzene	50 U	50 U	50 U	50 U
Toluene	100 U	100 U	100 U	100 U
Ethyl Benzene	400 U	400 U	400 U	400 U
Xylenes (Total)	400 U	400 U	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U	5,000 U	5,000 U
Date of Extraction:	---	---	---	6/30/88
Date of Analysis:	6/27/88	7/06/88	7/07/88	7/06/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alice L. Moore
Approved by Laboratory Manager

Title

11-155



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 79 OF 83

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

	<u>7/29/88</u> <u>Method Blank</u>	<u>7/30/88</u> <u>Method Blank</u>
Benzene	50 U	50 U
Toluene	100 U	100 U
Ethyl Benzene	400 U	400 U
Xylenes (Total)	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U
Date of Analysis:	7/29/88	7/30/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by _____
Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831


DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 11B-02242-HM525
PAGE 80 OF 83

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

	8/01/88 Method Blank	8/02/88 Method Blank	Extraction Blank
Benzene	50 U	50 U	50 U
Toluene	100 U	100 U	100 U
Ethyl Benzene	400 U	400 U	400 U
Xylenes (Total)	400 U	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U	5,000 U
Date of Extraction:	---	---	7/01/88
Date of Analysis:	8/01/88	8/02/88	8/02/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title

F-157



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93-9-85



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 16, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 54 OF 62

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

	<u>Extraction Blank</u>	<u>08/01/88 Method Blank</u>	<u>08/02/88 Method Blank</u>
Benzene	50 U	50 U	50 U
Toluene	100 U	100 U	100 U
Ethyl Benzene	400 U	400 U	400 U
Xylenes (total)	400 U	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U	5,000 U
Date of Extraction:	07/01/88	---	---
Date of Analysis:	08/02/88	08/01/88	08/02/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alyce R. Moore
Approved by Laboratory Manager

Title





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 16, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 55 OF 62

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

	08/03/88 Method Blank	08/09/88 Method Blank	08/02/88* Method Blank
Benzene	50 U	50 U	100 U
Toluene	100 U	100 U	100 U
Ethyl Benzene	400 U	400 U	100 U
Xylenes (total)	400 U	400 U	100 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U	2,000 U
Date of Extraction:	---	---	---
Date of Analysis:	08/03/88	08/09/88	08/02/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

*Analysis performed by gas chromatography/mass spectroscopy.

Alice L. Mason
Approved by _____
Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 118-02242-HM644
PAGE 53 OF 57

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

Benzene	50 U	50 U
Toluene	100 U	100 U
Ethyl Benzene	400 U	400 U
Xylenes (total)	400 U	400 U
Total Petroleum Hydrocarbons	5,000 U	5,000 U
Date of Analysis:	10/07/88	10/10/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 18, 1988
PROJECT CODE: MMOK 42231
ORDER NUMBER: 11B-02242-HM682
PAGE 16 OF 16

Sample Description: Method Blank Summary (Soil)

Concentration units are $\mu\text{g/kg}$ (ppb)

Benzene	50 U
Toluene	100 U
Ethyl Benzene	400 U
Xylenes (total)	400 U
Total Petroleum Hydrocarbons	5,000 U

Date of Extraction: 11/04/88
Date of Analysis: 11/07/88

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alfred R. Moore

Approved by Laboratory Manager





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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 118-02242-HM537
PAGE 24 OF 38

Sample Description: P8LK1 (Water)

PESTICIDE AND PCB TARGET COMPOUND LIST

Compound	Concentration (ug/liter)	Compound	Concentration (ug/liter)
α-BHC	0.050 U	endosulfan sulfate	0.10 U
β-BHC	0.050 U	4,4'-DDT	0.10 U
δ-BHC	0.050 U	methoxychlor	0.50 U
γ-BHC (lindane)	0.050 U	endrin ketone	0.10 U
heptachlor	0.050 U	α-chlordane	0.50 U
aldrin	0.050 U	γ-chlordane	0.50 U
heptachlor epoxide	0.050 U	toxaphene	1.0 U
endosulfan I	0.050 U	Aroclor 1016	0.50 U
dieldrin	0.10 U	Aroclor 1221	0.50 U
4,4'-DDE	0.10 U	Aroclor 1232	0.50 U
endrin	0.10 U	Aroclor 1242	0.50 U
endosulfan II	0.10 U	Aroclor 1248	0.50 U
4,4'-DDD	0.10 U	Aroclor 1254	1.0 U
		Aroclor 1260	1.0 U


Date Extracted: 07/12/88

Date Analyzed: 07/21/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit, for the sample.

This method blank applies to the following samples: 5168, 5170.


Approved by: _____
Laboratory Manager



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 118-02242-HM540
PAGE 18 OF 28

Sample Description: PBLK1 (Water)

PESTICIDE AND PCB TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (<u>ug/liter</u>)	<u>Compound</u>	<u>Concentration</u> (<u>ug/liter</u>)
α -BHC	0.050 U	endosulfan sulfate	0.10 U
β -BHC	0.050 U	4,4'-DDT	0.10 U
δ -BHC	0.050 U	methoxychlor	0.50 U
γ -BHC (lindane)	0.050 U	endrin ketone	0.10 U
heptachlor	0.050 U	α -chlordane	0.50 U
aldrin	0.050 U	γ -chlordane	0.50 U
heptachlor epoxide	0.050 U	toxaphene	1.0 U
endosulfan I	0.050 U	Aroclor 1016	0.50 U
dieldrin	0.10 U	Aroclor 1221	0.50 U
4,4'-DDE	0.10 U	Aroclor 1232	0.50 U
endrin	0.10 U	Aroclor 1242	0.50 U
endosulfan II	0.10 U	Aroclor 1248	0.50 U
4,4'-DDD	0.10 U	Aroclor 1254	1.0 U
		Aroclor 1260	1.0 U


Date Extracted: 07/13/88

Date Analyzed: 07/21/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following sample: 5189.


Approved by Laboratory Manager

509



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 11B-02242-HM544
PAGE 27 OF 41

Sample Description: PBLK1 (Water)

PESTICIDE AND PCB TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/liter}$)	<u>Compound</u>	<u>Concentration</u> ($\mu\text{g/liter}$)
α -BHC	0.050 U	endosulfan sulfate	0.10 U
β -BHC	0.050 U	4,4'-DDT	0.10 U
δ -BHC	0.050 U	methoxychlor	0.50 U
γ -BHC (lindane)	0.050 U	endrin ketone	0.10 U
heptachlor	0.050 U	α -chlordane	0.50 U
aldrin	0.050 U	γ -chlordane	0.50 U
heptachlor epoxide	0.050 U	toxaphene	1.0 U
endosulfan I	0.050 U	Aroclor 1016	0.50 U
dieldrin	0.10 U	Aroclor 1221	0.50 U
4,4'-DDE	0.10 U	Aroclor 1232	0.50 U
endrin	0.10 U	Aroclor 1242	0.50 U
endosulfan II	0.10 U	Aroclor 1248	0.50 U
4,4'-DDD	0.10 U	Aroclor 1254	1.0 U
		Aroclor 1260	1.0 U

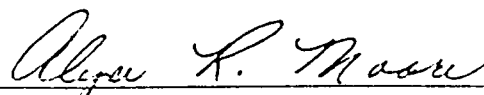
Date Extracted: 07/18/88

Date Analyzed: 07/22/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following samples: 5214, 5217, 5218, 5219.


Approved by _____
Laboratory Manager

Date

8-167



Approved by the American Association of Environmental Engineers and Chemists
This report was prepared by the American Association of Environmental Engineers and Chemists



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 43 OF 62

Sample Description: PBLK1 (Water)

PESTICIDE AND PCB TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/liter)</u>
α-BHC	0.050 U	endosulfan sulfate	0.10 U
β-BHC	0.050 U	4,4'-DDT	0.10 U
δ-BHC	0.050 U	methoxychlor	0.50 U
γ-BHC (lindane)	0.050 U	endrin ketone	0.10 U
heptachlor	0.050 U	α-chlordane	0.50 U
aldrin	0.050 U	γ-chlordane	0.50 U
heptachlor epoxide	0.050 U	toxaphene	1.0 U
endosulfan I	0.050 U	Aroclor 1016	0.50 U
dieldrin	0.10 U	Aroclor 1221	0.50 U
4,4'-DDE	0.10 U	Aroclor 1232	0.50 U
endrin	0.10 U	Aroclor 1242	0.50 U
endosulfan II	0.10 U	Aroclor 1248	0.50 U
4,4'-DDD	0.10 U	Aroclor 1254	1.0 U
		Aroclor 1260	1.0 U

Date Extracted: 06/24/88
Date Analyzed: 07/07/88
Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following samples: 5133, 5134.

Alice L. Moore
Approved by Laboratory Manager
Title



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 11B-02242-HM545
PAGE 22 OF 33

Sample Description: PBLK1 (Water)

PESTICIDE AND PCB TARGET COMPOUND LIST

Compound	Concentration ($\mu\text{g/liter}$)	Compound	Concentration ($\mu\text{g/liter}$)
α -BHC	0.050 U	endosulfan sulfate	0.10 U
β -BHC	0.050 U	4,4'-DDT	0.10 U
δ -BHC	0.050 U	methoxychlor	0.50 U
γ -BHC (lindane)	0.050 U	endrin ketone	0.10 U
heptachlor	0.050 U	α -chlordane	0.50 U
aldrin	0.050 U	γ -chlordane	0.50 U
heptachlor epoxide	0.050 U	toxaphene	1.0 U
endosulfan I	0.050 U	Aroclor 1016	0.50 U
dieldrin	0.10 U	Aroclor 1221	0.50 U
4,4'-DDE	0.10 U	Aroclor 1232	0.50 U
endrin	0.10 U	Aroclor 1242	0.50 U
endosulfan II	0.10 U	Aroclor 1248	0.50 U
4,4'-DDD	0.10 U	Aroclor 1254	1.0 U
		Aroclor 1260	1.0 U

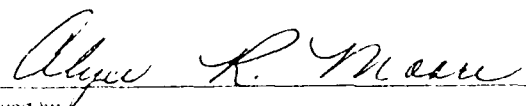
Date Extracted: 07/19/88

Date Analyzed: 07/22/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following samples: 5227, 5230, 5231, 5232.


Approved by _____
Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 28 OF 39

Sample Description: PBLK1 (Water)

PESTICIDE AND PCB TARGET COMPOUND LIST

Compound	Concentration (μ g/liter)	Compound	Concentration (μ g/liter)
α -BHC	0.050 U	endosulfan sulfate	0.10 U
β -BHC	0.050 U	4,4'-DDT	0.10 U
δ -BHC	0.050 U	methoxychlor	0.50 U
γ -BHC (lindane)	0.050 U	endrin ketone	0.10 U
heptachlor	0.050 U	α -chlordane	0.50 U
aldrin	0.050 U	γ -chlordane	0.50 U
heptachlor epoxide	0.050 U	toxaphene	1.0 U
endosulfan I	0.050 U	Aroclor 1016	0.50 U
dieldrin	0.10 U	Aroclor 1221	0.50 U
4,4'-DDE	0.10 U	Aroclor 1232	0.50 U
endrin	0.10 U	Aroclor 1242	0.50 U
endosulfan II	0.10 U	Aroclor 1248	0.50 U
4,4'-DDD	0.10 U	Aroclor 1254	1.0 U
		Aroclor 1260	1.0 U

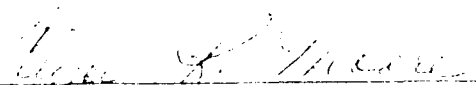
Date Extracted: 10/04/88

Date Analyzed: 10/11/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following samples: 5234, 5235, 5236.


Approved by: Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 29 OF 39

Sample Description: PBLK2-ST (Water)

PESTICIDE AND PCB TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> (ug/liter)	<u>Compound</u>	<u>Concentration</u> (ug/liter)
α-BHC	0.050 U	endosulfan sulfate	0.10 U
β-BHC	0.050 U	4,4'-DDT	0.10 U
δ-BHC	0.050 U	methoxychlor	0.50 U
γ-BHC (lindane)	0.050 U	endrin ketone	0.10 U
heptachlor	0.050 U	α-chlordane	0.50 U
aldrin	0.050 U	γ-chlordane	0.50 U
heptachlor epoxide	0.050 U	toxaphene	1.0 U
endosulfan I	0.050 U	Aroclor 1016	0.50 U
dieldrin	0.10 U	Aroclor 1221	0.50 U
4,4'-DDE	0.10 U	Aroclor 1232	0.50 U
endrin	0.10 U	Aroclor 1242	0.50 U
endosulfan II	0.10 U	Aroclor 1248	0.50 U
4,4'-DDD	0.10 U	Aroclor 1254	1.0 U
		Aroclor 1260	1.0 U

Date Extracted: 10/12/88

Date Analyzed: 10/12/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following sample: 5235.


Approved by Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 41 OF 56

Sample Description: PBLK1 (Soil)

PESTICIDE AND PCB TARGET COMPOUND LIST

Compound	Concentration (ug/kg dry weight)	Compound	Concentration (ug/kg dry weight)
α-BHC	8.0 U	endosulfan sulfate	16 U
β-BHC	8.0 U	4,4'-DDT	16 U
δ-BHC	8.0 U	methoxychlor	80 U
γ-BHC (lindane)	8.0 U	endrin ketone	16 U
heptachlor	8.0 U	α-chlordane	80 U
aldrin	8.0 U	γ-chlordane	80 U
heptachlor epoxide	8.0 U	toxaphene	160 U
endosulfan I	8.0 U	Aroclor 1016	80 U
dieldrin	16 U	Aroclor 1221	80 U
4,4'-DDE	16 U	Aroclor 1232	80 U
endrin	16 U	Aroclor 1242	80 U
endosulfan II	16 U	Aroclor 1248	80 U
4,4'-DDD	16 U	Aroclor 1254	160 U
		Aroclor 1260	160 U

Date Extracted: 06/20/88

Date Analyzed: 07/13/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following samples: 5000, 5000 (1:5), 5000 MS, 5000 MSD.

Allyn R. Moore
Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 11B-02242-HM525
PAGE 59 OF 83

Sample Description: PBLK1 (Soil)

PESTICIDE AND PCB TARGET COMPOUND LIST

Compound	Concentration ($\mu\text{g/kg}$ dry weight)	Compound	Concentration ($\mu\text{g/kg}$ dry weight)
α -BHC	8.0 U	endosulfan sulfate	16 U
β -BHC	8.0 U	4,4'-DDT	16 U
δ -BHC	8.0 U	methoxychlor	80 U
γ -BHC (lindane)	8.0 U	endrin ketone	16 U
heptachlor	8.0 U	α -chlordane	80 U
aldrin	8.0 U	γ -chlordane	80 U
heptachlor epoxide	8.0 U	toxaphene	160 U
endosulfan I	8.0 U	Aroclor 1016	80 U
dieldrin	16 U	Aroclor 1221	80 U
4,4'-DDE	16 U	Aroclor 1232	80 U
endrin	16 U	Aroclor 1242	80 U
endosulfan II	16 U	Aroclor 1248	80 U
4,4'-DDD	16 U	Aroclor 1254	160 U
		Aroclor 1260	160 U

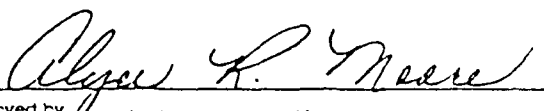
Date Extracted: 06/28/88

Date Analyzed: 07/12/88

Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following samples: 5001, 5002, 5003, 5004, 5005, 5006, 5007, 5007 (1:100), 5008, 5008 (1:5), 5009, 5009 (1:5), 5010, 5012.


Approved by _____
Laboratory Manager

Title



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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 39 OF 57

Sample Description: PBLK1 (Soil)

PESTICIDE AND PCB TARGET COMPOUND LIST

<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>	<u>Compound</u>	<u>Concentration</u> <u>(ug/kg dry weight)</u>
α-BHC	8.0 U	endosulfan sulfate	16 U
β-BHC	8.0 U	4,4'-DDT	16 U
δ-BHC	8.0 U	methoxychlor	80 U
γ-BHC (lindane)	8.0 U	endrin ketone	16 U
heptachlor	8.0 U	α-chlordane	80 U
aldrin	8.0 U	γ-chlordane	80 U
heptachlor epoxide	8.0 U	toxaphene	160 U
endosulfan I	8.0 U	Aroclor 1016	80 U
dieldrin	16 U	Aroclor 1221	80 U
4,4'-DDE	16 U	Aroclor 1232	80 U
endrin	16 U	Aroclor 1242	80 U
endosulfan II	16 U	Aroclor 1248	80 U
4,4'-DDD	16 U	Aroclor 1254	160 U
		Aroclor 1260	160 U

Date Extracted: 10/11/88
Date Analyzed: 10/17/88
Dilution Factor: 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

This method blank applies to the following samples: 5247, 5248, 5249, 5250, 5250 DL, 5250 MS, 5250 MS DL, 5250 MSD, 5250 MSD DL.

DL = Dilution

Allyce R. Moore
Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: September 22, 1988
PROJECT CODE: MMOK 41953
ORDER NUMBER: 11B-02242-HM629
PAGE 1 OF 7

Sample Description: Two (2) water samples received June 22, 1988

Concentration units are mg/liter (ppm)

	<u>Sodium</u>	<u>Calcium</u>	<u>Potassium</u>	<u>Magnesium</u>	<u>Manganese</u>
Preparation Blank	0.2 U	0.09	1 U	0.03 U	0.002 U
5133	131 E	28.2	8	10.6	0.002
5134	158 E	30.0	9	10.4	0.002

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

E - Value exceeded calibration range, but was within instrument linear range.


Approved by: Laboratory Manager

Title

E-172





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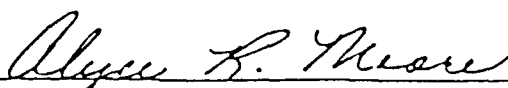
TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40893
ORDER NUMBER: 118-02242-DL-292
PAGE 22 OF 22

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	8FB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VSLK1	102	102	96
FODW01GW0309-8-02	103	109	107
VBLK2	100	101	98
FODW01GW0308-8-01	103	104	101
FODW01GW0308-8-01 MS	105	106	104
FODW01GW0308-8-01 MSD	100	100	99
FODW02GW0309-8-01	104	104	103
FODW02GW0309-8-02	105	105	104
FODW04GW0308-8-01	105	104	106
FODW04GW0309-8-02	104	105	106
FODW05GW0309-8-01	100	100	102
FOTB00RI0304-8-01	94	94	97

*Values in parenthesis represent USEPA contract required QC limits.


Approved by _____
Laboratory Manager

Title

E-173



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field of testing as listed on the current AALA Directory of Accredited Laboratories

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TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-DL-293
PAGE 40 OF 40

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK1	102	105	100
FODW03GW0310-8-01	97	103	96
FOSW05GW0310-8-01	98	106	97
FOER05RI0310-8-01	102	103	107
FOTB00RI0304-8-02	97	97	101
VBLKF2	98	109	92
FOSW01GW0311-8-01	96	109	92
FOSW02GW0311-8-01	95	113	97
FOSW03GW0311-8-01	97	112	89
VBLK1A	99	98	96
FODW06GW0311-8-01	98	96	96
FODW06GW0311-8-01 MS	99	97	94
FODW06GW0311-8-01 MSD	98	99	98
FOSW05GW0311-8-02	100	100	100
FOSW05GW0311-8-03	99	99	101
FODW05GW0311-8-02	101	104	102
VBLK2	103	107	98
FOF805RI0311-8-01	102	103	96
FOTB00RI0304-8-03	102	104	97
FODW05GW0311-8-03	102	102	98
FOSW04GW0311-8-01	96	96	93

*Values in parenthesis represent USEPA contract required QC limits.


Approved by _____
Laboratory Manager

Title



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field of testing. Listed in the current AALA Directory of Accredited Laboratories.



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 7 OF 61

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK1	101	94	106
5055	104	100	110
5064	108	100	110
5103	107	103	112
5104	101	95	104
5105	106	104	112

*Values in parenthesis represent USEPA contract required QC limits.

Approved by

R. M. Wagner
Operations Manager

Title

P-175



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test of testing facilities in the current AALA Directory of Accredited Laboratories

11-3-88



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 118-02242-HM519 & HM524
PAGE 6 OF 56

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK1	97	107	101
5107	100	97	93
5106	97	106	103
5085	101	103	100
5080	91	97	102

*Values in parenthesis represent USEPA contract required QC limits.

Approved by

R. M. Wagner
Operations Manager

Title

E-176



Accredited by the American Association of Laboratory Accreditation in the chemical and physical analysis of water in the State of Tennessee.

11-1-1

**CERTIFICATE OF ANALYSIS**

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41539
ORDER NUMBER: 11B-02242-HM530
PAGE 4 OF 21

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBK1	98	96	91
5152	94	95	90
5110	93	98	89

*Values in parenthesis represent USEPA contract required QC limits.


Approved by Laboratory Manager

Title

E-177



Accredited by the American Association for Laboratory Accreditation in the chemical
field of testing as listed in the current AALA Directory of Accredited Laboratories

11-1-88



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 118-02242-HM515
PAGE 7 OF 56

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK1	99	102	93
5018	95	101	94
5018 MS	104	104	91
VBLK2	107	103	96
5018 MSD	97	96	93
5101	96	93	94
5102	103	104	97

*Values in parenthesis represent USEPA contract required QC limits.

Alyce R. Moore
Approved by: Laboratory Manager

Title

P-178



Accredited by the American Association for Laboratory Accreditation in the Chemical
and Environmental Analysis Laboratory Accreditation Program

11-9-88



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 7 OF 83

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK3	97	101	93
5111	97	101	95
5161	98	100	99
5161 MS	99	102	103
5161 MSD	97	97	101
5112	100	104	101
5158	98	102	104

*Values in parenthesis represent USEPA contract required QC limits.

Alger R. Moore
Approved by Laboratory Manager

Title





CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 118-02242-HM537
PAGE 16 OF 38

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK1	102	104	91
5115	98	100	91
5113	99	101	94
5165	102	104	96
VBLK2	99	99	95
5167	99	99	95
5168	100	98	95
5169	98	96	94
5170	102	102	98
5171	107	104	101
VBLK3	94	96	79
5172	95	97	81
5173	96	99	85
5175	94	96	85
5176	97	98	86

*Values in parenthesis represent USEPA contract required QC limits.

Alyce R. Moore
Approved by Laboratory Manager

Title

11-170





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CERTIFICATE OF ANALYSIS

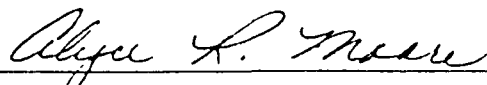
TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41616
ORDER NUMBER: 118-02242-HM538
PAGE 14 OF 24

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BF3 (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK1	99	102	87
5117	102	102	84
5118	96	98	79
5174	99	107	77
5177	103	107	90
5179-81	101	105	92
5179-81 MS	103	97	91
5179-81 MSD	103	101	87
5182	103	105	88
VBLK2	102	101	97
5183	106	101	103
5184	101	98	90
5185	100	97	92
5186	101	101	96

*Values in parenthesis represent USEPA contract required QC limits.


Approved by _____
Laboratory Manager
Title _____



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 118-02242-HM540
PAGE 12 OF 28

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BF3 (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK1	96	95	83
5119	103	96	86
5120	96	86	77
5187	95	92	79
VBLK2	93	90	90
5188	95	87	90
5190	98	90	90
5191	103	92	91
5192	105	88	82
5193	99	91	86
5194	100	91	83

*Values in parenthesis represent USEPA contract required QC limits.

Alger L. Moore
Approved by _____
Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS


TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 19, 1988
PROJECT CODE: MMOK 41637
ORDER NUMBER: 11B-02242-HM541
PAGE 7 OF 12

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBLK1	102	104	93
5195	97	99	80
5198	95	99	78
5198 MS	93	99	77
VBLK2	93	107	88
5198 MSD	98	98	87
5199	94	96	97

*Values in parenthesis represent USEPA contract required QC limits.


Approved by _____
Laboratory Manager

Title

F-133



Approved by the American Association of Environmental Scientists and Technicians (AAAI) for the purpose of certifying the results of the analysis.

11/1/88

**CERTIFICATE OF ANALYSIS**


TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 11B-02242-HM544
PAGE 15 OF 41

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBLK1	100	103	99
5214	96	98	85
5215	97	100	89
VBLK2	97	98	93
5216	100	100	88
5217	96	98	89
5218	100	101	93
5219	98	100	90
5220	96	97	88
5221	98	99	89
VBLK3	96	96	95
5222	105	101	93
5225	105	107	100
5226	96	98	91

*Values in parenthesis represent USEPA contract required QC limits.


Approved by _____
Laboratory Manager

Title _____

F-184



Approved by Alfred L. Moore
Laboratory Manager

Title

P-171

Approved by the American Association of Public Health Laboratories (AAPHL)

11-1-88



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 10 OF 62

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK3	100	109	89
5108	100	107	90
5109	98	104	94
5124	104	111	99
5133	99	104	92
VBLK4	99	103	96
5134	102	104	100
VBLK5	97	101	96
5134 Rerun	105	104	114

*Values in parenthesis represent USEPA contract required QC limits.

Alfred L. Moore
Approved by Laboratory Manager

Title

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Approved by the American Association of Public Health Laboratories (AAPHL)



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 16, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 62 OF 62

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
TCLP Extraction Blank	94	102	100
5099	95	99	95
5132	103	99	95

*Values in parenthesis represent USEPA contract required QC limits.

Alyce K. Moore
Approved by Laboratory Manager

Title





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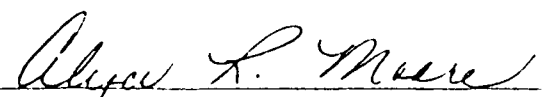
TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 11B-C2242-HM545
PAGE 19 OF 33

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBLK1	94	95	91
5227	95	97	88
5228	94	93	87
5230	91	91	85
5231	102	100	93
5232	100	97	94
VBLK2	93	94	93
5234	90	92	88
5235	97	98	95

*Values in parenthesis represent USEPA contract required QC limits.


Approved by Laboratory Manager

Title





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CERTIFICATE OF ANALYSIS


TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 118-02242-HM641
PAGE 18 OF 39

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BF3 (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBLK1	99	97	94
5234	98	95	91
5235	99	96	92
5236	101	99	94
5237	104	102	97
VBLK2	109	109	103
5244	105	104	103
5244 MS	102	102	99
5244 MSD	103	102	98
5239	104	103	101
5240	105	105	101
5241	104	105	100
5242	105	102	100
5243	103	104	104
VBLK3	97	99	97
5245	93	95	91
5246	100	102	96
5238	99	106	92

*Values in parenthesis represent USEPA contract required QC limits.


Approved by: Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 37 OF 51

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
VBLK1	100	100	94
5262	95	97	101
VBLK2	100	103	97
5263	97	100	99
5264	99	103	102
5265	99	101	92
5266-68	99	108	100
5266-68 MS	100	104	99
5266-68 MSD	101	104	101

*Values in parenthesis represent USEPA contract required QC limits.

Alfred A. Moore

Approved by Laboratory Manager





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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 118-02242-HM647
PAGE 38 OF 51

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	3FB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBLK2A	101	106	98
5270	102	102	100
5271	96	97	94
5272	99	102	97
VBLK3	101	103	96
5276	104	107	98
5276-78 MS	99	103	96
5276-78 MSD	103	102	100
5284	101	101	94
5284-86 MS	102	103	93
5284-86 MSD	106	109	98
5297	102	107	95
5288	99	100	94

*Values in parenthesis represent USEPA contract required QC limits.

Robert A. Martin
Approved by Laboratory Manager

File



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CERTIFICATE OF ANALYSIS

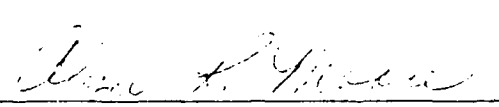
TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 39 OF 51

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	8FB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBLK4	98	96	94
5269	97	98	99
5273	98	103	100
5274	95	101	95
5275	94	99	95
5279	99	103	97
5280	101	109	101
5281	93	97	100
5282	97	104	100
5283	96	101	95
VBLK5	95	98	89
5294	95	102	91
5293	95	105	95
5292	99	104	94
5291	97	104	96
5290	99	106	92
5289	93	98	91

*Values in parenthesis represent USEPA contract required QC limits.


Approved by Laboratory Manager

The





CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 118-02242-HM644
PAGE 18 OF 57

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBLK1A	97	99	97
5251	100	104	102
VBLK2A	98	98	95
5261	97	95	94
5261 MS	107	99	97
5261 MSD	99	96	94
5252	101	99	93
5254	102	99	96
5255	100	98	92
5256	103	100	96
5257	104	101	96
5258	95	94	91
5259	105	101	96
VBLK4	101	106	98
5260	99	100	94
5315	99	100	97
VBLK2	107	91	94
5253	96	86	93

*Values in parenthesis represent USEPA contract required QC limits.

Alyce R. Moore
Approved by Laboratory Manager

Title



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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 18, 1988
PROJECT CODE: MMOK 42231
ORDER NUMBER: 11B-02242-HM682
PAGE 5 OF 16

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
5298	102	99	92
5299	99	98	89
5300	102	99	92
VBLK1	98	98	91

*Values in parenthesis represent USEPA contract required QC limits.

Alger L. Mason
Approved by Laboratory Manager



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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED December 6, 1988
PROJECT CODE MMOK 42335
ORDER NUMBER 11B-02242-HM680
PAGE 13 OF 17

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBK1	101	103	99
5308	105	103	100
5307	103	102	97
5307 MS	101	102	105
5306	90	89	94
5307 MSD	101	99	97
VBK2	107	103	95
5304	108	101	90
5305	110	103	91
VBK3	110	107	102
5301	107	110	100
5302	109	103	89
5303	101	96	88

*Values in parenthesis represent USEPA contract required QC limits.

Alyce L. Moore
Approved by Laboratory Manager

File

E-194



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: S. R. Rizk, K-25
P. O. Box 2003
Oak Ridge, TN 37831-7440

DATE REPORTED January 9, 1989
PROJECT CODE MMOK 42490
ORDER NUMBER 11B-02242-TU880
PAGE 8 OF 11

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (88-110%)*	BFB (86-115%)*	1,2 Dichloroethane-D4 (76-114%)*
VBLK1	97	99	98
5309	95	95	114
5309 MS	91	96	106
5309 MSD	92	94	109
VBLK2	98	93	85
5312	98	94	86
5310	99	93	88
5311	99	91	87

*Values in parenthesis represent USEPA contract required QC limits.

[Signature]

Laboratory Manager



CERTIFICATE OF ANALYSIS

TO:	Martin Marietta Energy Systems, Inc.	DATE REPORTED:	July 22, 1988
	ATTN: Mr. Stuart Goza	PROJECT CODE:	MMOK 41496
	P. O. Box P, MS 440	ORDER NUMBER:	118-02242-HM-514 & 518
	Oak Ridge, TN 37831		47 61
		PAGE	_____ OF _____

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-D4 (70-121%)*
VBLK1	101	94	106
5033	106	97	116
VBLK2	107	103	116
5034	104	95	109
5035	102	95	108
5036	108	103	113
5036 MS	101	93	104
5036 MSD	100	99	103
5037	104	97	101
VBLK3	107	99	92
5038	100	105	108
5039	101	105	104
5041	103	109	111
VBLK4	101	110	103
5040	99	109	116
5042	97	106	118
5043	98	105	119
5044	98	107	117
5046	97	110	118
5047	99	109	121
5045	97	110	116
5048	95	104	120

*Values in parenthesis represent USEPA contract required QC limits.

Robert M. Wagner
Approved by Operations Manager

Title




CERTIFICATE OF ANALYSIS

TO:	Martin Marietta Energy Systems, Inc.	DATE REPORTED:	July 22, 1988
	ATTN: Mr. Stuart Goza	PROJECT CODE:	MMOK 41496
	P. O. Box P, MS 440	ORDER NUMBER:	118-02242-HM-514 & 518
	Oak Ridge, TN 37831		48 61
		PAGE	OF


SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-04 (70-121%)*
VBLK5	101	103	100
5049	100	103	98
5050	99	102	101
5051	102	104	103
VBLK6	102	109	101
5052	99	112	107
5053	89	455**	110
VBLK7	98	104	101
5053 DL	98	109	112
5056	101	113	119
5058	95	109	117
5059	98	108	116
5060	96	105	107
5061	93	106	109
5062	93	105	103
5063	94	104	101
5063 MS	94	107	101
5063 MSD	91	113	100
5057	98	116	99

DL = Dilution

*Values in parenthesis represent USEPA contract required QC limits.

**Values are outside of contract required QC limits.


 Approved by Operations Manager

Title



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE 40 OF 56

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-D4 (70-121%)*
VBLK1	97	107	101
5065	107	113	110
5066	95	102	109
5067	97	107	108
VBLK2	99	100	97
5068	100	97	103
5069	96	97	99
5070	94	97	100
5071	101	104	104
5072	103	98	100
5073	98	92	101
VBLK3A	105	106	101
5074	102	103	99
5075	96	100	101
5076	98	98	100
VBLK4	104	105	97
5077	103	99	93
5078	101	99	89
5078 MS	101	100	94
5078 MSD	95	99	88
5079	94	99	88
5081	97	96	88

*Values in parenthesis represent USEPA contract required QC limits.

John M. Wagner
Approved by Operations Manager

Title



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE 41 OF 56

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-04 (70-121%)*
VBLK5	103	102	99
5082	96	92	95
5083	97	101	101
5084	97	100	92
5086	97	90	95
5087	100	99	95
5088	90	94	94
VBLK6	92	94	84
5089	92	93	84
5090	97	93	79
5091	98	89	103
5092	91	89	81

*Values in parenthesis represent USEPA contract required QC limits.

Approved by

Ray M. Wagon
Operations Manager

Title



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41539
ORDER NUMBER: 118-02242-HM530
PAGE 12 OF 21

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-04 (70-121%)*
VBLK2	99	111	102
5135	98	109	95
5136	95	116	98
5140	93	120	103
5145	88	114	97
5151	86	119	100
5148	88	121	110

*Values in parenthesis represent USEPA contract required QC limits.

Alyce R. Mason
Approved by Laboratory Manager
Title



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 118-02242-HM515
PAGE 34 OF 56

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (81-117%)*	BF3 (74-121%)*	1,2 Dichloroethane-D4 (70-121%)*
VBLK3	105	114	103
5000 (1:5)	103	142**	101
5000 MS (1:125)	99	102	103
5000 MSD (1:125)	94	111	110
5013	110	105	98
5014	109	115	100
VBLK4	105	108	99
5015	93	99	97
5015	100	105	96
5019	103	104	101
5000 (1:125) RE	104	115	102
VBLK5	99	101	87
5020	104	106	91
5021	96	98	82
5023	107	105	90
5024	101	101	85
5025	100	97	86
VBLK6	109	107	108
5027	110	109	111
5028	113	113	112
5029	105	106	113
5030	104	102	110
5031	110	108	113
5032	111	116	129
5022 (1:5)	95	103	101
5032 MS	108	107	126
5032 MSD	108	116	130
VBLK7	106	105	102
5022 (Rerun)	99	99	96

*Values in parenthesis represent USEPA contract required QC limits.

**Values are outside of contract required QC limits.

RE = Rerun

Alger R. Moore
Approved by Laboratory Manager

Title



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 113-G2242-HM520
PAGE 21 OF 62

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-04 (70-121%)*
VBLK10	98	96	95
VBLK10	103	101	93
5093	106	101	92
5094	110	105	97
5095	93	91	91
5096	98	86	84
5097	105	101	98
5098	103	104	92
5100	104	110	90
5121	103	107	93
not 5097 5121 MS	101	96	89
not 5097 5121 MSD	107	101	92

*Values in parenthesis represent USEPA contract required QC limits.

Alger R. Mason
APPROVED BY: Laboratory Manager

100





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box 9, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 35 OF 52

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-04 (70-121%)*
VBLK18	96	98	98
5125	100	93	97
5125 MS	97	94	96
5125 MSD	96	99	95
5122	99	101	98
5125	95	100	92
5127	92	97	95
5123	31	79	82
5129	94	99	101
VBLK2	102	103	96
5123	95	97	98
5131	99	98	95
VBLK6	107	114	101
5130	103	121	100

*Values in parenthesis represent USEPA contract required QC limits.

Alyce R. Moore
Laboratory Manager



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1983
PROJECT CODE: MMOK 42062
ORDER NUMBER: 118-02242-HM644
PAGE 25 OF 57

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-D8 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-D4 (70-121%)*
VBLK3	100	100	94
5250	104	88	91
5250 MS	99	84	92
5250 MSD	106	83	96
5248	102	90	97
5249	115	102	108
VBLK1	94	101	97
5247	85	69**	91

*Values in parenthesis represent USEPA contract required QC limits.

**Values are outside of contract required QC limits.

Roger L. Meene

Laboratory Manager



INTERNATIONAL
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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED November 18, 1988
PROJECT CODE MMOK 42231
ORDER NUMBER 118-02242-HM622
PAGE 11 OF 16

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (81-117%)*	BFB (74-121%)*	1,2 Dichloroethane-04 (70-121%)*
VELK2	91	94	89
5295 3'	93	93	97
5295 3' MS	91	97	94
5295 3' MSD	89	96	94
5295 6'	83	105	89
5297 9'	94	101	104

*Values in parenthesis represent USEPA contract required QC limits.

Alfred L. Moore
Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE 45 OF 56

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	BF3 (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
TCLP Extraction Blank	103	103	99
5054	110	111	100
5054 MS	102	105	98
5054 MSD	95	95	89

*Values in parenthesis represent USEPA contract required QC limits.

Approved by

R. M. Weger
Operations Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41539
ORDER NUMBER: 113-02242-HM530
PAGE 15 OF 21

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	VOLATILE		
	Toluene-08 (88-110%)*	8F3 (86-115%)*	1,2 Dichloroethane-04 (76-114%)*
5141	93	83	79
TCLP Extraction Blank	103	93	93

*Values in parenthesis represent USEPA contract required QC limits.

Allyce C. Mease
APPROVED: Laboratory Manager



INTERNATIONAL
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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1983
PROJECT CODE: MMOK 41608
ORDER NUMBER: 113-02242-HM537
PAGE 23 OF 32

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	SEMI-VOLATILE					
	Nitro- Benzene-35 (35-114%)*	2-Fluoro- Biphenyl (43-116%)*	Terphenyl- 014 (33-141%)*	Phenol-05 (10-94%)*	2-Fluoro- Phenol (21-100%)*	2,4,6 Tribromo- Phenol (10-123%)
5163	73	85	95	8**	15**	55
5170	69	79	86	6**	12**	47
SBLK1	79	84	111	38	63	93

*Values in parenthesis represent USEPA contract required QC limits.

**Values are outside of contract required QC limits.

Alger R. Mason
Approved by Laboratory Manager



ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-568-6401



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 118-02242-HM540
PAGE 17 OF 28

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	SEMI-VOLATILE					
	Nitro- Benzene-D5 (35-114%)*	2-Fluoro- Biphenyl (43-116%)*	Terphenyl- D14 (33-141%)*	Phenol-D5 (10-94%)*	2-Fluoro- Phenol (21-100%)*	2,4,6 Tribromo- Phenol (10-123%)*
5189	71	84	100	22	39	82
S8LK1	56	64	91	25	46	83

*Values in parenthesis represent USEPA contract required QC limits.

Alfred H. Moore
Approved by Laboratory Manager



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TECHNOLOGY
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5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 118-02242-HM544
PAGE 26 OF 41

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	SEMI-VOLATILE					2,4,6 Tribromo- Phenol (10-123%)*
	Nitro- Benzene-D5 (35-114%)*	2-Fluoro- Biphenyl (43-116%)*	Terphenyl- D14 (33-141%)*	Phenol-D5 (10-94%)*	2-Fluoro- Phenol (21-100%)*	
5214	59	73	101	33	60	95
5217	73	87	106	25	42	74
5218	72	82	105	27	44	67
5219	51	70	107	28	49	81
SBLK1	80	92	114	33	57	91

*Values in parenthesis represent USEPA contract required QC limits.

Alger R. Moore
Approved by: Laboratory Manager



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ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-Q2242-HM520
PAGE 42 OF 62

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	SEMI-VOLATILE					
	Nitro- Benzene-D5 (35-114%)*	2-Fluoro- Biphenyl (43-116%)*	Terphenyl- D14 (33-141%)*	Phenol-D5 (10-94%)*	2-Fluoro- Phenol (21-100%)*	2,4,6 Tribromo- Phenol (10-123%)*
5133	71	69	98	28	53	76
5134	74	74	89	27	48	70
S8LK1	82	74	86	34	53	78

*Values in parenthesis represent USEPA contract required QC limits.

Alfred R. Moore

Laboratory Manager



ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401



CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED August 23, 1988
PROJECT CODE MMOK 41655
ORDER NUMBER 11B-02242-HM545
PAGE 21 OF 33

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	SEMI-VOLATILE					
	Nitro- Benzene-D5 (35-114%)*	2-Fluoro- Biphenyl (43-116%)*	Terphenyl- D14 (33-141%)*	Phenol-D5 (10-94%)*	2-Fluoro- Phenol (21-100%)*	2,4,6 Tribromo- Phenol (10-123%)*
5227	91	87	111	12	70	111
5230	68	75	111	37	66	91
5231	76	83	108	39	69	97
5232	85	90	117	41	73	91
SBLK1	67	73	100	32	60	81

*Values in parenthesis represent USEPA contract required QC limits.

Alice R. Mann
Approved By Laboratory Manager



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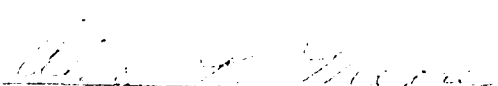
TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 27 OF 39

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	SEMI-VOLATILE					
	Nitro- Benzene-25 (35-114%)*	2-Fluoro- Biphenyl (43-116%)*	Terphenyl- D14 (33-141%)*	Phenol-D5 (10-94%)*	2-Fluoro- Phenol (21-100%)*	2,4,6 Tribromo- Phenol (10-123%)*
5234	79	77	90	36	52	71
5235	79	77	90	36	52	71
5236	73	68	84	34	48	56
S8LK1	44	53	57	25	46	74

*Values in parenthesis represent USEPA contract required QC limits.

Approved by 
Laboratory Manager



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 58 OF 83

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	SEMI-VOLATILE					
	Nitro- Benzene-D5 (23-120%)*	2-Fluoro- Biphenyl (30-116%)*	Terphenyl- D14 (18-137%)*	Phenol-D5 (24-113%)*	2-Fluoro- Phenol (25-121%)*	2,4,5 Tribromo- Phenol (18-122%)*
5001	71	74	99	71	70	86
5002	71	74	85	71	64	80
5003	90	75	82	70	68	72
5004	73	72	96	76	67	91
5005	75	78	92	75	71	76
5006	50	52	64	49	48	52
5007	89	79	95	66	68	70
5007 (1:12)	72	85	132	49	66	118
5008	63	71	80	62	63	65
5009	57	66	70	57	60	63
5010	80	77	92	74	73	78
5012	60	56	67	66	61	43
S3LK1	62	55	72	63	56	41

*Values in parenthesis represent USEPA contract required QC limits.


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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 118-02242-HM644
PAGE 38 OF 57

SOIL SURROGATE PERCENT RECOVERY SUMMARY

SEMI-VOLATILE

Sample No.	Nitro- Benzene-D5 (23-120%)*	2-Fluoro- Biphenyl (30-115%)*	Terphenyl- D14 (18-137%)*	Phenol-D5 (24-113%)*	2-Fluoro- Phenol (25-121%)*	2,4,6 Tribromo- Phenol (19-122%)*
5247	49	50	103	47	55	30
5248	65	56	94	57	66	44
5249	77	82	80	61	68	60
5250	73	67	105	27	65	35
5250 MS	77	64	100	63	65	35
5250 MSD	66	65	101	72	67	46
S3LK1	70	70	74	51	65	66

*Values in parenthesis represent USEPA contract required QC limits.

Alvin R. Mason
Approved by Laboratory Manager
Title



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 118-02242-HM515
PAGE 40 OF 56

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	SEMI-VOLATILE					
	Nitro- Benzene-D5 (23-120%)*	2-Fluoro- Biphenyl (30-115%)*	Terphenyl- D14 (18-137%)*	Phenol-D5 (24-113%)*	2-Fluoro- Phenol (26-121%)*	2,4,6 Tribromo- Phenol (18-122%)*
5000	241**	87	74	70	69	78
5000 MS	118	70	82	73	78	80
5000 MSD	139**	90	86	77	76	90
S8LK1	94	79	98	103	89	89

*Values in parenthesis represent USEPA contract required QC limits.

**Values are outside of contract required QC limits.

Allyce R. Meaw
Approved by Laboratory Manager

T-100



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 118-02242-HM537
PAGE 27 OF 38

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	Dibutylchlorodate (24-154%)*
5168	104
5170	182**
PBLK1	95

*Values in parenthesis represent USEPA advisory QC limits.
**Values are outside of contract required QC limits.

Alyce K. Moore
Approved by Laboratory Manager

File



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 11B-02242-HM540
PAGE 20 OF 28

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	Dibutylchlorodate (24-154%)*
5189	83
PBLK1	99

*Values in parenthesis represent USEPA advisory QC limits.

Alice L. Moore
Approved by Laboratory Manager

Title





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 22, 1988
PROJECT CODE: MMOK 41649
ORDER NUMBER: 118-02242-HM544
PAGE 32 OF 41

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	Dibutylchlorodate (24-154%)*
5214	90
5217	3**
5218	94
5219	1**
PBLK1	94

*Values in parenthesis represent USEPA advisory QC limits.

**Values are outside of contract required QC limits.

Allyce R. Moore
Approved by Laboratory Manager

Date





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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 46 OF 52

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	Dibutylchlorodate (24-154%)*
5133	102
5134	103
PBLK1	95

*Values in parenthesis represent USEPA advisory QC limits.

Allyce R. Moore
Approved by Laboratory Manager

END



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 118-02242-HM545
PAGE 27 OF 33

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	Dibutylchloroendate (24-154%)*
5227	89
5230	89
5231	97
5232	96
PBLK1	87

*Values in parenthesis represent USEPA advisory QC limits.

Alyce L. Mason
Approved by Laboratory Manager

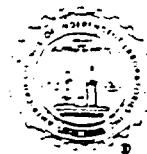
118





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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831


DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 33 OF 39

WATER SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	Dibutylchlorodate (24-154%)*
5234	95
5235	92
5236	96
PBLK1	193**
PBLK2	94

*Values in parenthesis represent USEPA advisory QC limits.

**Values are outside of contract required QC limits.


Approved By: Laboratory Manager

11/2/88





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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 71 OF 83

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	Dibutylchlorodate (20-150%)*
5001	80
5002	75
5003	93
5004	85
5005	96
5006	57
5007	52
5007 (1:100)	0
5008	100
5008 (1:5)	97
5009	84
5009 (1:5)	98
5010	85
5012	87
PBLK1	88

*Values in parenthesis represent USEPA advisory QC limits.

0 = Surrogate diluted out

Alyce R. Moore
Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 45 OF 57

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	<u>Dibutylchlorodate</u> (20-150%)*
5247	91
5248	71
5249	83
5250	68
5250 DL	60
5250 MS	93
5250 MS DL	86
5250 MSD	93
5250 MSD DL	58
PBLK1	78

*Values in parenthesis represent USEPA advisory QC limits.

DL = Dilution

Alyce R. Moore
Approved by Laboratory Manager

Title

11-224





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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 44 OF 56

SOIL SURROGATE PERCENT RECOVERY SUMMARY

Sample No.	PESTICIDE
	Dibutylchlorodate (20-150%)*
5000	88
5000 (1:5)	86
5000 MS	79
5000 MSD	92
PBLK1	77

*Values in parenthesis represent USEPA advisory QC limits.

Allyce A. Moore
Approved by Laboratory Manager

Title




CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40893
ORDER NUMBER: 118-02242-DL-292
PAGE 17 OF 22

Sample Description: F00W01GW0308-8-01

Field No. 0001

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added (ug/liter)	Sample Conc. (ug/liter)	MS Conc. (ug/liter)	MS % Rec.
1,1-dichloroethene	50.	5 U	56	112
trichloroethene	50.	5 U	46	?
benzene	50.	5 U	51	102
toluene	50.	5 U	50.	100
chlorobenzene	50.	5 U	51	102

Compound	Conc. Spike Added (ug/liter)	MSD Conc. (ug/liter)	MSD % Rec.	RPD
1,1-dichloroethene	50.	55	110	-
trichloroethene	50.	45	90.	2
benzene	50.	49	98	-
toluene	50.	50.	100	-
chlorobenzene	50.	50.	100	?

RPD = Relative Percent Difference

U = Compound was analyzed for but not detected. The number is the detection limit for sample.

Alice R. Moore
Approved by _____
Laboratory Manager

Title _____

P-226



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5-14



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ATTN: Ms. Susan R. Rizk
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: April 29, 1988
PROJECT CODE: MMOK 40894
ORDER NUMBER: 118-02242-DL-293
PAGE 31 OF 40

Sample Description: FODW03GW0310-8-01

Field No. 0009

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added (ug/liter)	Sample Conc. (ug/liter)	MS Conc. (ug/liter)	MS Rec
1,1-dichloroethene	50.	5 U	54	108
trichloroethene	50.	5 U	49	98
benzene	50.	5 U	51	102
toluene	50.	5 U	51	102
chlorobenzene	50.	5 U	52	104

Compound	Conc. Spike Added (ug/liter)	MSD Conc. (ug/liter)	MSD % Rec.	% RPD
1,1-dichloroethene	50.	55	110	-2
trichloroethene	50.	48	96	2
benzene	50.	50.	100	2
toluene	50.	51	102	0
chlorobenzene	50.	52	104	0

RPD = Relative Percent Difference

U = Compound was analyzed for but not detected. The number is the detection limit for sample.

Alyce R. Moore
Approved by Laboratory Manager

Title



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P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 3 OF 56

Sample Description: 5018


WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

<u>Compound</u>	<u>Conc. Spike Added (ug/liter)</u>	<u>Sample Conc. (ug/liter)</u>	<u>MS Conc. (ug/liter)</u>	<u>MS % Rec.</u>
1,1-dichloroethene	50	5 U	41	82
trichloroethene	50	5 U	49	98
benzene	50	5 U	53	106
toluene	50	5 U	58	116
chlorobenzene	50	5 U	61	122

<u>Compound</u>	<u>Conc. Spike Added (ug/liter)</u>	<u>MSD Conc. (ug/liter)</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	50	39	78	5
trichloroethene	50	50	100	-2
benzene	50	49	98	8
toluene	50	51	102	13
chlorobenzene	50	59	118	3

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by: Laboratory Manager

Title

E-228



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03-9-8


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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 6 OF 83

Sample Description: 5161

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY


Compound	Conc. Spike Added (ug/liter)	Sample Conc. (ug/liter)	MS Conc. (ug/liter)	MS % Rec.
1,1-dichloroethene	50	5 U	23	46*
trichloroethene	50	5 U	46	92
benzene	50	5 U	47	94
toluene	50	5 U	54	108
chlorobenzene	50	5 U	58	116

Compound	Conc. Spike Added (ug/liter)	MSD Conc. (ug/liter)	MSD % Rec.	% RPD
1,1-dichloroethene	50	22	44*	4
trichloroethene	50	48	96	-4
benzene	50	47	94	0
toluene	50	54	108	0
chlorobenzene	50	59	118	-2

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

*Asterisked values are outside USEPA advisory QC limits.


Approved by _____
Laboratory Manager
Title _____



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41616
ORDER NUMBER: 118-02242-HM538
PAGE 7 OF 24

Sample Description: 5179, 5180, 5181

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added (ug/liter)	Sample Conc. (ug/liter)	MS Conc. (ug/liter)	MS % Rec.
1,1-dichloroethene	50	5 U	50	100
trichloroethene	50	5 U	49	98
benzene	50	5 U	52	104
toluene	50	5 U	52	104
chlorobenzene	50	5 U	52	104

Compound	Conc. Spike Added (ug/liter)	MSD Conc. (ug/liter)	MSD % Rec.	% RPD
1,1-dichloroethene	50	51	102	-2
trichloroethene	50	47	94	4
benzene	50	52	104	0
toluene	50	53	106	-2
chlorobenzene	50	53	106	-2

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alyce L. Moore
Approved by Laboratory Manager
Title

F-230



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ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 19, 1988
PROJECT CODE: MMOK 41637
ORDER NUMBER: 118-02242-HM541
PAGE 4 OF 12

Sample Description: 5198

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added (ug/liter)	Sample Conc. (ug/liter)	MS Conc. (ug/liter)	MS % Rec.
1,1-dichloroethene	50	5 U	48	96
trichloroethene	50	5 U	52	104
benzene	50	5 U	50	100
toluene	50	5 U	47	94
chlorobenzene	50	5 U	54	108

Compound	Conc. Spike Added (ug/liter)	MSD Conc. (ug/liter)	MSD % Rec.	% RPD
1,1-dichloroethene	50	50	100	-4
trichloroethene	50	51	102	2
benzene	50	55	110	-10
toluene	50	52	104	-10
chlorobenzene	50	53	106	2

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alyce R. Moore
Approved by Laboratory Manager

Title



Oak Ridge Gaseous Diffusion Plant
Analytical Chemistry Department
Results of Analyses

ANALIS ID: 880714-070 Project: G111 AKW Customer Sample ID: TB-5200
Customer: FORBES FIELD Requisition Number:
Date Sampled: Date Sample Received: 14-JUL-1988
Sampled By: Date Sample Completed: 17-AUG-1988
Material Description: WELL WATERS

Activ. Preparation	Analysis					QA	Dat
Number	Procedure No.	Analysis	Result	Units	Analyst	File Number	Compl. ec

***** Comments from the Organic Mass Spectroscopy Laboratory *****

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

COMPOUND	SPIKE ADDED (ug/L)	SAMPLE CONC (ug/L)	MS CONC (ug/L)	MS % REC #	QC LIMITS REC.
1,1-Dichloroethene	50.00	0.00	42.00	83	61-145
Trichloroethene	50.00	0.00	46.00	91	71-120
Benzene	50.00	0.00	47.00	93	76-127
Toluene	50.00	0.00	51.00	101	76-125
Chlorobenzene	50.00	0.00	47.00	94	75-130

COMPOUND	SPIKE ADDED (ug/L)	MSD CONC (ug/L)	MSD % REC #	% RPD #	QC LIMITS RPD REC.
1,1-Dichloroethene	50.00	43.00	86	3	14 61-145
Trichloroethene	50.00	57.00	114	22*	14 71-120
Benzene	50.00	48.00	96	3	11 76-127
Toluene	50.00	60.00	120	17*	13 76-125
Chlorobenzene	50.00	56.00	111	16*	13 75-130

* Values outside of qc limits

Program Manager: MS Miller
Date Approved: 17-AUG-1988



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 118-02242-HM641
PAGE 13 OF 39

Sample Description: 5244

Concentration units are $\mu\text{g/liter}$ (ppb)


WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	Conc. Spike Added	Sample Conc.	MS Conc.	MS % Rec.	QC Limits Rec.
1,1-dichloroethene	50	5 U	50	100	61 - 145
trichloroethene	50	5 U	49	98	71 - 120
benzene	50	5 U	49	98	76 - 127
toluene	50	5 U	50	100	76 - 125
chlorobenzene	50	5 U	51	102	75 - 130

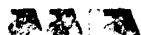
	Conc. Spike Added	MSD Conc.	MSD % Rec.	% RPD	QC Limits RPD Rec.
1,1-dichloroethene	50	51	102	-2	14 61 - 145
trichloroethene	50	51	102	-4	14 71 - 120
benzene	50	51	102	-4	11 76 - 127
toluene	50	52	104	-4	13 76 - 125
chlorobenzene	50	53	106	-4	13 75 - 130

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

11/2/88





CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 14 OF 57

Sample Description: 5261

Concentration units are $\mu\text{g/liter}$ (ppb)

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	50	5 U	46	92	61 - 145
trichloroethene	50	5 U	51	102	71 - 120
benzene	50	5 U	51	102	76 - 127
toluene	50	5 U	51	102	76 - 125
chlorobenzene	50	5 U	52	104	75 - 130

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>	<u>QC Limits RPD Rec.</u>
1,1-dichloroethene	50	46	92	0	14 61 - 145
trichloroethene	50	51	102	0	14 71 - 120
benzene	50	51	102	0	11 76 - 127
toluene	50	50	100	2	13 76 - 125
chlorobenzene	50	51	102	2	13 75 - 130

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Robert R. Moore
Laboratory Manager

Title



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 8 OF 51

Sample Description: 5266-68

Concentration units are $\mu\text{g/liter}$ (ppb)

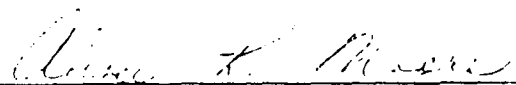
WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	50	5 U	47	94	61 - 145
trichloroethene	50	5 U	51	102	71 - 120
benzene	50	5 U	56	112	76 - 127
toluene	50	5 U	55	110	76 - 125
chlorobenzene	50	5 U	58	116	75 - 130

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>	<u>RPD</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	50	46	92	2	14	61 - 145
trichloroethene	50	50	100	2	14	71 - 120
benzene	50	54	108	4	11	76 - 127
toluene	50	54	108	2	13	76 - 125
chlorobenzene	50	58	116	0	13	75 - 130

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by _____ Laboratory Manager

Title _____





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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 118-02242-HM647
PAGE 15 OF 51

Sample Description: 5276-78

Concentration units are $\mu\text{g/liter}$ (ppb)

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	50	5 U	46	92	61 - 145
trichloroethene	50	5 U	51	102	71 - 120
benzene	50	5 U	50	100	76 - 127
toluene	50	5 U	51	102	76 - 125
chlorobenzene	50	5 U	51	102	75 - 130

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>	<u>QC Limits RPD Rec.</u>
1,1-dichloroethene	50	46	92	0	14 61 - 145
trichloroethene	50	51	102	0	14 71 - 120
benzene	50	50	100	0	11 76 - 127
toluene	50	50	100	2	13 76 - 125
chlorobenzene	50	52	104	-2	13 75 - 130

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alan H. Thomas

Approved by Laboratory Manager

Date





ANALYTICAL SERVICES

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TO
Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 118-02242-HM647
PAGE 17 OF 51

Sample Description: 5284-86

Concentration units are $\mu\text{g/liter}$ (ppb)

WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	50	5 U	44	88	61 - 145
trichloroethene	50	5 U	50	100	71 - 120
benzene	50	5 U	48	96	76 - 127
toluene	50	5 U	49	98	76 - 125
chlorobenzene	50	5 U	50	100	75 - 130

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>	<u>QC Limits RPD Rec.</u>
1,1-dichloroethene	50	46	92	-4	14 61 - 145
trichloroethene	50	53	106	-6	14 71 - 120
benzene	50	51	102	-6	11 76 - 127
toluene	50	52	104	-6	13 76 - 125
chlorobenzene	50	53	106	-6	13 75 - 130

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title



CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: December 6, 1988
PROJECT CODE: MMOK 42335
ORDER NUMBER: 11B-02242-HM680
PAGE 12 OF 17

Sample Description: 5307 (Water)

Concentration units are µg/liter (ppb)

VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	50	5 U	44	88	59 - 172
trichloroethene	50	5 U	45	90	62 - 137
benzene	50	4 J	52	96	66 - 142
toluene	50	5 U	48	96	59 - 139
chlorobenzene	50	5 U	52	104	60 - 133

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>RPD</u>	<u>QC Limits RPD Rec.</u>
1,1-dichloroethene	50	42	84	5	22 59 - 172
trichloroethene	50	44	88	2	24 62 - 137
benzene	50	49	90	6	21 66 - 142
toluene	50	49	98	-2	21 59 - 139
chlorobenzene	50	51	102	2	21 60 - 133

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Allyce F. Moore
Approved by Laboratory Manager

Title



CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: S. R. Rizk, K-25
P. O. Box 2003
Oak Ridge, TN 37831-7440

DATE REPORTED January 9, 1989
PROJECT CODE MMOK 42490
ORDER NUMBER 118-02242-TU880
PAGE 3 OF 11

Sample Description: 5309

Concentration units are µg/liter (ppb)


WATER VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	50	5 U	51	102	61 - 145
trichloroethene	50	5 U	52	104	71 - 120
benzene	50	5 U	42	84	76 - 127
toluene	50	5 U	47	94	76 - 125
chlorobenzene	50	5 U	48	96	75 - 130

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>RPD</u>	<u>RPD</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	50	49	98	4	14	61 - 145
trichloroethene	50	52	104	0	14	71 - 120
benzene	50	42	84	0	11	76 - 127
toluene	50	48	96	-2	13	76 - 125
chlorobenzene	50	48	96	0	13	75 - 130

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


 Approved by _____
 Laboratory Manager

File



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 10 OF 56

Sample Description: 5000 (1:125)

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>
1,1-dichloroethene	7,500	750 U	6,000	80
trichloroethene	7,500	750 U	7,500	100
benzene	7,500	750 U	7,700	103
toluene	7,500	750 U	8,200	109
chlorobenzene	7,500	750 U	10,000	133

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	7,500	6,500	87	-8
trichloroethene	7,500	7,700	103	-3
benzene	7,500	8,200	109	-6
toluene	7,500	7,800	104	5
chlorobenzene	7,500	9,400	125	6

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Alyce L. Moore Laboratory Manager

Title _____



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 31 OF 56

Sample Description: 5032

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

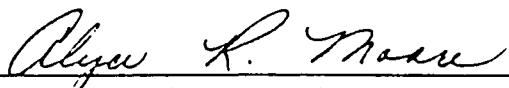
	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>
1,1-dichloroethene	62	6 U	66	106
trichloroethene	62	6 U	54	87
benzene	62	6 U	70	113
toluene	62	6 U	68	110
chlorobenzene	62	6 U	68	110

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	62	50	81	27*
trichloroethene	62	51	82	6
benzene	62	71	114	-1
toluene	62	65	105	5
chlorobenzene	62	68	110	0

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

*Asterisked values are outside USEPA advisory QC limits.


Approved by Laboratory Manager

Title





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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 14 OF 61

Sample Description: 5036

Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>
1,1-dichloroethene	62	6 U	43	69
trichloroethene	62	6 U	59	95
benzene	62	6 U	54	87
toluene	62	6 U	65	105
chlorobenzene	62	6 U	65	105

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	62	44	71	-3
trichloroethene	62	58	94	-1
benzene	62	55	89	-2
toluene	62	63	102	3
chlorobenzene	62	65	105	0

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by

Robert M. Wagner
Operations Manager

Title



F-242
Accredited by the American Association for Laboratory Accreditation in the chemical
field of testing, as listed in the current AALA Directory of Accredited Laboratories

93-9-85



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 118-02242-HM-514 & 518
PAGE 46 OF 61

Sample Description: 5063

Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>Rec.</u>
1,1-dichloroethene	60	6 U	38	63
trichloroethene	60	6 U	59	98
benzene	60	6 U	58	97
toluene	60	6 U	63	105
chlorobenzene	60	6 U	70	117

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	60	39	65	-3
trichloroethene	60	58	97	1
benzene	60	57	95	2
toluene	60	62	103	2
chlorobenzene	60	70	117	0

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Operations Manager

Title



Accredited by the American Association for Laboratory Accreditation in the chemical analysis of soil and water. Listed in the current AALA Directory of Accredited Laboratories.

11-1-85



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE: 25 OF 56

Sample Description: 5078

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>
1,1-dichloroethene	60	6 U	41	68
trichloroethene	60	6 U	63	105
benzene	60	6 U	64	107
toluene	60	6 U	68	113
chlorobenzene	60	6 U	72	120

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	61	43	70	-3
trichloroethene	61	66	108	-3
benzene	61	64	105	2
toluene	61	68	111	2
chlorobenzene	61	73	120	0

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Operations Manager

Title

P-244



Accredited by the American Association for Laboratory Accreditation in the chemical field of testing as listed in the current AAAL Directory of Accredited Laboratories

93-5



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 13A OF 62

Sample Description: 5097

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>
1,1-dichloroethene	64	6 U	36	56
trichloroethene	64	6 U	51	80
benzene	64	6 U	53	83
toluene	64	9	58	91
chlorobenzene	64	6 U	61	95

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	64	35	55	2
trichloroethene	64	50	78	2
benzene	64	52	81	2
toluene	64	58	91	0
chlorobenzene	64	60	94	1

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alyce R. Moore
Approved by Laboratory Manager

Title



Approved by the American Society for Testing and Materials (ASTM) for use in the laboratory.



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 11, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 118-02242-HM520
PAGE 25 OF 62

Sample Description: 5125

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY


	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec</u>
1,1-dichloroethene	68	7 U	36	53*
trichloroethene	68	7 U	66	97
benzene	68	7 U	65	96
toluene	68	7 U	72	106
chlorobenzene	68	7 U	77	113

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	68	36	53*	0
trichloroethene	68	65	96	1
benzene	68	64	94	-2
toluene	68	72	106	0
chlorobenzene	68	77	113	0

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

*Asterisked values are outside USEPA advisory QC limits.


Approved by: Laboratory Manager

Title

F-246



Accredited by the American Association for Laboratory Accreditation in the chemical testing field as listed in the current AALA Directory of Accredited Laboratories

11-2



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 11B-02242-HM525
PAGE 32 OF 83

Sample Description: 5163

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>
1,1-dichloroethene	60	6 U	25	42*
trichloroethene	60	6 U	52	87
benzene	60	6 U	48	80
toluene	60	6 U	57	95
chlorobenzene	60	6 U	65	108

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
1,1-dichloroethene	60	24	40*	5
trichloroethene	60	53	88	-1
benzene	60	48	80	0
toluene	60	58	97	-2
chlorobenzene	60	67	112	-4

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

*Asterisked values are outside USEPA advisory QC limits.

Approved by

Alyce R. Mason

Laboratory Manager

Title

P-247



Accredited by the American Association for Laboratory Accreditation in the chemical
field of testing listed in the current AALA directory of Accredited Laboratories

21-4-88


CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 25 OF 57

Sample Description: 5250

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight

SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	64	6 U	55	86	59 - 172
trichloroethene	64	6 U	60	94	62 - 137
benzene	64	6 U	66	103	66 - 142
toluene	64	6 U	64	100	59 - 139
chlorobenzene	64	6 U	65	102	60 - 133

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>	<u>QC Limits RPD Rec.</u>
1,1-dichloroethene	64	57	89	-3	22 59 - 172
trichloroethene	64	62	97	-3	24 62 - 137
benzene	64	66	103	0	21 66 - 142
toluene	64	70	109	-9	21 59 - 139
chlorobenzene	64	68	106	-4	21 60 - 133

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title



CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 18, 1988
PROJECT CODE: MMOK 42231
ORDER NUMBER: 11B-02242-HM682
PAGE 8 OF 16

Sample Description: 5295 3'

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight


SOIL VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
1,1-dichloroethene	59	6 U	47	80	59 - 172
trichloroethene	59	6 U	50	85	62 - 137
benzene	59	6 U	54	92	66 - 142
toluene	59	6 U	54	92	59 - 139
chlorobenzene	59	6 U	56	95	60 - 133

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>RPD</u>	<u>QC Limits RPD Rec.</u>
1,1-dichloroethene	59	48	81	-1	22 59 - 172
trichloroethene	59	50	85	0	24 62 - 137
benzene	59	54	92	0	21 66 - 142
toluene	59	53	90	2	21 59 - 139
chlorobenzene	59	56	95	0	21 60 - 133

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


 Approved by Laboratory Manager

Title



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5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 11B-02242-HM519 & HM524
PAGE 44 OF 56

Sample Description: 5054 (TCLP Extract)

VOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added ($\mu\text{g/liter}$)	Sample Conc. ($\mu\text{g/liter}$)	MS Conc. ($\mu\text{g/liter}$)	MS % Rec.
1,1-dichloroethene	50	5 U	37	74
trichloroethene	50	5 U	51	102
benzene	50	5 U	49	98
toluene	50	5 U	57	114
chlorobenzene	50	5 U	58	116

Compound	Conc. Spike Added ($\mu\text{g/liter}$)	MSD Conc. ($\mu\text{g/liter}$)	MSD % Rec.	% RPD
1,1-dichloroethene	50	38	76	-3
trichloroethene	50	52	104	-2
benzene	50	49	98	0
toluene	50	54	108	5
chlorobenzene	50	60	120	3

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by

R. M. Wagner
Operations Manager

Title



Accredited by the American Association for Laboratory Accreditation in the chemical field. Testing is listed in the current AALA Directory of Accredited Laboratories.

93-2



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 39 OF 56

Sample Description: 5000

Concentration units are $\mu\text{g/kg}$ dry weight

SOIL SEMIVOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	Conc. Spike Added	Sample Conc.	MS Conc.	MS % Rec.
phenol	8,050	1,600 U	5,330	66
2-chlorophenol	8,050	1,600 U	5,100	63
1,4-dichlorobenzene	4,020	1,600 U	2,480	62
n-nitroso-di-n-propylamine	4,020	1,600 U	4,980	124
1,2,4-trichlorobenzene	4,020	1,600 U	2,770	69
4-chloro-3-methylphenol	8,050	1,600 U	4,990	62
acenaphthene	4,020	1,600 U	2,930	73
4-nitrophenol	8,050	7,700 U	4,140	51
2,4-dinitrotoluene	4,020	1,600 U	3,930	98*
pentachlorophenol	8,050	7,700 U	4,230	53
pyrene	4,020	259 J	3,090	70
	Conc. Spike Added	MSD Conc.	MSD % Rec.	% RPD
phenol	8,110	5,630	69	-4
2-chlorophenol	8,110	5,060	62	2
1,4-dichlorobenzene	4,060	2,370	58	7
n-nitroso-di-n-propylamine	4,060	4,350	107	15
1,2,4-trichlorobenzene	4,060	2,850	70	-1
4-chloro-3-methylphenol	8,110	7,120	88	-35*
acenaphthene	4,060	2,770	68	7
4-nitrophenol	8,110	4,780	59	-15
2,4-dinitrotoluene	4,060	3,910	96*	2
pentachlorophenol	8,110	3,570	44	19
pyrene	4,060	3,290	75	-7

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

*Asterisked values are outside USEPA advisory QC limits.

RPD = Relative Percent Difference

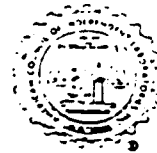
Approved by

Cheryl L. Moore
Laboratory Manager

Title

E-251





CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 37 OF 57

Sample Description: 5250
Concentration units are µg/kg dry weight

SOIL SEMIVOLATILE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>
phenol	8,550	840 U	5,130	60
2-chlorophenol	8,550	840 U	5,770	67
1,4-dichlorobenzene	4,280	840 U	2,570	60
n-nitroso-di-n-propylamine	4,280	840 U	3,040	71
1,2,4-trichlorobenzene	4,280	840 U	2,600	61
4-chloro-3-methylphenol	8,550	840 U	5,800	68
acenaphthene	4,280	840 U	3,020	71
4-nitrophenol	8,550	4,100 U	6,090	71
2,4-dinitrotoluene	4,280	840 U	2,240	52
pentachlorophenol	8,550	4,100 U	4,790	56
pyrene	4,280	1,130	3,740	61

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
phenol	8,460	5,400	64	-6
2-chlorophenol	8,460	6,360	75	-11
1,4-dichlorobenzene	4,230	2,710	64	-6
n-nitroso-di-n-propylamine	4,230	3,180	75	-5
1,2,4-trichlorobenzene	4,230	2,580	61	0
4-chloro-3-methylphenol	8,460	6,440	76	-11
acenaphthene	4,230	3,120	74	-4
4-nitrophenol	8,460	6,640	78	-9
2,4-dinitrotoluene	4,230	2,230	53	-2
pentachlorophenol	8,460	5,060	60	-7
pyrene	4,230	3,820	64	-5

RPD - Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Approved by

Robert L. Moore
Laboratory Manager

Title



ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 118-02242-HM515
PAGE 46 OF 56

Sample Description: 5018

Concentration units are $\mu\text{g/liter}$ (ppb)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Benzene	2.2	0.5 U	2.1	95	2.6	118	-21
Toluene	3	1 U	3	100	3	100	0
Ethyl Benzene	20	4 U	20	100	20	100	0
m-Xylene	6.4	1.3 U	6.6	103	6.6	103	0
p-Xylene	6.4	1.3 U	6.6	103	6.5	102	1
o-Xylene	6.6	1.3 U	7.0	106	6.8	103	3

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alyce R. Moore
Approved by Laboratory Manager

Title

PL-253



Accredited by the American Association for Laboratory Accreditation in the chemical
and physical sciences in the United States and in the United Kingdom

93-4-45



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42047
ORDER NUMBER: 11B-02242-HM641
PAGE 37 OF 39

Sample Description: 5244 (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Benzene	2.44	0.5 U	2.70	111	2.95	121	-9
Toluene	4.8	3	9.5	135	10.0	146	-8
Ethyl Benzene	19.4	4 U	21.9	113	23.7	122	-8
Total Xylenes	19.4	4 U	22.3	115	24.2	125	-8

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by / Laboratory Manager

Title

F-254



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11-4-88



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 118-02242-HM537
PAGE 31 OF 38

Sample Description: 5165

Concentration units are $\mu\text{g/liter}$ (ppb)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>Sample Result</u>	<u>Conc. MS</u>	<u>% Rec.</u>	<u>Conc. MSD</u>	<u>% Rec.</u>	<u>RPD</u>
benzene	2.2	0.5 U	2.8	127	2.8	127	0
toluene	2.6	1.1	4.1	115	3.9	108	6
ethyl benzene	20	4 U	24.8	124	24.2	121	2
m-xylene	6.4	1.3 U	8.3	130	7.8	122	6
p-xylene	6.4	1.3 U	8.7	136	8.1	126	8
o-xylene	6.6	3.4 J	10.2	103	9.7	95	8

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

J - Indicates an estimated value less than the detection limit.

Allyce R. Moore

Approved by

Laboratory Manager

Title

E-255



Accredited by the American Association for Laboratory Accreditation, a Department of the American Society for Testing and Materials (ASTM), 1900 B Road, West Conshohocken, PA 19380

93-9-87

**CERTIFICATE OF ANALYSIS**

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41624
ORDER NUMBER: 118-02242-HM540
PAGE 23 OF 28

Sample Description: 5190

Concentration units are $\mu\text{g/liter}$ (ppb)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>Sample Result</u>	<u>Conc. MS</u>	<u>% Rec.</u>	<u>Conc. MSD</u>	<u>% Rec.</u>	<u>RPE</u>
benzene	2.2	0.5 U	2.2	100	2.2	100	0
toluene	5	1 U	4	80	4	80	0
ethyl benzene	20	4 U	19	95	19	95	0
m-xylene	6.4	1.3 U	6.5	102	6.3	98	4
p-xylene	6.4	1.3 U	6.1	95	6.2	97	-2
o-xylene	6.6	1.3 U	6.9	104	6.5	98	6

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by _____
Laboratory Manager

Title



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 23, 1988
PROJECT CODE: MMOK 41655
ORDER NUMBER: 11B-02242-HM545
PAGE 30 OF 33

Sample Description: 5232

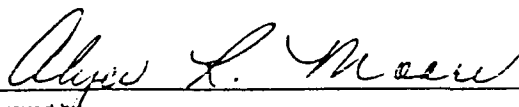
Concentration units are $\mu\text{g/liter}$ (ppb)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
benzene	2.2	0.5 U	2.3	104	2.2	100	4
toluene	5	1 U	5	100	4	80	22
ethyl benzene	20	4 U	20	100	19	95	5
m-xylene	6.4	1.3 U	6.7	105	6.3	98	7
p-xylene	6.4	1.3 U	6.3	98	6.2	97	1
o-xylene	6.6	1.3 U	6.9	104	6.4	97	7

RPD - Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title

P-257



Accredited by the American Association of Laboratory Accreditation in the Chemical and Environmental Analysis of Water, Air, and Soil.

11/1/88



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 49 OF 57

Sample Description: 5261


Concentration units are $\mu\text{g/liter}$ (ppb)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>Sample Result</u>	<u>Conc. MS</u>	<u>% Rec.</u>	<u>Conc. MSD</u>	<u>% Rec.</u>	<u>RPD</u>
Benzene	2.44	0.5 U	2.06	84	1.96	80	5
Toluene	4.8	1 U	4.3	90	4.0	83	8
Ethyl Benzene	19.4	4 U	13.6	70	15.5	80	-13
Total Xylenes	19.4	4 U	15.5	78	15.8	81	-4

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title

F-258



Accredited by the American Association for Laboratory Accreditation in the chemical

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 47 OF 51

Sample Description: 5266-68 (Water)

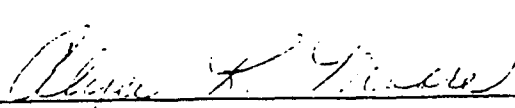
Concentration units are $\mu\text{g/liter}$ (ppb)

MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Benzene	2.44	0.5 U	2.51	103	2.49	102	1
Toluene	4.8	1 U	5.4	112	5.4	112	0
Ethyl Benzene	19.4	4 U	17.1	88	20.0	103	-16
Total Xylenes	19.4	4 U	18.1	93	18.7	96	-3

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by: Laboratory Manager

File



ANALYTICAL SERVICES

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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE 48 OF 51

Sample Description: 5276-78 (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Benzene	2.44	0.5 U	1.80	74	1.79	73	1
Toluene	4.8	1 U	3.5	72	3.7	76	-5
Ethyl Benzene	19.4	4 U	14.3	74	14.5	75	-1
Total Xylenes	19.4	4 U	14.5	75	14.7	76	-1

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Date

P-260



Accredited by the American Association for Laboratory Accreditation in the Chemical

11-1-85



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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: October 31, 1988
PROJECT CODE: MMOK 42068
ORDER NUMBER: 11B-02242-HM647
PAGE ~~49~~ ^{CF} ~~51~~

Sample Description: 5284-86 (Water)

Concentration units are $\mu\text{g/liter}$ (ppb)

MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Benzene	2.44	0.5 U	2.43	100	2.44	100	0
Toluene	4.8	1 U	5.0	103	5.0	103	0
Ethyl Benzene	19.4	4 U	19.3	99	19.3	99	0
Total Xylenes	19.4	4 U	19.6	101	19.8	102	1.0

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alvin L. Maden

Approved by / Laboratory Manager

Title

**CERTIFICATE OF ANALYSIS**

TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: December 6, 1988
PROJECT CODE: MMOK 42335
ORDER NUMBER: 11B-02242-HM680
PAGE 17 OF 17

Sample Description: 5306 (Water)

Concentration units are µg/liter (ppb)

MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>Sample Result</u>	<u>Conc. MS</u>	<u>% Rec.</u>	<u>Conc. MSD</u>	<u>% Rec.</u>	<u>RPD</u>
Benzene	2.15	0.5 U	1.94	90	2.19	102	-12
Toluene	5	1 U	5	100	5.6	112	-11
Ethyl Benzene	9.4	4 U	10.1	107	10.6	113	-5
Xylenes (total)	19.4	4 U	26.4	136	21.2	109	22

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by _____ Laboratory Manager

Title _____



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO Martin Marietta Energy Systems, Inc.
ATTN: S. R. Rizk, K-25
P. O. Box 2003
Oak Ridge, TN 37831-7440

DATE REPORTED: January 9, 1989
PROJECT CODE: MMOK 42490
ORDER NUMBER: 11B-02242-TU880
PAGE 11 OF 11

Sample Description: 5309


Concentration units are $\mu\text{g/liter}$ (ppb)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Benzene	2.5	0.5 U	2.4	96	2.4	96	0
Toluene	5.0	1 U	5.1	102	4.9	98	4
Ethyl Benzene	9.6	4 U	9.7	101	9.6	100	1
Xylenes (Total)	19	4 U	21	111	20	105	6

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by: _____ Laboratory Manager



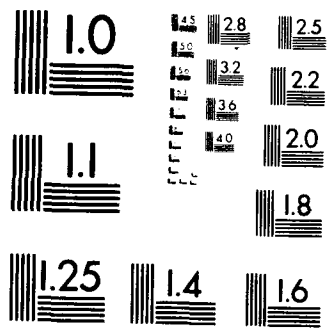
AD-A231 870

INSTALLATION RESTORATION PROGRAM REMEDIAL INVESTIGATION 7/8
REPORT: FORBES F.L. (U) MARTIN MARLETTA ENERGY SYSTEMS
INC OAK RIDGE TN OCT 89 XF-NCB DE-AC85-840R21400

UNCLASSIFIED

ML





MICROCOPY RESOLUTION TEST CHART
 NATIONAL BUREAU OF STANDARDS
 STANDARD REFERENCE MATERIAL 1010a
 (ANSI and ISO TEST CHART No. 2)

IT-Knoxville
Bud GibsonQUALITY CONTROL RESULTS SUMMARY
BTX

Job No. 45452
 Field Sample Nos. "EE4917, EE4918, EE4919"
 Lab Sample Nos. 3896
 MS/MSD Sample Nos. 3921, 3922
 Sample Matrix:
 / X / Water (ug/L)
 / / Other _____
 Spike Source 8020 std 10ppb

QC Report No. BTX-88-09
 Date Analyzed 3-26-88
 Laboratory Supervisor Approval:
 P. Chapman
 Dilution Factor NA
 *Moisture _____

Compound	SA	Blank	SR	MS	% REC MS	MSD	% REC MSD	RPD
Benzene	10	ND<0.5		10	100	10	100	0
Ethylbenzene	10	ND<0.5		10	100	10	100	0
Toluene	11	ND<0.5		11	100	10	91	10
Total Xylenes	31	ND<0.5		30	97	29	94	3

ND - This compound was not detected; the limit of detection for this analysis is less than amount stated in the table above.

IT-Knoxville
Bud GibsonJob #45452
Page 4QUALITY CONTROL REPORT
Volatile Fuel Hydrocarbons

JOB NO. 45452
FIELD SAMPLE NO. EE4917, EE4918, EE4919
LAB SAMPLE NOS:
ORIGINAL 3896
SPIKE 3946
SPIKE-DUPLICATE 3947
SAMPLE MATRIX:
☒ WATER (ug/L)
☐ SOIL (ug/Kg) or (ug/g)
☐ OTHER _____

QC REPORT NO. 8015-88-06
DATE ANALYZED 3-29-88
DILUTION FACTOR NA
SPIKE SOURCE JP-4 (Jet Fuel)

COMPOUND	ORIGINAL RESULT	AMT OF SPIKE	SPIKE RESULT	PERCENT RECOVERY	SPIKE-DUP RESULT	PERCENT RECOVERY	RPD
Jet Fuel	ND<50	1000	960	96	900	90	6

ND - This compound was not detected; the limit of detection for this analysis is less than amount stated in the table above.



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 48 OF 56

Sample Description: 5000

Concentration units are $\mu\text{g/kg}$ (opb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
	MS	MSD						
Benzene	2,110	2,050	250 U	2,220	105	2,200	107	-2
Toluene	2,500	2,430	500 U	3,140	126	2,840	117	7
Total Xylenes	18,700	18,700	14,400 U	34,800	109	33,900	104	5

RPD - Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Allyn L. Mason
Approved by Laboratory Manager

Title

F-266



Accredited by the American Association for Laboratory Accreditation in the chemical field of testing. As listed in the current AALA Directory of Accredited Laboratories

93-94



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 11B-02242-HM-514 & 518
PAGE 58 OF 61

Sample Description: 5036

Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc.		Conc.		RPD
	MS	MSD		MS	% Rec.	MSD	% Rec.	
Benzene	203	201	50 U	146	72	122	61	16
Toluene	241	238	100 U	176	73	152	64	13
m-Xylene	598	592	130 U	457	76	407	69	10
p-Xylene	595	589	130 U	465	78	418	71	9
o-Xylene	608	602	130 U	461	76	412	68	11

RPD - Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by

Robert M. Wayne
Operations Manager

Title



P-267
Accredited by the American Association for Laboratory Accreditation in the chemical
field of testing. Listed in the current AALA Directory of Accredited Laboratories

93-1-95



ANALYTICAL SERVICES

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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: July 22, 1988
PROJECT CODE: MMOK 41496
ORDER NUMBER: 11B-02242-HM-514 & 518
PAGE 59 OF 61

Sample Description: 5063

Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc.		% Rec.	Conc.		% Rec.	RP
	MS	MSD		MS			MSD			
Benzene	214	213	50 U	142		66	166		78	-17
Toluene	254	253	100 U	182		72	197		78	-
m-Xylene	630	627	130 U	484		77	526		84	-
p-Xylene	628	624	130 U	479		76	517		83	-9
o-Xylene	641	638	130 U	502		78	553		87	-1

RPD - Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by

Robert M. Wozniak
Operations Manager

Title

F-268



Accredited by the American Association for Laboratory Accreditation in the chemical field of testing. As listed in the current AALA Directory of Accredited Laboratories

93-9-A



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41507
ORDER NUMBER: 118-02242-HM519 & HM524
PAGE 54 OF 56

Sample Description: 5078

Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc.		% Rec.	Conc.		% Rec.	RPD
	MS	MSD		MS			MSD			
Benzene	212	208	50 U	159		75	151		72	4
Toluene	252	248	100 U	195		77	185		74	4
m-Xylene	625	614	130 U	548		88	514		84	5
p-Xylene	622	611	130 U	546		88	503		82	7
o-Xylene	636	625	130 U	553		87	523		84	4

RPD - Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Approved by

Operations Manager

Title

F-269



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93 9 85



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 16, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 53 OF 62

Sample Description: 5125

Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc. MS	% Rec.	Conc. MSD		RPD
	MS	MSD				MSD	Rec.	
Benzene	207	210	50 U	155	75	170	81	-8
Toluene	245	250	100 U	177	72	195	78	-8
Total Xylenes	1,830	1,860	400 U	1,490	81	1,590	85	-5

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Allyce L. Moore
Approved by Laboratory Manager

Title

F-270



Approved by the American Association for Laboratory Accreditation in the chemical
and physical sciences, Department of Energy, Health, Safety and Environment

11-1



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 2, 1988
PROJECT CODE: MMOK 41539
ORDER NUMBER: 118-02242-HM530
PAGE 19 OF 21

Sample Description: 5151


Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
	MS	MSD						
Benzene	211	216	50 U	164	78	167	77	1
Toluene	251	256	100 U	222	88	217	85	4
m-Xylene	622	635	130 U	492	79	512	81	-2
p-Xylene	620	632	130 U	483	78	512	81	-4
o-Xylene	633	646	130 U	512	81	532	82	-1

RPD - Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


 Approved by Alyce R. Moore
 Laboratory Manager
 Title

**CERTIFICATE OF ANALYSIS**

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41549
ORDER NUMBER: 118-02242-HM525
PAGE 78 OF 83

Sample Description: 5163


Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc. MS	% Rec.	Conc. MSD		RPD
	MS	MSD				MSD	Rec.	
Benzene	202	206	50 U	162	80	164	80	0
Toluene	239	244	100 U	192	80	201	82	-2
m-Xylene	594	607	130 U	508	86	518	85	1
p-Xylene	591	604	130 U	503	85	508	84	1
o-Xylene	604	617	130 U	520	86	530	86	0

RPD - Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title





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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box 9, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 118-02242-HM644
PAGE 52 OF 57

Sample Description: 5250

Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
	MS	MSD						
Benzene	97	98	50 U	75.4	78	75.2	77	1
Toluene	193	195	100 U	163	84	158	81	4
Ethyl Benzene	773	782	400 U	663	86	645	82	5
Total Xylenes	774	783	400 U	669	86	657	84	2

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alvin L. Moore
Approved by Laboratory Manager

Title



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TO Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 18, 1988
PROJECT CODE: MMOK 42231
ORDER NUMBER: 11B-02242-HM682
PAGE 15 OF 16

Sample Description: 5295, 3'

Concentration units are $\mu\text{g/kg}$ (ppb)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added		Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
	MS	MSD						
Benzene	530	550	50 U	610	115	660	120	-4
Toluene	1,200	1,300	100 U	960	80	1,000	77	4
Ethyl Benzene	2,300	2,400	400 U	1,900	83	2,100	88	-6
Xylenes (total)	4,800	5,000	400 U	3,700	77	4,300	86	-11

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alfred R. Moore
Approved by Laboratory Manager

Title

F-274



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11-1-88



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 118-02242-HM515
PAGE 43 OF 56

Sample Description: 5000

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight

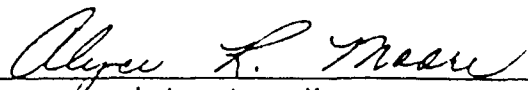
SOIL PESTICIDE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>
γ -BHC (Lindane)	32.3	9.8 U	26.2	81
Heptachlor	32.3	9.8 U	37.1	115
Aldrin	32.3	9.8 U	31.1	96
Dieldrin	80.7	20 U	58.9	73
Endrin	80.7	20 U	70.6	87
4,4'-DDT	80.7	20 U	74.6	92

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>
γ -BHC (Lindane)	32.5	28.8	89	-9
Heptachlor	32.5	36.5	112	3
Aldrin	32.5	31.3	96	0
Dieldrin	81.2	58.9	72	1
Endrin	81.2	69.8	86	1
4,4'-DDT	81.2	76.3	94	-2

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by _____
Laboratory Manager

Title _____



Accredited by the American Association for Laboratory Accreditation in the chemical field as testing to meet the current AALA Directory of Accredited Laboratories

93-9-95



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 118-02242-HM644
PAGE 44 OF 57

Sample Description: 5250

Concentration units are $\mu\text{g/kg}$ (ppb) dry weight


SOIL PESTICIDE MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

	<u>Conc. Spike Added</u>	<u>Sample Conc.</u>	<u>MS Conc.</u>	<u>MS % Rec.</u>	<u>QC Limits Rec.</u>
Lindane	34.1	10 U	29.2	86	46 - 127
Heptachlor	34.1	10 U	31.1	91	35 - 130
Aldrin	34.1	10 U	27.5	81	34 - 132
Dieldrin	85.3	20 U	60.9	71	31 - 134
Endrin	85.3	20 U	87.4	102	42 - 139
4,4'-DDT	85.3	20 U	72.9	85	23 - 134

	<u>Conc. Spike Added</u>	<u>MSD Conc.</u>	<u>MSD % Rec.</u>	<u>% RPD</u>	<u>QC Limits RPD Rec.</u>
Lindane	33.8	26.5	78	10	50 46 - 127
Heptachlor	33.8	31.8	94	-3	31 35 - 130
Aldrin	33.8	26.7	79	2	43 34 - 132
Dieldrin	84.5	61.2	72	-1	38 31 - 134
Endrin	84.5	86.7	103	-1	45 42 - 139
4,4'-DDT	84.5	75.2	89	-4	50 23 - 134

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41616
ORDER NUMBER: 118-02242-HM538
PAGE 22 OF 24

Sample Description: 5179, 5180, 5181


Concentration units are mg/liter (ppm)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Antimony	0.54	0.03 U	0.52	96.3	0.49	90.7	6
Beryllium	0.054	0.001 U	0.044	81.5	0.042	77.8	4.
Cadmium	0.054	0.005 U	0.050	92.6	0.050	92.6	0
Chromium	0.22	0.01 U	0.19	86.4	0.18	81.8	5.5
Copper	0.27	0.01 U	0.25	92.6	0.24	88.9	4.1
Mercury	0.010	0.0001 U	0.008	80.0	0.010	100.0	-22.2
Nickel	0.54	0.02 U	0.49	90.7	0.47	87.0	4.2
Silver	0.054	0.005 U	0.045	83.3	0.042	77.8	6.5
Zinc	0.54	0.022	0.49	86.7	0.48	84.8	2.2

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


 Approved by _____
 Laboratory Manager
 Title _____



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 18, 1988
PROJECT CODE: MMOK 41616
ORDER NUMBER: 11B-02242-HM538
PAGE 23 OF 24

Sample Description: 5179, 5180, 5181

Concentration units are mg/liter (ppm)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	F D
Arsenic	0.044	0.03 U	0.03 U	NR	0.03 U	NR	- -
Selenium	0.011	0.3 U	0.3 U	NR	0.3 U	NR	- -
Lead	0.022	0.02 U	0.022	100.0	0.028	127.3	-24.0
Thallium	0.054	0.006 U	0.038	70.4	0.052	96.3	-31 1

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

RPD = Relative Percent Difference

NR = Not recovered; due to matrix interferences, the sample quantitation limit was raised to a level greater than or close to the spike concentration.

Alyce R. Mason

Approved by Laboratory Manager

Title

F-278



As required by the American Association for Laboratory Accreditation in the chemical field, this laboratory is subject to the current AAALAC Laboratory Accredited Inspection.

13 1



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 4, 1988
PROJECT CODE: MMOK 41482
ORDER NUMBER: 11B-02242-HM515
PAGE 55 OF 56

Sample Description: 5000

Concentration units are mg/kg (ppm)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Antimony	34	3 U	8	23.5	10	29.4	-22.3
Arsenic	4.0	4.0	7.9	97.5	7.2	80.0	19.7
Beryllium	3.2	0.4	3.3	90.6	3.3	90.6	0
Cadmium	3.4	0.9	4.9	117.6	4.3	100.0	16.2
Chromium	15	9	24	100.0	23	93.3	6.9
Copper	17	14	30	94.1	27	76.5	20.6
Lead	50	61	113	104.0	105	88.0	16.7
Mercury	0.10	0.02	0.11	90.0	0.10	80.0	11.8
Nickel	35	12	48	102.9	37	71.4	36.1
Selenium	1.0	2 U	2 U	NR	2 U	NR	---
Silver	3.1	0.5 U	2.2	71.0	2.4	77.4	-8.6
Thallium	168	4	135	78.0	136	78.6	-0.8
Zinc	50	425	523	196.0*	446	42.0*	129

RPD = Relative Percent Difference

NR = Not recovered; due to matrix interference, the sample detection limit was raised to a level greater than the spike concentration.

*Spike added is less than four times the native analyte concentration; therefore, the acceptance criteria do not apply.

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alyce R. Moser
Approved by Laboratory Manager

Title

F-279



Accredited by the American Association for Laboratory Accreditation in the chemical

11-9-85



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 55 OF 57

Sample Description: 5250


Concentration units are mg/kg (ppm)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Antimony	42	3 U	9	21.4	14	33.3	-43.5
Lead	39	38	72	87.2	72	87.2	0
Nickel	42	18	53	83.3	52	81.0	2.8
Zinc	44	118	150	72.7	149	70.5	3.1
Copper	25	9	29	80.0	28	76.0	5.1
Chromium	20	15	36	105.0	32	85.0	21.1
Beryllium	5.0	1.0	5.3	86.0	5.4	88.0	2.3
Cadmium	5.0	1.4	6.1	100.0	6.1	100.0	0
Silver	3.8	0.5 U	2.3	60.5	3.1	81.6	-29.6

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


 Approved by Laboratory Manager
 Title _____



CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 56 OF 57

Sample Description: 5250

Concentration units are mg/kg (ppm)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>Sample Result</u>	<u>Conc. MS</u>	<u>% Rec.</u>	<u>Conc. MSD</u>	<u>% Rec.</u>	<u>RPD</u>
Mercury	0.10	0.04	0.13	90.0	0.13	90.0	0

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager

Title



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: November 1, 1988
PROJECT CODE: MMOK 42062
ORDER NUMBER: 11B-02242-HM644
PAGE 57 OF 57

Sample Description: 5250


Concentration units are mg/kg (ppm)

SOIL MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Arsenic	4.0	7.1	9.4	57.5	10.6	87.5	-41.4
Selenium	1.0	1 U	0.8	80.0	0.5	50.0	46.2
Thallium	5.0	0.4	4.4	80.0	4.6	84.0	-4.9

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by Laboratory Manager
Title



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TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 16, 1988
PROJECT CODE: MMOK 41517
ORDER NUMBER: 11B-02242-HM520
PAGE 57 OF 62

Sample Description: 5134

Concentration units are mg/liter (ppm)

WATER MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERY

Compound	Conc. Spike Added	Sample Result	Conc. MS	% Rec.	Conc. MSD	% Rec.	RPD
Chloride	192	171	331	84	332	84	0
Fluoride	95.6	1.92	94.4	97	95.2	98	-1
Nitrate, as N	2.44	0.5 U	2.86	117	3.02	124	-5
Phosphate, as P	261	1.5 U	284	109	289	111	-2
Sulfate	574	152	717	98	760	106	-6

RPD = Relative Percent Difference

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by _____
Laboratory Manager

Title

F-283



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and physical testing of the subject material by a certified laboratory.

01.1.15



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CERTIFICATE OF ANALYSIS

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 17, 1988
PROJECT CODE: MMOK 41608
ORDER NUMBER: 118-02242-HM537
PAGE 36 OF 38

Sample Description: 5165

Concentration units are mg/liter (ppm)

WATER MATRIX SPIKE ANALYSIS REPORT

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>Sample Result</u>	<u>Conc. MS</u>	<u>% Rec.</u>
Chloride	4.8	7.8	12.4	96
Fluoride	1.1	1.0	2.0	91
Nitrate, as N	4.8	2.5 U	4.8	100
Phosphate, as P	38	1.0 U	35	92
Sulfate	52.6	164	216	99

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.

Alyce L. Moore

Approved by Laboratory Manager

Title

P-284



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field of testing as listed in the current AALA Directory of Accredited Laboratories

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**CERTIFICATE OF ANALYSIS**

TO: Martin Marietta Energy Systems, Inc.
ATTN: Mr. Stuart Goza
P. O. Box P, MS 440
Oak Ridge, TN 37831

DATE REPORTED: August 19, 1988
PROJECT CODE: MMOK 41637
ORDER NUMBER: 11B-02242-HM541
PAGE 11 OF 12


Sample Description: 5198 (Water)

Concentration units are mg/liter (ppm)

MATRIX SPIKE ANALYSIS

<u>Compound</u>	<u>Conc. Spike Added</u>	<u>Sample Result</u>	<u>Conc. MS</u>	<u>% Rec.</u>
Chloride	47.6	26.5	67.6	86
Fluoride	4.9	1.4	5.8	90
Nitrate, as N	5.0	5.0 U	5.0	100
Phosphate, as P	91.0	10 U	99.1	109
Sulfate	58.2	160	213	91

U - Compound was analyzed for but not detected. The number is the detection limit for the sample.


Approved by _____
Laboratory Manager
Title _____

APPENDIX G

MONITORING WELL AND COREHOLE LOGS

LITHOLOGIC AND WELL-COMPLETION DIAGRAMS FOR THE MONITORING WELLS AND COREHOLES

This appendix contains the lithologic and well-completion diagrams for the monitoring wells and coreholes installed at Forbes Field ANGB during the remedial investigation in 1988. MW001 through MW028 are alluvial monitoring wells and CH001 through CH003 are open coreholes (cased and grouted through alluvial sediments). The reader is referred to Plate 1 for well locations. It is important to note that MW004 was subsequently filled with cement and abandoned.

The patterns used to illustrate well-construction materials and lithology (graphic logs on the diagrams) are identified below. A brief narrative description of each lithologic unit is provided on the diagrams, including information regarding moisture content. In the descriptions for the alluvial monitoring wells, colors are delineated using the nomenclature of the Munsell Soil Color Chart. This is not true of the corehole descriptions because the rotary drilling method used for hole installation does not permit detailed color delineation.

Designated Patterns Used on the Lithologic and Well-Completion Diagrams

WELL CONSTRUCTION MATERIALS

	Cement/Bentonite Grout
	Bentonite Pellets
	Sand Pack
	Well Screen

LITHOLOGIC SYMBOLS

	Fill, road base, sand and gravel.
	Concrete
	Claystone, red-brown to yellow-brown, bedrock.
	Silty clay, gray to brown

LITHOLOGIC SYMBOLS (cont.)

	Silt, generally yellowish-brown (siltstone in bedrock)
	Mudstone, gray
	Shale, dark gray to black, carbonaceous
	Limestone, massive, fossiliferous
	Clayey Gravel, limestone gravel in clay
	Gravelly Clay, limestone gravels in dark gray clay
	Sandy Clay, fine to medium grained in silty clay
	Sand, fine to coarse grained
	Coal, sub-bituminous

F0324



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By F. G. GARDNER Date 6/14/88 Page 1 of 1
Ho'e No. MW01 Elevation 1028.5' Location SITE 6, DITCH INTERSECTION
Total Depth 14.5 No. of Completions 1 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				FILL	Gravel veneer, grass roots, mixed fill material
2					
3					OH SILTY CLAY: very dark gray, (10YR 3/1), becoming stained with limonite, plastic, uniform, fat in part.
4					
5					CH SILTY CLAY: gray, (2.5Y N5), abundant limonite staining, plastic, fat, slightly moist.
6					
7					
8					CH SILTY CLAY: dark yellowish brown, (10YR 4/4), increasingly siltier, abundant limonite staining, plastic, mottled appearance.
9					
10					GC CLAYEY GRAVEL: up to 2", very angular, fossiliferous limestone gravels in a yellow-brown, (10YR 5/8), very wet clay matrix, abundant crinoid stems and brachs. 2" layer of sand and limestone fragments in clayey matrix underlying gravel zone.
11					
12					BEDROCK: weathered silty claystone, visible relict bedding planes, yellow-brown, (10YR 5/8), abundant gray carbonaceous laminations, noncalcareous, damp.
13					COAL: thin bedded, soft, greasy coals interbedded in gray and yellow-brown silty claystones, damp.
14					CLAYSTONE: gray, (2.5Y N5), very fissile, very fine mica disseminated throughout, trace fossil shadows, becoming shale at 14.5'.
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	F. G. GARDNER		Date	6/14/88		Page	1 of 1	
Hole No.	MW02		Elevation	1025.9'		Location	SITE 6 - 35' N35E FROM STEEL POST	
Total Depth	16.5'		No. of Completions	1		Rig Type	MOBILE B-61	
Auger Size	7 5/8" x 4 1/4"		Sample Type	5' CONTINUOUS STAINLESS STEEL				
Project	FORBES FIELD ANGB		Data Verified By	P.M. KEARL		Date	10/16/88	

DEPTH (FEET)	BLOWS/6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

FILL Gravel veneer, road base and fill material, mottled very dark brown clays and scattered pebbles.

OH CLAY: black, (5Y 2.5/1), plastic, fat, homogenous, dry.

CH SILTY CLAY: dark grayish brown, (2.5Y 4/2), becoming stained with limonite at 6', plastic, fat, mottled and discolored appearance.

CH SILTY CLAY: as above, increasingly silty and sandy streaks at 8.5', wet from 8.5' to 10'.

BEDROCK: very weathered light olive brown, (2.5Y 5/4), claystone with greasy gray clay interbeds, abundant coal partings, noncalcareous, damp.

COAL: black, very soft, sub-bituminous, thin bedded greasy coals bedded with gray & yellow-brown clays.

CLAYSTONE: weathered yellow brown & gray clays bedded with thin coal laminations, fissile, some dark red shale partings, micaceous in part, non calcareous, dry.

2-inch sand lens, medium to coarse grains, poorly sorted, subangular, dry, unconsolidated.

CLAYSTONE: gray, (7.5YR N5), fissile, soft, very thinly bedded, waxy, very fine mica disseminated throughout abundant plant fossil shadows, occasional truncated relict bedding, non- to very slightly calcareous.



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By F. G. CARDNER Date 6/15/88 Page 1 of 1
Hole No. MW03 Elevation 1053.7' Location SITE: SE CORNER OF BASE
Total Depth 18' No. of Completions 1 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				ASPHALT	ASPHALT (3")
				CONCRETE	CONCRETE (18")
					8" HOLE CORED THROUGH ASPHALT & CONCRETE. 8" MANHOLE SET FLUSH WITH ASPHALT
2				FILL	FILL (3") SAND & CLAY BASE
3					CH SILTY CLAY: gray, (2.5YR N5), abundant limonite staining, plastic, fat
4					
5					
6					
7					
8					CH SILTY CLAY: gray as above, increasing dark reddish brown limonite staining, slight dampness between 8.5' and 9'.
9					
10					
11					
12					OH SILTY CLAY: gray mottled with dark brown limonite stains, (7.5YR 4/4), abundant coal partings and organic material, dry.
13					
14					
15					OH CLAY: light olive brown, (2.5Y 6/4), very plastic, abundant scattered coal and shaley partings, dense, waxy.
16					
17					BEDROCK: weathered claystone, light yellow brown, (2.5YR 6/4), relict beds, silty, friable.
18					SANDY CLAYSTONE: light yellowish brown, (2.5Y 6/4), very fine grained, coal & shale partings, silty, wet.



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By F. C. GARDNER Date 6/15/88 Page 1 of 1
Hole No. MW04 Elevation NOT MEASURED Location SITE SE CORNER
Total Depth 19.5' No. of Completions 0 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANCB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
			▽▽▽▽▽▽	ASPHALT	ASPHALT (3")
1			▽▽▽▽▽▽	CONCRETE (18")	CONCRETE (18")
			▽▽▽▽▽▽	8" HOLE CORED THROUGH ASPHALT & CONCRETE. HOLE PLUGGED AND ABANDONED	
2			▽▽▽▽▽▽	FILL	FILL (9") SAND & CLAY BASE
3			▽▽▽▽▽▽		CH SILTY CLAY: gray,(2.5YR N5),clays mottled with light brown silts,plastic with occasional limonite staining.
4			▽▽▽▽▽▽		SC SANDY CLAY: gray,(2.5YR N5),3" layer of sandy clay,abundant limonite staining,predominantly fine to medium grained and poorly sorted,angular,dry.
5			▽▽▽▽▽▽		
6			▽▽▽▽▽▽		OH SILTY CLAY: brown,(7.5YR 4/6),silts mottled with gray clay matrix.increasing black carbonaceous and coaly partings disseminated throughout.abundant orange limonite staining with occasional yellow limonitic nodules,damp,plastic.
7			▽▽▽▽▽▽		
8			▽▽▽▽▽▽		
9			▽▽▽▽▽▽		
10			▽▽▽▽▽▽		
11			▽▽▽▽▽▽		
12			▽▽▽▽▽▽		OH SILTY CLAY: light olive brown,(2.5Y 5/6),abundant very fine disseminated coal partings,occasional sand streaks,some calcareous pelletoidal inclusions resembling ostracods scattered toward lower contact with weathered bedrock,dry overall.
13			▽▽▽▽▽▽		
14			▽▽▽▽▽▽		
15			▽▽▽▽▽▽		BEDROCK: weathered claystone,light olive brown,(2.5Y 5/6),occasional sandy interbeds,fissile,waxy in part, relict bedding,occasional carbonaceous inclusions, dry.
16			▽▽▽▽▽▽		
17			▽▽▽▽▽▽		
18			▽▽▽▽▽▽		
19			▽▽▽▽▽▽		CLAYSTONE: yellow brown,(10YR 5/8),friable,sandy in part,abundant coaly partings increasing toward bottom of sample,dry.
20			▽▽▽▽▽▽		



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	<u>F. G. GARDNER</u>		Date	<u>6/16/88</u>		Page	<u>1</u> of <u>1</u>	
Hole No.	<u>MW05</u>		Elevation	<u>1047.4'</u>		Location	<u>SITE 7</u>	
Total Depth	<u>13.5'</u>		No. of Completions	<u>1</u>		Rig Type	<u>MOBILE B-61</u>	
Auger Size	<u>7 5/8" x 4 1/4"</u>		Sample Type	<u>5' CONTINUOUS STAINLESS STEEL</u>				
Project	<u>FORBES FIELD ANGB</u>		Data Verified By	<u>P.M. KEARL</u>		Date	<u>10/16/88</u>	

DEPTH (FEET)	BLOWS/6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				ASPHALT	ASPHALT (3") CONCRETE (18")
2				FILL	8" HOLE CORED THROUGH ASPHALT & CONCRETE. 8" MANHOLE SET FLUSH WITH ASPHALT. FILL (9") SAND AND CLAY BASE
3					CH SILTY CLAY: very dark gray,(7.5YR N3),homogenous, plastic,very fine disseminated mica throughout, abundant root matter,very slight moisture sheen on freshly exposed clay faces,earthy texture.
4					
5					
6					
7					
8					
9					
10					CL SILTY CLAY: gray,(5Y 4/1), fat,plastic,visible water sheen,damp,occasional limonite nodules increasing with depth.
11					
12					
13					BEDROCK: weathered claystone,yellow brown,(10YR 5/8), visible bedding,fissile noncalcareous,dry.
14					
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By <u>F. C. GARDNER</u>		Date <u>6/16/88</u>		Page <u>1</u> of <u>1</u>	
Hole No. <u>MW06</u>		Elevation <u>1048.9'</u>		Location <u>SITE 7</u>	
Total Depth <u>15.2'</u>		No. of Completions <u>1</u>		Rig Type <u>MOBILE B-61</u>	
Auger Size <u>7 5/8" x 4 1/4"</u>		Sample Type <u>5' CONTINUOUS STAINLESS STEEL</u>			
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	
DEPTH (FEET)	BLOWS/6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				ASPHALT	ASPHALT (3")
2				CONCRETE	CONCRETE (18")
3					8" HOLE CORED THROUGH ASPHALT & CONCRETE. 8" MANHOLE SET FLUSH WITH ASPHALT.
4				FILL	FILL (6") SAND AND CLAY BASE
5					OH SILTY CLAY: very dark gray,(7.5YR N3),occasional green silty streaks between 2' and 3',abundant root debris from 4' to 5',becoming lighter gray @ 6', plastic and fat organic clays,slight moisture sheen on freshly broken clay faces.
6					
7					
8					
9					OH SILTY CLAY: dark gray,(2.5Y N4),greasy clays with silty interbeds,grading to a grayish red-brown limonite stained interval from 8.5' to 13.5',plastic, slightly damp.
10					
11					
12					
13					
14					BEDROCK: weathered claystone,yellow brown,(10YR 5/8), relic beds,fissile,abundant gray shale partings,becoming wet at 14.2',wet zone has scattered dark red shale partings,very soft,noncalcareous.
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By <u>F. G. GARDNER</u>		Date <u>6/16/88</u>		Page <u>1</u> of <u>1</u>	
Hole No. <u>MW07</u>		Elevation <u>1048.8'</u>		Location <u>SOUTHEAST CORNER</u>	
Total Depth <u>14.5'</u>		No. of Completions <u>1</u>		Rig Type <u>MOBILE B-61</u>	
Auger Size <u>7 5/8" ± 4 1/4"</u>		Sample Type <u>5' CONTINUOUS STAINLESS STEEL</u>			
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	
DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				ASPHALT	ASPHALT (3")
					CONCRETE (18")
2				FILL	FILL (6") SAND AND CLAY BASE
3					OH SILTY CLAY: very dark gray,(7.5YR N3),homogenous, very plastic, organic soil, fine disseminated mica, abundant plant root material.
4					
5					
6					OH SILTY CLAY: dark gray,(5Y 4/1),increasing silt content,limonite stains and streaks at 5',becoming siltier with depth.
7					
8					
9					OH SILTY CLAY: dark brown,(10YR 4/3),abundant red- brown and dark gray carbonaceous shaley partings, plastic,very stained with limonite.
10					
11					
12					
13					OH SILTY CLAY: dark brown as above,occasional irreg- ular claystone inclusions in clay matrix,slightly damp.
14					BEDROCK: weathered yellowish-brown claystone with very fissile thin relict beds,(10YR 5/6),occasional gray shale partings,wet at 13.7'.
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By F. G. GARDNER Date 6/17/88 Page 1 of 1
Hole No. MW08 Elevation 1045.0' Location SITE 7, NE CORNER BLDG 662
Total Depth 11.3' No. of Completions 1 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					CL SILTY CLAY: gray, (5Y 5/1), dry, scattered worm tracks limonite streaks, very fine disseminated mica.
2					
3					
4					OH SILTY CLAY: gray, (5Y 5/1), mottled with yellow- brown and red-brown limonite stained streaks, faint moisture sheen on fresh clay faces between 7' and 9', occasional black carbonaceous partings throughout, limonite stains increasing with depth.
5					
6					
7					OH SILTY CLAY: yellow brown, (10YR 5/6), sticky, damp, very plastic, abundant coal and gray clay partings.
8					
9					BEDROCK: weathered yellow-brown claystone, (10YR 5/6), very thin relict beds, fissile, abundant gray and black carbonaceous interbeds, slightly damp.
10					
11					
12					
13					
14					
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	<u>F. G. GARDNER</u>		Date	<u>6/17/88</u>		Page	<u>1</u> of <u>1</u>	
Hole No.	<u>MW09</u>		Elevation	<u>1038.5'</u>		Location	<u>SITE 5, 27' NW OF BLDG 671</u>	
Total Depth	<u>8.5'</u>		No. of Completions	<u>1</u>		Rig Type	<u>MOBILE B-61</u>	
Auger Size	<u>7 5/8" x 4 1/4"</u>		Sample Type	<u>5' CONTINUOUS STAINLESS STEEL</u>				
Project	<u>FORBES FIELD ANGB</u>		Data Verified By	<u>P.M. KEARL</u>		Date	<u>10/16/88</u>	

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					CL SILTY CLAY: very dark gray,(2.5Y N/3),dry,occasional gravel chips,some gray shale partings,distinct odor of fuel,very slightly damp.
2					
3					
4					OH SILTY CLAY: very dark gray,(2.5Y N3),very strong fuel odor,visible sheen,abundant red-brown limonite stains throughout,very discolored zone from 3.5' to 7'. Increasingly limonite stained below 7'. Increasing moisture consisting of water and fuel.
5					
6					
7					
8					BEDROCK: weathered yellow-brown claystone,(10YR 5/6), interbedded with gray and black carbonaceous shales.non-calcareous.
9					
10					
11					
12					
13					
14					
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By <u>F. G. GARDNER</u>		Date <u>6-17-88</u>		Page <u>1</u> of <u>1</u>	
Hole No. <u>MW10</u>		Elevation <u>1037.5'</u>		Location <u>SITE 5 - 96' SW OF BLDG 671</u>	
Total Depth <u>9.5'</u>		No. of Completions <u>1</u>		Rig Type <u>MOBILE B-61</u>	
Auger Size <u>7 5/8" x 4 1/4"</u>		Sample Type <u>5' CONTINUOUS STAINLESS STEEL</u>			
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	
DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					CL SILTY CLAY: dark gray (10YR 4/1) dry, friable, medium dry strength. Roots to 1.5', limonite staining at 1.5', few gray to black carbonaceous inclusions. Few worm tracks.
2					
3					
4					OH SILTY CLAY: yellowish brown (10YR 5/6) wet from 4.5' to 8', abundant dark gray to black shale and clay streaks/partings, very soft, plastic, jet fuel odor at 6'.
5					
6					
7					BEDROCK: weathered yellow-brown (10YR 5/6) claystone, wet, calcareous, occasional red and gray shale, claystone partings, visible relict bedding planes along gray shale laminations. Borehole augered to 9.5' for well completion.
8					
9					
10					
11					
12					
13					
14					
15					
16					

Well Summary Information

Prepared By <u>F. G. GARDNER</u>		Date <u>6-17-88</u>	Page <u>1</u> of <u>1</u>
Hole No. <u>MW11</u>		Elevation <u>1040.8'</u>	Location <u>SITE 8</u>
Total Depth <u>17.9'</u>		No. of Completions <u>1</u>	Rig Type <u>MOBILE B-61</u>
Auger Size <u>7 5/8" x 4 1/4"</u>		Sample Type <u>5' CONTINUOUS STAINLESS STEEL</u>	
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>	Date <u>10/16/88</u>

DEPTH (FEET)	BLOWS/6"	SAMPLE INTERVAL	CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				ASPHALT	ASPHALT (5")
2				CONCRETE (18")	CONCRETE (18") 8" HOLE CORED THROUGH ASPHALT & CONCRETE. 8" MANHOLE SET FLUSH WITH ASPHALT.
3				FILL	FILL (3") SAND & CLAY BASE
4					CL SILTY CLAY: dark gray (N4/) with grayish green mottling, plastic, blocky, noncalcareous. 1/2" very fine grain sand stringer at 4', wet.
5					
6					
7					CL SILTY CLAY: dark gray (N4/) with greenish gray (5BG 5/1) silty interbeds and partings, silt is very micaceous, noncalcareous.
8					
9					CL SILTY CLAY: dark gray (N4/), highly oxidized (limonite) from 8.5' to 10.5' (rusty discoloration).
10					
11					OH SILTY CLAY: dark gray (5Y 3/1) plastic, greasy luster on fresh cut, fat, carbonaceous stringers.
12					
13					
14					OH SILTY CLAY: very dark gray (5Y 3/1) with greenish gray (5BG 5/1) silty interbeds, very micaceous, wet at 13.2' (3" zone).
15					BEDROCK: yellowish brown (10YR 5/8) weathered clay-stone, visible bedding with light gray beds, abundant crinoid stems at 16.8', shell imprints, casts, and molds, wet at 17.3'.
16					
17					
18					
19					
20					
21					

Well Summary Information

Prepared By <u>F. G. GARDNER</u>		Date <u>6-18-88</u>		Page <u>1</u> of <u>1</u>	
Hole No. <u>MW12</u>		Elevation <u>1040.7'</u>		Location <u>SITE 9</u>	
Total Depth <u>20.0'</u>		No. of Completions <u>1</u>		Rig Type <u>MOBILE B-61</u>	
Auger Size <u>7 5/8" x 4 1/4"</u>		Sample Type <u>5' CONTINUOUS STAINLESS STEEL</u>			
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	

DEPTH (FEET)	BLOWS / 6"	SAMPLE INTERVAL	CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				ASPHALT	ASPHALT (3")
2				CONCRETE (18")	CONCRETE (18")
3				8" HOLE CURED THROUGH ASPHALT & CONCRETE, 8" MANHOLE SET FLUSH WITH ASPHALT	8" HOLE CURED THROUGH ASPHALT & CONCRETE, 8" MANHOLE SET FLUSH WITH ASPHALT
4				FILL	FILL (3") SAND & CLAY BASE
5				CH	CH SILTY CLAY: very dark gray (5Y 3/1), oxidized and discolored, friable at top, increasingly plastic and fat, probable fill.
6				CH	CH CLAY: gray (10YR 5/1), heavily oxidized from 4' to 5.5'.
7				OH	OH SILTY CLAY: very dark gray (5Y 3/1), occasional greenish gray (5BG 5/1) silty interbeds and partings, very micaceous, sticky fat organic clays.
8					
9					
10					
11					
12					
13					
14					OH SILTY CLAY: dark gray transition to yellow-brown, (10YR 5/8), very sticky, fat, plastic clays, very organic.
15					BEDROCK: yellow-brown (10YR 5/8) weathered claystone, dark gray to black carbonaceous inclusions and massive claystone partings, abundant crinoid stems and bryozoan imprints between 17' and 19'. Visible relic bedding at 18', wet at 18.5'.
16					
17					
18					
19					
20					
21					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By <u>F. G. GARDNER</u>		Date <u>6-18-88</u>		Page <u>1</u> of <u>1</u>	
Hole No. <u>MW13</u>		Elevation <u>1041.2'</u>		Location <u>SITE 9</u>	
Total Depth <u>15.5'</u>		No. of Completions <u>1</u>		Rig Type <u>MOBILE B-61</u>	
Auger Size <u>7 5/8" x 4 1/4"</u>		Sample Type <u>5' CONTINUOUS STAINLESS STEEL</u>			
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	
DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				ASPHALT	ASPHALT (3")
2				CONCRETE (18")	CONCRETE (18")
3				8" HOLE CORED THROUGH ASPHALT & CONCRETE, 8" MANHOLE SET FLUSH WITH ASPHALT.	
4				FILL	FILL (3") SAND & CLAY BASE
5				CH SILTY CLAY	CH SILTY CLAY: highly oxidized gray and reddish brown (5YR 4/4) clay, strong red shale partings, dry, increasingly plastic with depth.
6				CH SILTY CLAY	CH SILTY CLAY: very dark gray (5Y 3/1) plastic, occasional gray and green reduced zones limonite nodules in grayish green matrix.
7				GC GRAVELLY CLAY	GC GRAVELLY CLAY: up to 1/2" subangular limestone gravels in dark gray sticky clay matrix (2") layer.
8				OH SILTY CLAY	OH SILTY CLAY: very dark gray (5Y 3/1), abundant fine roots, resembles peat.
9				OH SILTY CLAY	OH SILTY CLAY: gray (7.5YR N5), greasy, soft, plastic, organic clay and silt mixture.
10				BEDROCK	BEDROCK: weathered yellow-brown (10YR 5/8) clay-stone with gray claystone partings, occasional carbonaceous matter scattered throughout, faint relict bedding at 12' increasing with depth, wet from 13.5' to 15'.
11					
12					
13					
14					
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By <u>F. G. GARDNER</u>		Date <u>6/18/88</u>		Page <u>1</u> of <u>1</u>	
Hole No. <u>MW14</u>		Elevation <u>1035.0'</u>		Location <u>SITE 5 DOWN-GRADIENT</u>	
Total Depth <u>12.6'</u>		No. of Completions <u>1</u>		Rig Type <u>MOBILE B-61</u>	
Auger Size <u>7 5/8" x 4 1/4"</u>		Sample Type <u>5' CONTINUOUS STAINLESS STEEL</u>			
Project <u>FORBES FIELD ANCB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	
DEPTH (FEET)	BLOWS/6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
					CONCRETE: with thin veneer of asphalt.
				FILL	FILL: clay and sand base.
1					CH SILTY CLAY: dark gray to very dark gray, (5Y 3/1), occasional red-brown limonite nodules and staining, plastic, fat, dense clays.
2					
3					
4					
5					
6					CH SILTY CLAY: very dark gray, (5Y 3/1), increasingly stained with red-brown limonite, faint fuel odor, plastic, sticky clays.
7					
8					
9					BEDROCK: weathered yellow-brown claystone, (10YR 5/8) visible relict bedding, abundant carbonaceous and shaley laminations with occasional dark red shale partings and carbonaceous streaks within dark gray shale laminations.
10					
11					
12					SILTSTONE: olive-yellow, (2.5Y 6/8), very argillaceous, abundant very fine carbonaceous laminations, very calcareous matrix, saturated at 12.2'.
13					
14					
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	<u>J.L. ZUTMAN</u>	Date	<u>6-19-88</u>	Page	<u>1</u> of <u>1</u>
Hole No.	<u>MW15</u>	Elevation	<u>1034.7'</u>	Location	<u>DOWN GRADIENT OF SITE 8</u>
Total Depth	<u>127'</u>	No. of Completions	<u>1</u>	Rig Type	<u>MOBILE B-61</u>
Auger Size	<u>7 5/8" x 4 1/2"</u>	Sample Type	<u>5' CONTINUOUS STAINLESS STEEL</u>		
Project	<u>FORBES FIELD ANGB</u>	Data Verified By	<u>P.M. KEARL</u>	Date	<u>10/16/88</u>

DEPTH FEET	BLOWS 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					<i>OH SILTY CLAY: dark grayish brown (10YR 4/2) silty clay mottled with red and yellow clay, abundant organic matter (roots, wood debris), red interbedded clay nodules at 3'. Very dry.</i>
2					
3					
4					
5					<i>OH SILTY CLAY: 8" stringer of moderately well rounded poorly sorted sand and gravel (to 1/2") in silty clay matrix. Damp.</i>
6					
7					<i>OH SILTY CLAY: very dark gray (5Y 2/1) silty clay, damp with water sheen.</i>
8					
9					
10					<i>BEDROCK: yellowish brown (10YR 5/8) weathered silty claystone mottled with oxidized zones of gray and orange clay, contorted relict bedding, fossils (crinoids) present at 11', wet at 12'.</i>
11					
12					
13					
14					
15					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By J.L. ZUTMAN Date 6-19-88 Page 1 of 1
Well No. MW16 Elevation 1032.9' Location SITE 8
Total Depth 17.9' No. of Completions 1 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANG Data Verified By P.M. KEARL Date 10/16/88

DEPTH FEET	LOGS 6"	SAMPLE INTERVAL	CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					<i>OH SILTY CLAY: very dark gray (5Y 3/1), plastic silty clay mottled with small amounts of red and yellow clay. Limestone gravels to 1/2" at 3' to 5'. 2" stringer of clean well rounded sand at 5' grading to silty clay with alternating bands of yellow and orange clay to 7'. Wet with 4" stringer of subangular limestone and chert gravels (to 1/2").</i>
2					
3					
4					
5					<i>CL SILTY CLAY: very dark gray (5Y 3/1) homogeneous silty clay, moist with medium plasticity.</i>
6					
7					
8					
9					<i>BEDROCK: yellowish brown (10YR 5/8) silty claystone contorted relict bedding, moist to damp, grading to bluish gray siltstone.</i>
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					



Well Summary Information

DAK RIDGE NATIONAL LABORATORY

Prepared By	<u>D. A. PICKERING</u>	Date	<u>6/19/88</u>	Page	<u>1</u> of <u>1</u>
Well No.	<u>MW17</u>	Elevation	<u>1037.2'</u>	Location	<u>SITE 9 - DOWNGRADE</u>
Total Depth	<u>17.5'</u>	No. of Completions	<u>1</u>	Rig Type	<u>MOBILE B-61</u>
Auger Size	<u>7 5/8" x 4 1/4"</u>	Sample Type	<u>5' CONTINUOUS STAINLESS STEEL</u>		
Project	<u>FORBES FIELD ANGB</u>		Date Verified By	<u>P.M. KEARL</u>	Date <u>10/16/88</u>

DEPTH FEET	SAMPLE INTERVAL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1		F I L L	FILL very dark gray silty clay, (10YR 3/1), abundant root matter in upper 1 foot, becoming mottled with yellow-brown clays, clean well rounded, poorly sorted sand layer at 3.8', occasional chert fragments. Clayey sand from 4.0' to 4.5' with angular lime-stone gravels and chert fragments (to 1/2" diameter).
2			
3			
4			
5			OH SILTY CLAY: dark brown, (10YR 4/3), sticky, plastic, mottled with red & yellow clay streaks, some red shaley partings, occasional black carbonaceous partings, dry.
6			OH SILTY CLAY: strong brown, (7.5YR 4/6), black carbonaceous stringers, mottled with dark gray silty clays, increasing limonite staining.
7			
8			
9			
10			OH SILTY CLAY: strong brown, (7.5YR 4/6), scattered red & yellow clay partings, abundant black carbonaceous partings & streaks throughout.
11			
12			
13			
14			BEDROCK: weathered claystone, yellow brown (10YR 5/8) interbedded with very dark gray silty claystone, 2" thick carbonaceous member at 14.8' with some fine-grained and well graded sands, wet, grading to a damp calcareous siltstone at 17'
15			
16			
17			



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	<u>J.L. ZUTMAN</u>	Date	<u>6-20-88</u>	Page	<u>1</u> of <u>1</u>
Hole No.	<u>MW18</u>	Elevation	<u>1039.4'</u>	Location	<u>SITE 1</u>
Total Depth	<u>13.2'</u>	No. of Completions	<u>1</u>	Rig Type	<u>MOBILE B-61</u>
Auger Size	<u>7 5/8" x 4 1/4"</u>	Sample Type	<u>5' CONTINUOUS STAINLESS STEEL</u>		
Project	<u>FORBES FIELD ANGB</u>	Data Verified By	<u>P.M. KEARL</u>	Date	<u>10/16/88</u>

DEPTH FEET	BLOGS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					<i>OH SILTY CLAY: very dark grayish brown (10YR 3/2) plastic, damp, few oxidized pieces of red shale particles and limestone pebbles, abundant roots.</i>
2					
3					
4					<i>CH SILTY CLAY: olive gray (5Y 3/2), damp with oxidized red and yellow clay becoming moist at 6.5'.</i>
5					
6					
7					<i>CH SILTY CLAY: olive (5Y 4/3), damp, sticky, plastic, mottled with small amounts of red and yellow clay.</i>
8					
9					
10					<i>BEDROCK: incomplete sample - angular limestone rock fragments in olive (5Y 4/3) clay matrix. Very wet with strong hydrocarbon odor. Weathered claystone with contorted relict bedding beneath limestone stringer.</i>
11					
12					
13					
14					
15					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	<u>J.L. ZUTMAN</u>	Date	<u>6-20-88</u>	Page	<u>1</u> of <u>1</u>
Hole No.	<u>MW19</u>	Elevation	<u>1035.5'</u>	Location	<u>SITE 1, ~300' W OF NW TANK</u>
Total Depth	<u>9.6'</u>	No. of Completions	<u>1</u>	Rig Type	<u>MOBILE B-61</u>
Auger Size	<u>7 5/8" x 4 1/4"</u>	Sample Type	<u>5' CONTINUOUS STAINLESS STEEL</u>		
Project	<u>FORBES FIELD ANGB</u>	Data Verified By	<u>P.M. KEARL</u>	Date	<u>10/16/88</u>

DEPTH (FEET)	LOGS/INCH	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					<i>OH SILTY CLAY: very dark brown (10YR 2/2) silty clay, abundant roots and organic matter -topsoil- becoming lighter and mottled at 3'.</i>
2					
3					
4					<i>OH SILTY CLAY: dark brown (10YR 3/3) silty clay mottled with dark gray to black carbonaceous streaks, few red and yellow oxidized particles interbedded in silty clay matrix, damp, plastic.</i>
5					
6					
7					
8					<i>OH SILTY CLAY: dark reddish brown (5YR 3/3) silty clay, moist with water hues. Dark waxy nodules interbedded in matrix at 8'.</i>
9					
10					<i>BEDROCK: yellowish brown (10YR 5/8) weathered silty claystone, friable with contorted relict bedding, damp with few fossils present.</i>
11					
12					
13					
14					
15					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By J.L. ZUTMAN Date 6-20-88 Page 1 of 1
Hole No. MW20 Elevation 1036.9' Location SITE 1, ~300' W OF SW TANK
Total Depth 12.5' No. of Completions 1 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					OH SILTY CLAY: very dark brown (10YR 2/2) silty clay, abundant roots, dry to 2', - topsoil -.
2					
3					
4					OH SILTY CLAY: dark brown (10YR 3/2), damp, mottled with black carbonaceous, red, and yellow streaks.
5					
6					OH SILTY CLAY: dark reddish brown (5YR 3/3) mottled with carbonaceous clay and red and yellowish brown shale fragments, wet from 5.8' to 7'.
7					
8					CH SILTY CLAY: olive brown (2.5Y 4/4), sticky, plastic with few limestone gravels (to 3/4").
9					
10					BEDROCK: weathered silty claystone, olive (5Y 5/4) with contorted relict bedding, abundant clam and crinoid stem fossils, numerous vertical and horizontal lenses of gypsum.
11					
12					
13					
14					
15					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By <u>J.L. ZUTMAN</u>		Date <u>6-20-88</u>		Page <u>1</u> of <u>1</u>	
Hole No. <u>MW21</u>		Elevation <u>1033.4'</u>		Location <u>SITE 1, N OF TANK FARM</u>	
Total Depth <u>13.5'</u>		No. of Completions <u>1</u>		Rig Type <u>MOBILE B-61</u>	
Auger Size <u>7 5/8" x 4 1/4"</u>		Sample Type <u>5' CONTINUOUS STAINLESS STEEL</u>			
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	
DEPTH (FEET)	BLOGS 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					<i>OH SILTY CLAY: very dark brown (10YR 2/2) silty clay, dry to 2' with abundant roots.</i>
2					
3					
4					<i>OH SILTY CLAY: olive gray (5Y 4/2) damp, plastic, with oxidized clay nodules (pebble size) interbedded in silty clay matrix. Some carbonaceous material present (dark gray to black streaks), strong hydrocarbon odor and visible oil hues at 4' to 8.5', plastic to 6' grading to more friable. Saturated at 6.5' to 8', abundant clay nodules (pebble size) at 8' to 8.5'.</i>
5					
6					
7					
8					
9					
10					<i>BEDROCK: incomplete sample - limestone fragments blocking sampling shoe. Augered to 13.5' for completion.</i>
11					
12					
13					
14					
15					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	F. G. GARDNER		Date	6/21/88		Page	1 of 1	
Hole No.	MW22		Elevation	1017.4'		Location	SITE 6, 20' S OF COREHOLE 1	
Total Depth	16'		No. of Completions	1		Rig Type	MOBILE B-61	
Auger Size	7 5/8" x 4 1/4"		Sample Type	5' CONTINUOUS STAINLESS STEEL				
Project	FORBES FIELD ANGB		Data Verified By	P.M. KEARL		Date	10/16/88	

DEPTH (FEET)	BLOWS/6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				GRAVEL & SAND	road base
2				OH SILTY CLAY	dark grayish brown (2.5Y 4/2), some root material, very fine disseminated mica, abundant dark gray to black organic and carbonaceous matter, plastic, fat.
3					
4					
5					
6				BEDROCK	weathered yellow-brown claystone (10YR 5/8), soft yellow-brown mudstones interbedded with light gray shales, non-calcareous, visible fissile relict bedding.
7				COAL	soft, black, sub-bituminous, greasy, occasional claystone interbeds, very argillaceous.
8				CLAYSTONE	brownish yellow (10YR 6/8), very fissile, thin bedded with gray shales, occasional minor stringers, very soft and wet yellow-brown clay at 9'.
9					
10					Augered hole to 16' for completion.
11					
12					
13					
14					
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By J.L. ZUTMAN Date 6-22-88 Page 1 of 1
Hole No. MW23 Elevation 1043.9' Location LATERAL 6, HYD. 3, "HOT SPOT"
Total Depth 15.3' No. of Completions 1 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	CONSTRUCTION	LITHOLOGY	DESCRIPTION
				ASPHALT	ASPHALT (3")
1				CONCRETE (18")	CONCRETE (18")
				8" HOLE CORED THROUGH ASPHALT & CONCRETE, 8" MANHOLE SET FLUSH WITH ASPHALT.	8" HOLE CORED THROUGH ASPHALT & CONCRETE, 8" MANHOLE SET FLUSH WITH ASPHALT.
2				FILL	FILL (3") SAND & CLAY BASE
3					OH SILTY CLAY: very dark gray mottled with dark greenish gray (5GY 4/1) clay, few shale fragments, dense, damp, plastic.
4					
5					
6					
7					
8					OH SILTY CLAY: dark gray (5Y 4/1) with oxidized yellow and dark gray stringers, unstratified with some organic debris (stems) at 7.5'.
9					
10					OH SILTY CLAY: grayish brown (10YR 3/2), moist with oxidized shale particles (yellow and orange) becoming damp and compacted at 12'.
11					
12					
13					
14					BEDROCK: yellowish brown (10YR 5/8) silty claystone with contorted relict bedding at 13', wet at 13.2'.
15					
16					



ORNL
OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	F. G. CARDNER		Date	6/21/88		Page	1 of 1	
Hole No.	MW24		Elevation	1062.8'		Location	UPGRADIENT WELL FOR BASE	
Total Depth	43.5'		No. of Completions	1		Rig Type	MOBILE B-61	
Auger Size	7 5/8" x 4 1/2"		Sample Type	5' CONTINUOUS STAINLESS STEEL				
Project	FORBES FIELD ANGB		Date Verified By	P. M. KEARL		Date	10/16/88	

DEPTH (FEET)	BLOWS/6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
0				FILL	GRAVEL & SAND FILL, ROAD BASE.
2				CL	SILTY CLAY: gray (5Y 5/1) with red-brown limonite stains and nodules, occasional very dark gray to black carbonaceous partings, becoming very plastic at 3.5'.
4				OL	SILTY CLAY: yellowish red (5YR 4/6) with gray & black organic threads, trace carbonaceous matter at 5.5' to 8.5', dry, friable red clayey matrix.
6					
8				CL	SILT: yellowish-brown (10YR 5/8), occasional yellow-red clays, trace carbonaceous partings and inclusions, friable, argillaceous, grading to silty clay at 23'.
10					
12					
14				CL	SILTY CLAY: yellow-brown (10YR 5/8), very silty, occasional very fine carbonaceous partings, friable, trace moisture (26' to 27').
16					
18					
20				SM	SAND: yellowish brown (10YR 5/8), thin stringer of fine to medium grained, well rounded, well sorted, dry.
22				SM	SAND: as above.
24				CL	SILTY CLAY: yellow-brown (10YR 5/8), slightly damp interval between 31' and 31.5', occasional very silty and sandy members, predominantly friable.
26					
28				SW	SAND: predominantly medium grained quartz sand with some yellow-brown silt matrix, well rounded, well graded sands with trace amounts of feldspar and hornblende as accessory minerals, noncalcareous, saturated, unconsolidated.
30					
32					
34					
36					
38					
40					
42					
44				BEDROCK	SANDSTONE, light yellowish brown (2.5Y 6/4), fine grained, well sorted, silty and argillaceous matrix, occasional oxidized mineral laminations & streaks, noncalcareous, dry. CLAYSTONE: red-brown to yellow brown, fissile, thin bedded, silty laminations in part, carbonaceous partings, large red shale partings, noncalcareous.



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By F. G. GARDNER Date 6/22/88 Page 1 of 1
Hole No. MW25 Elevation 1017.8' Location SITE 6, 8' SE OF MW22
Total Depth 16' No. of Completions 1 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOGS 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
0					GRAVEL & SAND: road base
1					OH SILTY CLAY: very dark gray (5Y 3/1), rich soil character, abundant root matter, organic debris, dry, friable in part.
2					
3					CL SILTY CLAY: yellow-brown (10YR 5/8), mottled with gray silty clays, abundant limonite stains, becoming more plastic with depth.
4					
5					
6					BEDROCK: weathered claystone, yellow-brown (10YR 5/8) very silty interbeds, noncalcareous, visible relict beds, coaly interbeds and partings, damp.
7					COAL: black, sub-bituminous, greasy, very soft, abundant yellow-brown argillaceous interbeds, wet.
8					CLAYSTONE: as above, abundant coaly interbeds, moisture sheen along relict bedding planes.
9					
10					COAL: interbedded with yellow brown claystones, wet.
11					MUDSTONE: gray with minor yellow-brown silty stringers, slightly carbonaceous, noncalcareous, grading to gray shales at 10.8'. Augered hole to 16' for completion.
12					
13					
14					
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By F. G. GARDNER Date 6/23/88 Page 1 of 1
Hole No. MW26 Elevation 1033.1' Location SITE 1
Total Depth 14' No. of Completions 1 Rig Type MOBILE B-61
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1					CL SILTY CLAY: very dark gray (5Y 3/1), dry & friable, some root matter, scattered limonite nodules from 3.2' to 5', increasingly sticky and more plastic at 3'.
2					
3					
4					CH SILTY CLAY: dark grayish brown (10YR 4/2), moist from 5' to 7', predominantly plastic, damp, sticky clays from 7' to 8.5', slight jet fuel odor.
5					
6					
7					BEDROCK: weathered claystone (2"), yellow-brown, relic beds underlain by 4" of weathered dark gray carbonaceous limestone with limonite deposits along fractures. Bottom 3" is weathered yellow-brown claystone with silty gray interbeds. All very calcareous, very wet.
8					
9					
10					Borehole augered to 14' for well completion.
11					
12					
13					
14					
15					
16					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	F. G. GARDNER	Date	6/23/88	Page	1 of 1
Hole No.	MW27	Elevation	1059.9'	Location	SE CORNER, UPGRADE WELL
Total Depth	25.5'	No. of Completions	1	Rig Type	MOBILE B-61
Auger Size	7 5/8" x 4 1/4"	Sample Type	5' CONTINUOUS STAINLESS STEEL		
Project	FORBES FIELD ANGB	Data Verified By	P.M. KEARL	Date	10/16/88

DEPTH (FEET)	BLOWS/INTERVAL	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				FILL	GRAVEL & SAND ROAD BASE
2					OL SILTY CLAY: yellow-brown (10YR 5/8), dry, friable, abundant carbonaceous threads and partings from 1.5' to 3.5'
3					
4					
5					
6					OL SILTY CLAY: yellowish red (5YR 4/8), dry, friable, very lustrous clays on fresh breaks, abundant carbonaceous threads throughout, noncalcareous.
7					
8					
9					
10					
11					
12					OL SILTY CLAY: brownish yellow (10YR 6/6), increasing silt content, decreasing carbonaceous inclusions, very fine disseminated mica, noncalcareous, predominantly friable, trace dampness at 18'.
13					
14					
15					
16					
17					
18					
19					OL SILTY CLAY: as above, increasing moisture and more plastic.
20					
21					
22					
23					SC SANDY CLAY: strong brown (7.5YR 4/6), fine to med. grained, subround to subangular sands in a silty clay matrix, some elliptical black nodules, wet.
24					SM SAND: strong brown (7.5YR 4/6), fine to medium grained sand in silty matrix, some angular quartz fragments & siliceous pebbles, wet.
25					BEDROCK: weathered claystone, yellow brown (10YR 5/8), pronounced angled channel cut at contact, underlain by 2" weathered calcite and siltstone lens, moist.
26					CLAYSTONE: very laminated & fissile, calcareous, gray and yellow brown interbeds.



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By D.A. PICKERING Date 11-1-88 Page 1 of 1
Hole No. MW28 Elevation 1041.0' Location SITE 1, TANK FARM W OF PUMPHOUSE
Total Depth 15.5' No. of Completions 1 Rig Type ACKER
Auger Size 7 5/8" x 4 1/4" Sample Type 5' CONTINUOUS STAINLESS STEEL
Project FORBES FIELD ANGB Data Verified By P. M. KEARL Date 1/19/89

DEPTH (FEET)	B.C.W.S. 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
1				F	Dark topsoil, organics, grasses.
2				I	OH SILTY CLAY: very dark brown (10YR 2/2), hard,
				L	dry, abundant roots.
3				L	
4					OH SILTY CLAY: dark brown (7.5YR 4/4), brown,
5					yellow and red shale partings, organic streaks,
					minor roots to 3', very dry, hard, plastic.
6					
7					OH SILTY CLAY: dark olive-gray (5Y 3/2), dry, organic
					streaks, yellow and red shale partings.
8					
9					CH SILTY CLAY: olive (5Y 4/3), red and yellow
					shale partings, organic streaks, jet fuel odor at 7',
10					moist.
11					
12					Angular fossiliferous limestone fragments in olive clay
13					matrix (5Y 5/5), wet.
14					
15					BEDROCK: SAMPLER REFUSAL-NO SAMPLE
					Sampler removed. Augered to 15.5' for well comple-
					tion.



Well Summary Information

OAK RIDGE NATIONAL LABORATORY

Prepared By	J. A. RICE		Date	6/18/88		Page	1 of 3	
Hole No.	CH01		Elevation	1028.5'		Location	NW OF TANK FARM	
Total Depth	70'		No. of Completions	1		Rig Type	ROTARY	
Auger Size	N/A		Sample Type	N/A				
Project	FORBES FIELD ANGB		Data Verified By	P.M. KEARL		Date	10/16/88	

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
2					
4					
6					
8					
10					
12					
14					
16					
18					
20					
22					
24					
26					
28					
30					
32					

LITHOLOGIC DESCRIPTIONS TO 20 FEET
ARE TAKEN FROM DRILL CUTTINGS.

6 5/8" STEEL CASING

weathered limestone

shales, very soft, interbedded with sandstones and claystones.

competent bedrock, mostly grey shales.

SANDSTONE: fine grain, well cemented, calcite cement, micaceous.

SHALE: argillaceous, very thin bedded, interbedded with siltstone, platy, scattered pyrite nodules.

SANDSTONE: very fine grain, well cemented, calcite cement.

SILTSTONE: argillaceous, platy, friable.

WASHED OUT

SILTSTONE AND CLAYSTONE: argillaceous, very thin bedded, calcareous.

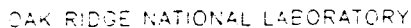


OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By J. A. RICE Date 06/18/88 Page 2 of 3
Hole No. CH01 Elevation 1028.5' Location NW OF TANK FARM
Total Depth 70' No. of Completions 1 Rig Type ROTARY
Auger Size N/A Sample Type N/A
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH FEET	BLOWS / FEET	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
34					<i>SILTSTONE AND CLAYSTONE: very micaceous, calcareous, well cemented, scattered pyrite nodules.</i>
36					
38					
40					
42					
44					<i>CLAYSTONE: silty, slightly calcareous, poorly cemented, interbedded with siltstone.</i>
46					
48					
50					<i>CLAYSTONE: very argillaceous, medium cement, moderately friable, calcite stringers.</i>
52					
54					<i>CLAYSTONE: silty, micaceous, calcareous, very well cemented, calcite stringers, scattered pyrite nodules.</i>
56					
58					
60					<i>LIMESTONE: hard, Crinoid stems, interbedded with very argillaceous, poorly cemented siltstone.</i>
62					
64					<i>SHALE black, carbonaceous, slightly platy.</i>



Prepared By J. A. RICE Date 06/18/88 Page 3 of 3
 Hole No. CH01 Elevation 1028.5 Location NW OF TANK FARM
 Total Depth 70' No. of Completions 1 Rig Type ROTARY
 Auger Size N/A Sample Type N/A
 Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

(1) (2)



Well Summary Information

OAK RIDGE NATIONAL LABORATORY

Prepared By <u>J. A. RICE</u>		Date <u>06/20/88</u>		Page <u>1</u> of <u>3</u>	
Hole No. <u>CH02</u>		Elevation <u>1017.8'</u>		Location <u>NW CORNER OF BASE</u>	
Total Depth <u>75'</u>		No. of Completions <u>1</u>		Rig Type <u>ROTARY</u>	
Auger Size <u>N/A</u>		Sample Type <u>N/A</u>			
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	
DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
2					
4					
6					
8					
10					
12					
14					
16					
18					
20					
22					
24					
26					
28					
30					
32					

*LITHOLOGIC DESCRIPTIONS TO 24 FEET
ARE TAKEN FROM DRILL CUTTINGS.*

yellow-brown clay

dark brown clay

gray clay

gravel

sandy shale

silty shale, medium hard

limestone, thin bedded

NO CORE RECOVERED

*CLAYSTONE: poor to well cemented, calcareous,
abundant limestone stringers.*



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By	<u>J. A. RICE</u>		Date	<u>06/20/88</u>		Page	<u>2</u>	of	<u>3</u>
Hole No.	<u>CH02</u>		Elevation	<u>1017.8'</u>		Location	<u>NW CORNER OF BASE</u>		
Total Depth	<u>75'</u>		No. of Completions	<u>1</u>		Rig Type	<u>ROTARY</u>		
Auger Size	<u>N/A</u>		Sample Type	<u>N/A</u>					
Project	<u>FORBES FIELD ANGB</u>		Data Verified By	<u>P.M. KEARL</u>		Date	<u>10/16/88</u>		
DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION				
34					<i>CLAYSTONE: poor to well cemented, calcareous, abundant limestone stringers.</i>				
36									
38									
40									
42									
44									
46									
48									
50									
52									
54					<i>LIMESTONE: massive, interbedded with poorly cemented claystone (<1" thick), very fossiliferous, crinoid stems and brachiopods.</i>				
56					<i>MUDSTONE: very poorly cemented, calcareous, platy, 1 foot washed out.</i>				
58					<i>SHALE: black, carbonaceous, slightly calcareous, very well cemented, laminated, scattered pyrite nodules.</i>				
60					<i>LIMESTONE: massive, interbedded with thin partings of sandy claystone.</i>				
62					<i>CLAYSTONE: platy, calcareous, abundant, limestone stringers.</i>				
64					<i>LIMESTONE: massive, abundant fusulinids.</i>				



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By J. A. RICE Date 06/20/88 Page 3 of 3
Hole No. CH02 Elevation 1017.8' Location NW CORNER OF BASE
Total Depth 75' No. of Completions 1 Rig Type ROTARY
Auger Size N/A Sample Type N/A
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
66					LIMESTONE: massive, abundant Fusilinids.
					WASHED OUT
68					LIMESTONE: massive, abundant bryozoans, shell fragments, crinoid stems, brachiopods.
70					
72					
74					
76					



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By <u>J. A. RICE</u>		Date <u>06/21/88</u>		Page <u>1</u> of <u>3</u>	
Hole No. <u>CH03</u>		Elevation <u>1060.0'</u>		Location <u>AIRCRAFT PARKING APRON, SE CORNER</u>	
Total Depth <u>69'</u>		No. of Completions <u>1</u>		Rig Type <u>ROTARY</u>	
Auger Size <u>N/A</u>		Sample Type <u>N/A</u>			
Project <u>FORBES FIELD ANGB</u>		Data Verified By <u>P.M. KEARL</u>		Date <u>10/16/88</u>	
DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
2					
4					
6					
8					
10					
12					
14					
16					
18					
20					
22					
24					
26					
28					
30					
32					

LITHOLOGIC DESCRIPTIONS TO 22 FEET
ARE FROM DRILL CUTTINGS

6 5/8" STEEL CASING

gray shale

competent bedrock, gray sandy shale

limestone stringers

LIMESTONE: massive, brachiopods, shell fragments,
1" of very poorly cemented clay at top.

SILTSTONE: yellow-brown, interbedded with limestone.

LIMESTONE: massive, very hard, with calcite crystals,
laminated, fossiliferous (crinoid stems).

CLAYSTONE

SHALE: black, very thin laminations.

COAL: interbedded with carbonaceous claystone, cleats.



OAK RIDGE NATIONAL LABORATORY

Well Summary Information

Prepared By J. A. RICE Date 06/21/88 Page 2 of 3
Hole No. CH03 Elevation 1060.0' Location AIRCRAFT PARKING APRON, SE CORNER
Total Depth 69' No. of Completions 1 Rig Type ROTARY
Auger Size N/A Sample Type N/A
Project FORBES FIELD ANGB Data Verified By P.M. KEARL Date 10/16/88

DEPTH (FEET)	BLOWS/ 6"	SAMPLE INTERVAL	WELL CONSTRUCTION	LITHOLOGY	DESCRIPTION
34					CLAYSTONE: very poorly cemented, dry, plastic, some carbonaceous material.
36					
38					
40					
42					
44					CLAYSTONE: micaceous, very poorly cemented to poorly cemented, thinly laminated.
46					CLAYSTONE: slightly micaceous, very poorly cemented, dry, plastic, sticky.
48					
50				CLAYSTONE	
				SILTSTONE	
52					CLAYSTONE: micaceous, well cemented, laminated shell fragments.
54					CLAYSTONE: medium cement, limestone stringers.
56					
58					
60					
62					
64					



Prepared By J. A. RICE Date 06/21/88 Page 3 of 3
Hole No. CH03 Elevation 1060.0' Location AIRCRAFT PARKING APRON, SE CORNER
Total Depth 69' No. of Completions 1 Rig Type ROTARY
Auger Size N/A Sample Type N/A
Project FORBES FIELD ANGB Data Verified By P. M. KEARL Date 10/16/88

G-38

APPENDIX H

TEMPERATURE, pH, AND CONDUCTIVITY OF GROUNDWATER SAMPLES

TEMPERATURE, pH, AND CONDUCTIVITY OF GROUNDWATER SAMPLES

Appendix H is arranged by the sampling date and contains all parameters measured in the field on groundwater samples. Some of the parameters were not measured on all samples due to malfunction of field instruments.

Column headings are defined as follows:

Sample location:

DW - deep well (Weston)	The numeric portion of the string
SW - shallow well (Weston)	refers to the monitoring well or
MW - monitoring well (ORNL)	corehole number where the sample
CH - corehole (ORNL)	was collected

Sample date: Date the sample was collected in the field.

Sample interval: Samples of groundwater are listed according to the ordinal sequence in which they were collected on a given day. For example, a triplicate sample of groundwater taken from monitoring well MW023 on 7/10/88 would have interval values of 01, 02, and 03. Samples taken from the same well on consecutive days would each have a sample interval of 01. In some cases, a sample of the groundwater was collected before and after purging to determine if the stagnant water contained "floating product". The stagnant water sample would have an interval of 01; the fresh water sample would have an interval of 02.

Field number: Each sample collected is given a unique four-digit number which is recorded in the project sample log-book, chain-of-custody form, field data base, and ORNL/CAT data base in Grand Junction, Colorado. Replicate samples are numbered sequentially.

TEMPERATURE, pH, and CONDUCTIVITY (at 25° C) OF GROUNDWATER SAMPLES

SAMPLE LOCATION	DATE	SAMPLE INTERVAL	FIELD NUMBER	TEMPERATURE* CENTIGRADE	pH*	CONDUCTIVITY* uMHOS
DW001	03/08/88	01	0001	0.0	0.00	0
	03/09/88	02	0002	14.9	6.02	1300
DW002	03/09/88	01	0003	0.0	0.00	0
	03/09/88	02	0004	18.1	7.03	1400
DW004	03/09/88	01	0005	0.0	0.00	0
	03/09/88	02	0006	16.2	6.26	720
DW005	03/09/88	01	0007	0.0	0.00	0
DW003	03/10/88	01	0009	18.5	6.50	1300
SW005	03/10/88	01	0010	0.0	0.00	0
SW001	03/11/88	01	0013	11.3	7.10	1200
SW002	03/11/88	01	0014	9.4	7.20	1600
SW003	03/11/88	01	0015	15.2	6.70	2800
SW004	03/11/88	01	0016	15.8	6.40	3400
SW005	03/11/88	02	0017	8.0	6.80	1000
DW005	03/11/88	02	0019	13.0	6.20	1800
	03/11/88	03	0020	0.0	0.00	0
DW006	03/11/88	01	0021	14.4	7.10	3500
MW019	07/07/88	01	5165	18.8	6.39	980
MW001	07/07/88	01	5168	17.5	6.25	1600
MW020	07/08/88	01	5169	17.0	7.00	1100
MW021	07/08/88	01	5170	15.6	6.24	1300
MW026	07/08/88	01	5173	17.7	5.90	920
MW018	07/09/88	01	5174	16.7	6.60	1200
MW013	07/08/88	01	5175	21.4	6.00	3400
MW005	07/08/88	01	5176	21.3	6.40	2000
MW012	07/09/88	01	5177	20.4	6.19	4400
MW011	07/10/88	01	5179	20.3	6.26	4300
MW007	07/10/88	01	5182	21.1	6.24	2200
MW023	07/10/88	01	5183	21.7	6.10	2500
MW002	07/10/88	01	5185	17.1	6.15	1600
MW027	07/10/88	01	5186	17.8	6.39	1400
MW008	07/11/88	01	5187	0.0	0.00	0
MW024	07/11/88	01	5188	18.7	6.41	1200
MW014	07/11/88	01	5190	23.1	6.31	990
MW010	07/11/88	01	5191	18.5	6.08	650
MW009	07/11/88	01	5192	20.6	6.00	1100
CH001	07/11/88	01	5194	17.0		2400
MW016	07/12/88	01	5195	17.2	6.20	2200
MW025	07/12/88	01	5196	20.8	6.33	1100
MW003	07/12/88	01	5197	20.6	6.54	1000
MW015	07/12/88	01	5198	17.9	6.12	1400
MW003	07/13/88	01	5214	21.0	6.54	1000
MW017	07/13/88	01	5215	16.7	6.20	2500
MW006	07/13/88	01	5220	23.2	6.34	2400

* 0 or 0.00 indicates parameter was not measured

TEMPERATURE, pH, and CONDUCTIVITY (at 25° C) OF GROUNDWATER SAMPLES

SAMPLE LOCATION	DATE	SAMPLE INTERVAL	FIELD NUMBER	TEMPERATURE* CENTIGRADE	pH*	CONDUCTIVITY* uMHOS
CH002	07/14/88	01	5227	17.3	10.70 ¹	4200
CH003	07/14/88	01	5230	19.9	7.16	2200
MW014	09/30/88	01	5237	0.0	0.00	0
SW005	09/30/88	01	5238	0.0	0.00	0
MW018	09/30/88	01	5241	0.0	0.00	0
MW026	09/30/88	01	5242	0.0	0.00	0
MW010	09/30/88	01	5243	0.0	0.00	0
MW023	09/30/88	01	5244	0.0	0.00	0
CH003	10/03/88	01	5251	17.5	0.00	2200
MW024	10/03/88	01	5252	16.4	0.00	1000
MW027	10/03/88	01	5253	16.4	0.00	1200
MW005	10/03/88	01	5254	22.0	0.00	1700
MW012	10/03/88	01	5255	26.0	0.00	3300
MW013	10/03/88	01	5256	23.3	0.00	2800
MW014	10/03/88	01	5257	23.8	0.00	860
CH001	10/03/88	01	5258	17.5	0.00	2100
MW001	10/03/88	01	5259	21.5	0.00	1500
MW025	10/03/88	01	5260	21.6	0.00	930
MW023	10/03/88	01	5261	22.6	0.00	1900
MW020	10/04/88	01	5262	14.1	0.00	2000
MW019	10/04/88	01	5263	15.1	0.00	950
MW021	10/04/88	01	5264	15.5	0.00	1000
MW018	10/04/88	01	5266	14.9	0.00	1000
MW006	10/04/88	01	5269	19.6	0.00	2000
MW007	10/04/88	01	5270	20.3	0.00	2000
MW011	10/04/88	01	5271	20.4	0.00	3500
MW017	10/04/88	01	5272	16.9	0.00	2100
MW016	10/04/88	01	5273	20.4	0.00	1600
MW015	10/04/88	01	5275	18.9	0.00	1100
MW002	10/04/88	01	5276	20.1	0.00	1300
MW003	10/04/88	01	5279	18.6	0.00	850
MW026	10/05/88	01	5281	13.3	0.00	2000
CH002	10/05/88	01	5282	11.9	0.00	3000
SW001	10/05/88	01	5283	14.2	0.00	1200
MW010	10/05/88	01	5284	14.6	0.00	660
MW009	10/05/88	01	5287	15.6	0.00	950
SW002	10/05/88	01	5289	0.0	0.00	0
SW003	10/05/88	01	5290	15.3	0.00	1800
SW004	10/05/88	01	5291	19.8	0.00	2100
MW008	10/05/88	01	5292	15.2	0.00	750
SW005	10/05/88	01	5293	16.3	0.00	1200
MW028	11/18/88	01	5301	0.0	0.00	0
	11/18/88	02	5307	16.2	6.70	1200
	12/15/88	01	5311	9.8	6.70	1500

* 0 or 0.00 indicates parameter was not measured

¹ Measurement probably invalid; see discussion in Sect. 2.2.7.2.

APPENDIX I

LOCATION AND ELEVATION SURVEY

LOCATION AND ELEVATION SURVEY

A land survey of all monitoring wells, coreholes, soil-gas locations, and several topographic features was performed by ORNL personnel. In addition, a number of building corners were surveyed as reference monuments which are needed for control points. All survey points were referenced to the U. S. Department of Commerce Environmental Science Services Administration Coast and Geodetic Survey (USCGS), North American 1927 Datum Monuments, and Topeka Municipal Monuments. Horizontal surveys were within ± 1 ft. Vertical surveys were within ± 0.01 ft.

The equipment used by ORNL consisted of a Leitz SET3 total station and a Nikon NT3 Autolevel. Field notes were taken in a standard hardbound transit record book. Additional equipment included a Leitz Philadelphia level rod and Leitz prisms using level bubbles and tripods with tribrach adaptors to hold the sighting point plumb.

The origin horizontal control point is USCGS monument COOP, located approximately 2500 ft southwest of the survey baseline established by ORNL and 500 ft west of the tank farm (Fig. I-1). The monument COOP is a standard brass disk set in concrete located on top of the 130 ft Pauline grain elevator. The monument Pauline CAA MAST, located approximately 6200 ft to the west, was used as the reference azimuth, with the Topeka Capitol Dome serving as a secondary azimuth check mark. All angles and distances were doubled for precision and verification. A description of COOP and Pauline CAA MAST is provided in Fig. I-2 and I-3, respectively.

The baseline for the Forbes Field ANGB survey trends northwesterly to southeasterly and is parallel to the aircraft parking ramp access road. The baseline is directly over the water line and the fire hydrants (Fig. I-1). Survey pins along this line consist of twelve 18 in. #5 rebar with plastic caps driven in flush with the ground, with the exception of point FP9 which is a PK nail set in concrete. Baseline stations FP6 and FP10 (Fig. I-1) were located from USCGS monument COOP and used to establish the modified state plane coordinates used for all monitoring wells, coreholes, soil-gas, and selected building corner locations. These coordinates were used in constructing the base map of Forbes Field ANGB. Eastings, northings, and elevations for the monitoring wells and coreholes are provided in Table I-1. Coordinates for the control points and building corners are listed in Table I-2. In addition, coordinates and elevations of the unnamed tributary to the South Branch of Shunganunga Creek are shown in Table I-3.

The Kansas certified and licensed surveyor (G.W. Surveying) also established the location and elevation of MW28.

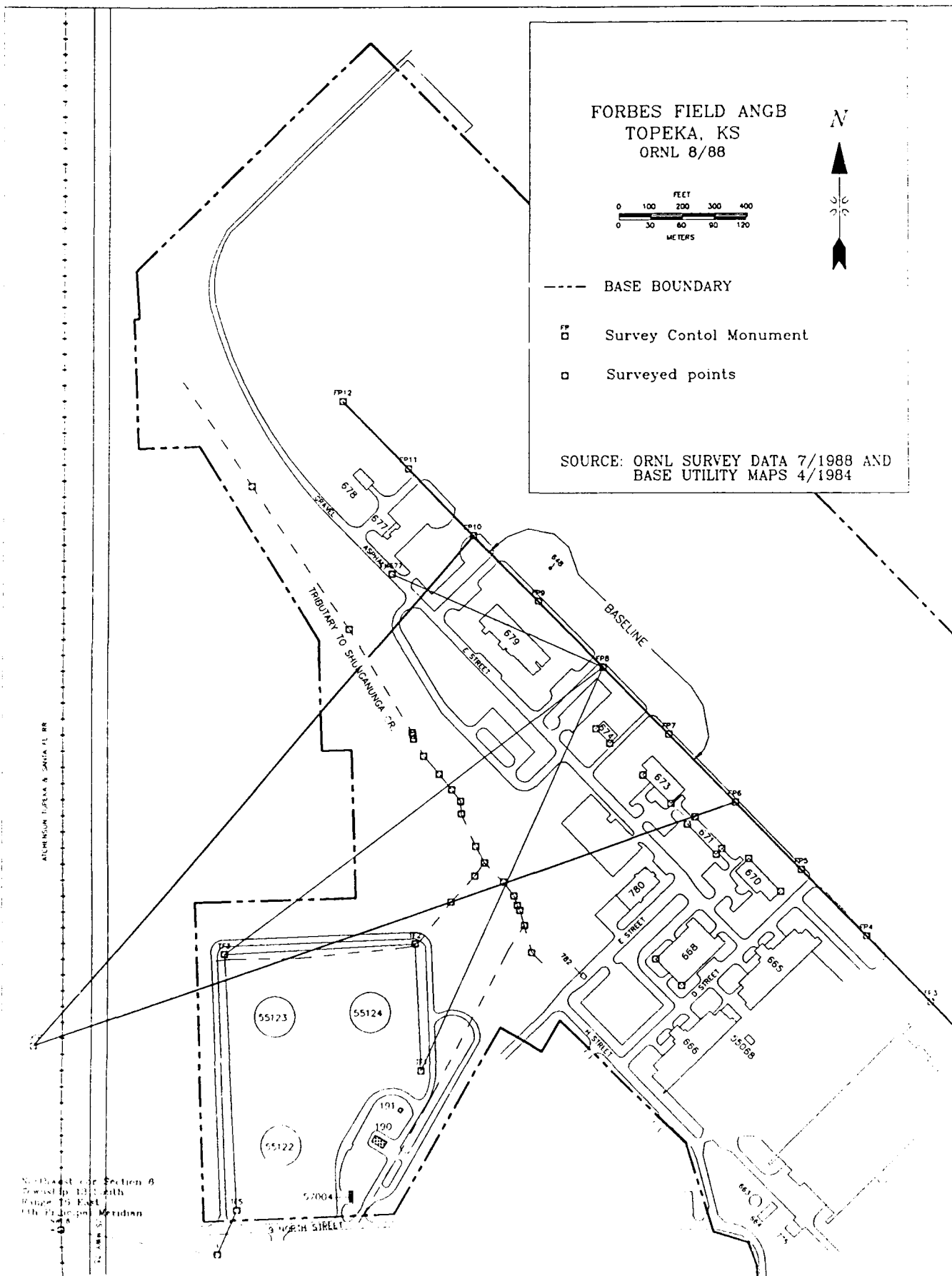


Fig. I-1 Survey baseline

THE UNIVERSITY OF CHICAGO
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 540 EAST 58TH STREET
 CHICAGO, ILL. 60637

PRINTED AND PUBLISHED BY:
U. S. DEPARTMENT OF COMMERCE
COAST AND GEODETIC SURVEY
WASHINGTON, D. C.

by the
Coast and Geodetic Survey
NORTH AMERICAN 1927 DATUM

ADJUSTED HORIZONTAL CONTROL DATA

05K1

NAME OF EVATOR, PAULINE, C.A.A., WAST

NAME OF STATION, F

STATE: Kansas

STATE: Kansas

Thinomara Triangulation source, 0-12457
Piscataway, N.J.

DESCRIPTION OF TRIANGULATION INTERSECTION STATION

NAME OF STATION, PAULINE, C.A.A., INC.

CHIEF OF PARTY: "S. S."

County: Elmore

The station is about 4 miles northwest of Pauline and about 1 mile southeast of the
 _____ place, in a pasture.

Sunny Elevation School, in a pasture.

To reach the station from the Post Office at Phillips go north on U.S. Highway 75 for 0.1 mile to a side road left (S.W. corner). Turn right and go south and west on the road for 1.5 miles to a T-junction. Turn left and go north on the mainline road for 1.5 miles to a T-junction. Turn right and go north on the mainline road the second 0.5 mile to a crossroad. Turn right and go north on the crossroad the second 0.5 mile to a crossroad. Sunny Elevation School in the northeast angle. Turn right and go east on the crossroad the second 0.5 mile to a gate. Pass thru gate and go south on the track road 0.1 mile to the station.

To the station, a single column steel structure retained alternately red and white, has a single column steel structure retained the point, covered wing,

GRID DATA		COORDINATES (Feet)		PLACES TO WHICH FROM DISTANCE		MAGN	
STATE	COND.	N	E	N	E		
STATE: KANS.		2,637,881.82					
ZONE: 1501		259,876.93		+ 1 25	140		
STATE: KANS.		2,770,702.20					
ZONE: S		850,321.05		+ 1 81	07		
STATE: KANS.							
ZONE: 1502							

GEOLOGIC DATA	LATITUDE: LONGITUDE:	MAGNITUDE: ELEVATION:	SECONDS IN MINUTES		DISTANCE (Feet)	ELEVATION (Feet)
			SECONDS	MINUTES		
INDIAN ELEVATION COOP PAULINE	38° 58' 13" 086 95 45 27.632					

GEOLOGIC DATA	LATITUDE: LONGITUDE:	MAGNITUDE: ELEVATION:	SECONDS IN MINUTES		DISTANCE (Feet)	ELEVATION (Feet)
			SECONDS	MINUTES		
INDIAN ELEVATION COOP PAULINE	38° 58' 13" 086 95 45 27.632					

Described by *L. N. Yates*

1750

Fig. I-3 Horizontal control data for monument Pauline CAA MAST

TABLE I-1
(well sites)

STATION NAME		EASTING	NORTHING	Collar	<u>ELEVATION</u> Ground	Water *
ORMW	MW001	2658860.	236709.	1030.66	1028.5	1025.21
ORMW	MW002	2658673.	237135.	1027.85	1025.9	1020.10
ORMW	MW003	** 2661090.	236043.	1053.41	1053.7	1040.95
ORMW	MW004	ABANDONED			ABANDONED	
ORMW	MW005	2660346.	236504.	1046.96	1047.4	1038.61
ORMW	MW006	2660502.	236442.	1048.62	1048.9	1039.23
ORMW	MW007	2660332.	237230.	1048.45	1048.8	1038.17
ORMW	MW008	2660206.	236326.	1046.53	1045.0	1035.30
ORMW	MW009	** 2659493.	236847.	1040.36	1038.5	1035.55
ORMW	MW010	2659457.	236744.	1039.38	1037.5	1033.38
ORMW	MW011	2659686.	237131.	1040.50	1040.8	1034.00
ORMW	MW012	2659454.	237386.	1040.39	1040.7	1030.76
ORMW	MW013	2659303.	237517.	1040.81	1041.2	1031.32
ORMW	MW014	2659287.	236807.	1034.60	1035.0	1031.23
ORMW	MW015	2659146.	237066.	1036.58	1034.7	1027.36
ORMW	MW016	2659124.	237168.	1036.54	1032.9	1025.80
ORMW	MW017	2659152.	237319.	1039.65	1037.2	1024.89
ORMW	MW018	2658431.	236027.	1041.30	1039.4	1032.54
ORMW	MW019	2658004.	236254.	1037.39	1035.5	1029.80
ORMW	MW020	2658017.	235854.	1038.94	1036.9	1031.91
ORMW	MW021	2658296.	236543.	1035.45	1033.4	1027.59
ORMW	MW022	2657885.	238526.	1018.91	1017.4	1016.91
ORMW	MW023	2659956.	237189.	1043.63	1043.9	1034.96
ORMW	MW024	2661938.	235953.	1064.37	1062.8	1039.55
ORMW	MW025	** 2657889.	238520.	1019.61	1017.8	1017.06
ORMW	MW026	2658325.	236583.	1036.53	1033.1	1027.35
ORMW	MW027	2661647.	236245.	1061.32	1059.9	1040.38
ORMW	MW028	*** 2658497.	235854.	1041.03	1037.9	1037.75
WESTON	SW001	2659041.	237061.	1034.42	1032.5	1025.50
WESTON	SW002	2659262.	237304.	1040.06	1038.3	1033.58
WESTON	SW003	2659482.	237083.	1039.87	1037.8	1031.40
WESTON	SW004	2659463.	237289.	1039.40	1039.6	1030.65
WESTON	SW005	2659672.	236815.	1042.03	1039.6	1035.85
WESTON	SW006	2658670.	237865.	1034.42	1033.1	1023.77
COREHOLE	CH001	2658483.	236866.	1029.66	1028.5	1015.93
COREHOLE	CH002	2657885.	238545.	1018.11	1017.8	1000.73
COREHOLE	CH003	2661288.	236251.	1059.95	1060.0	1038.75

Note: * water levels measured between 5 July and 15 July
 ** indicate wells compared to contract surveyor
 *** water level measured 14 December

TABLE I-2
(control monument coordinates)

Station	ORNL		G.W. SURVEYING	
	Easting	Northing	Easting	Northing
FP1	2660696.29	235847.32		
FP2	2660491.54	236056.29		
FP3	2660286.78	236265.25		
FP4	2660082.03	236474.22		
FP5	2659877.28	236683.18		
FP6 *	2659671.40	236893.30	2659671.40	236893.30
FP7	2659465.53	237103.42		
FP8	2659259.63	237313.55		
FP9	2659055.51	237521.88		
FP10 *	2658851.39	237730.20	2658851.39	237730.20
FP11	2658645.29	237940.54		
FP12	2658439.18	238150.89		
COOP *	2657475.57	236127.67	2657475.57	236127.67
TF1	2658689.95	236052.51		
TF2	2658668.97	236451.01		
TF3	2658070.93	236417.66		
TF5	2658114.12	235620.60		
FH677	2658595.14	237609.98		
NWC6	2657566.66	235556.82		
Topeka #180	2660866.38	235681.12		
DRR	2657631.17	234055.57		

Building corners miscellaneous points surveyed

1	2658053.87	235480.13
674NW	2659237.12	237121.24
674SW	2659281.62	237076.34
673NW	2659387.00	236971.00
673SW	2659467.00	236891.00
671NW	2659525.00	236819.00
671SW	2659609.13	236734.00
671SE	2659636.08	236755.47
671NE	2659550.00	236841.00
670NE	2659713.33	236718.56
670NE	2659813.09	236615.27
668SW	2659505.42	236319.18
668NW	2659424.66	236403.43

NOTE: * indicates control points compared to contract surveyor

TABLE I-3
(ditch survey locations)

	Easting	Northing	Site	Elevation
DITCH	2657833.05	238486.55	D1	1007.6
DITCH	2657883.89	238294.03	D2	1008.0
DITCH	2658154.62	237885.38	D3	1013.0
DITCH	2658461.25	237434.85	D4	1016.5
DITCH	2658658.64	237109.95	D5	1018.7
DITCH	2658714.01	236713.60	D6	1024.9
DITCH	2659036.47	236423.84	D7	
DITCH	2659012.71	236509.00	D8	
DITCH	2658999.13	236556.83	D9	
DITCH	2658991.08	236572.34	D10	
DITCH	2658980.08	236602.87	D11	
DITCH	2658947.39	236646.16	D12	
DITCH	2658887.20	236706.76	D13	
DITCH	2658859.87	236757.05	D14	
DITCH	2658857.09	236664.44	D15	
DITCH	2658782.49	236583.66	D16	
DITCH	2658814.25	236857.74	D17	
DITCH	2658811.87	236897.61	D18	
DITCH	2658784.46	236932.97	D19	
DITCH	2658744.29	236981.59	D20	
DITCH	2658694.60	237037.15	D21	
DITCH	2658662.98	237090.98	D22	
DITCH	2658660.94	237102.26	D23	

Ditch water elevations measured on 10 July 1988

Vertical control was established from a Topeka municipal vertical control brass cap designated as Topeka #180. The brass cap is set in a concrete curb adjacent to the aircraft parking ramp approximately 250 ft northeast of the Civil Engineering building 760 (Fig. I-4). The elevation survey consisted of five independent loops, all referencing Topeka #180. In addition, temporary bench marks located on the fire hydrants along the aircraft parking ramp were used as secondary check points (Fig. I-5).

An independent verification of the land survey was performed by G. W. Surveying, a Kansas certified and licensed surveyor. The verification surveyor checked the horizontal control and elevation of three monitoring wells and two control points. All check locations were satisfactory except for one elevation measurement on level circuit 5, which was for elevations of those wells in the northwest corner of the base. The Kansas certified surveyor performed a new survey through level circuit 5 and measurements from the new survey were used for final data. The surveyors certificate is shown in Fig. I-6.

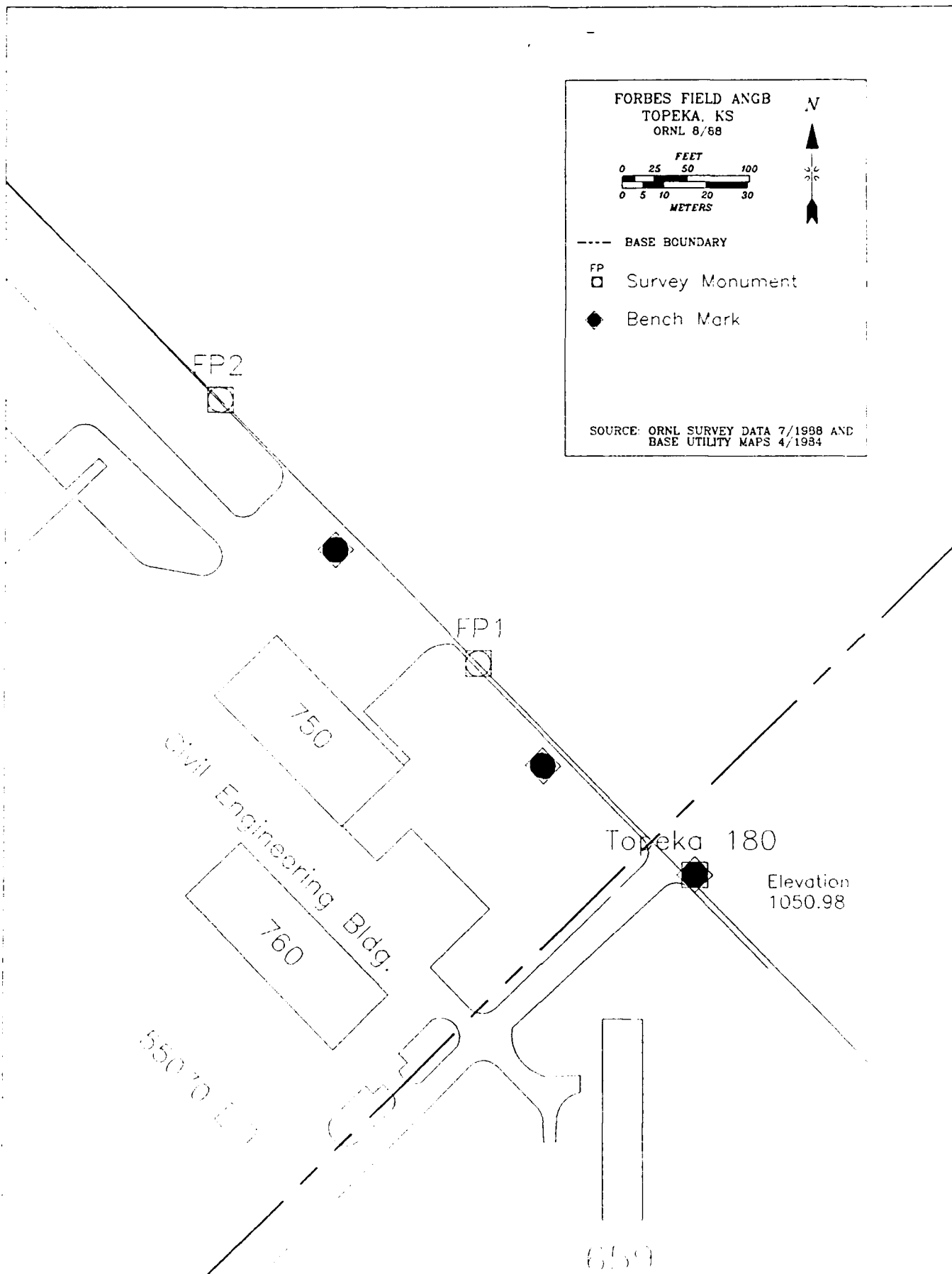


Fig. I-4 Topeka #180 benchmark location

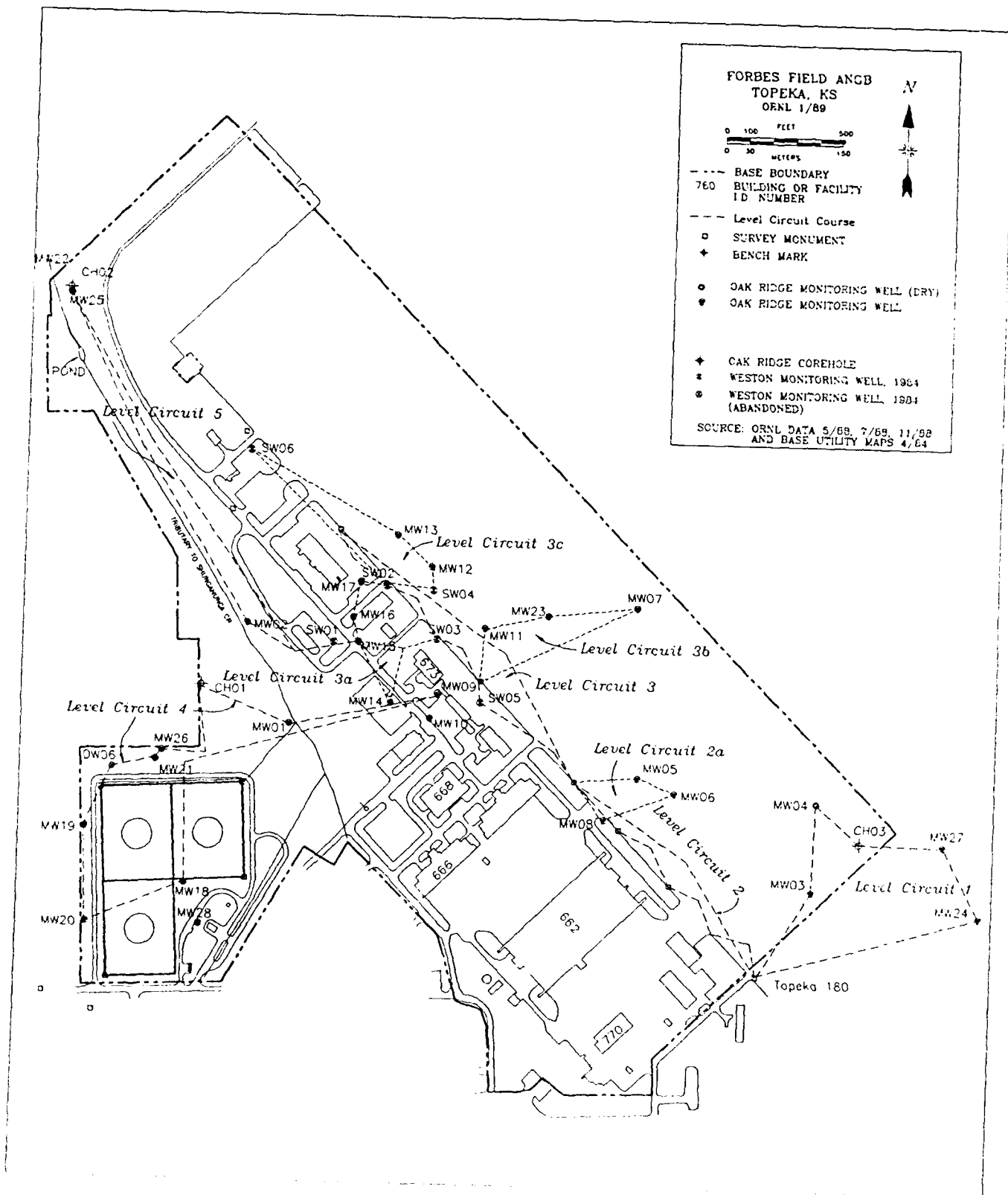


Fig. I-5. Elevation level loops.

G.W. SURVEYING

RR 1 Box 135
Carbondale, Kansas 66414

14 July 1988

Kim Woynowski
Oak Ridge National Laboratory
Grand Junction, Colorado 81502

Job #8856

Checked horizontal control and vertical control on monitoring wells
MW03, MW09, and MW25. Also the horizontal control on control points
FP6 and FP10 at the Kansas Air National Guard, Forbes Field, Kansas.


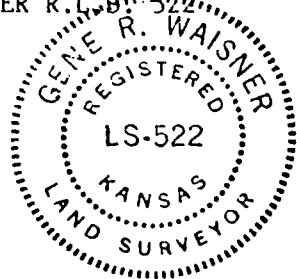
The results of work performed are as follows:

STATE PLANE COORDINATES

POINT DESCRIPTION	NORTH	EAST	ELEVATION
MW03	236,043.1779343955	2,661,089.3390534990	1053.42
MW09	236,846.3807929551	2,659,492.4979801340	1040.36
MW25	238,519.0386393192	2,657,888.5006496380	1019.57
FP-6	236,893.3009363086	2,659,671.4046373510	1039.45
FP-10	237,730.1967913732	2,658,851.3892167330	1038.63

I hereby certify that the above is a true finding of field work performed
by me.

DATE July 14 1988


GENE WAISNER R.L.S. 522


APPENDIX J

RISK ASSESSMENT METHODS

RISK ASSESSMENT METHODS

Appendix J, Risk Assessment Methods, is an independent report included as an appendix to support the conclusions of the remedial investigation report. This risk assessment was prepared by the Office of Risk Analysis, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

DRAFT
PRELIMINARY
RISK ASSESSMENT

FORBES FIELD AIR NATIONAL GUARD BASE
TOPEKA, KANSAS

Dennis B. Miller
C. Wilson McGinn
Robin K. White

Office of Risk Analysis
Oak Ridge National Laboratory*
Oak Ridge, Tennessee

May 22, 1989

*Operated by Martin Marietta Energy Systems, Inc. Contract
No. DE-AC05-84OR21400 with the U. S. Department of Energy.

TABLE OF CONTENTS

	<u>Page No.</u>
INTRODUCTION	J-7
SITE BACKGROUND	J-7
REPORT ORGANIZATION	J-8
SITE CHARACTERIZATION	J-9
Site No. 1, the Tank Farm	J-9
Site No. 5, Pumphouse E	J-12
Site No. 6, Surface Drainage Ditch and Storm Sewer Outflow . .	J-12
Aircraft Parking Apron Sites	J-13
CONTAMINATION CHARACTERIZATION	J-16
ENVIRONMENTAL PATHWAYS	J-26
Groundwater	J-26
Surface Water	J-28
Drainage Ditch Sediment	J-29
Soil	J-30
Air	J-30
Food Chain	J-31
EXPOSURE PATHWAYS	J-32
Exposure Analysis	J-32
Groundwater	J-33
Surface water	J-33
Ditch sediment	J-36
Soil	J-36
Receptors	J-37
Summary	J-37
EXPOSURE CHARACTERIZATION	J-39
Exposure Scenarios	J-39
Construction Worker Scenario	J-40
Maintenance Worker Scenario	J-40
General Residential Scenario	J-40
Child Scenario	J-41
Estimation of Exposure	J-41

	<u>Page No.</u>
RISK CHARACTERIZATION	J-47
Toxicological Effects of Contaminants of Concern	J-47
Estimations of Risk	J-51
Site-specific Risk Evaluation	J-53
Site No. 1.	J-53
Site No. 5.	J-54
Site No. 6.	J-54
Site No. 7	J-62
Site No. 8.	J-63
Site No. 9.	J-63
The Southeast Corner	J-63
CONCLUSIONS	J-69

LIST OF FIGURES

<u>Figure</u>		<u>Page No.</u>
1	Site location map of Forbes Field ANGB.	J-10
2	Location of known groundwater wells within a 2.5 mile radius of Forbes Field Air National Guard Base.	J-35

LIST OF TABLES

<u>Table</u>	<u>Page No.</u>
1 Indicator chemicals for Forbes Field ANGB.	J-20-25
2 Location of domestic wells within a 2.5 mile radius of Forbes Field Air National Guard Base.	J-34
3 Assumptions and calculations for construction worker scenario	J-42
4 Assumptions and calculations for maintenance worker scenario	J-43
5 Assumptions and calculations for general resident scenario .	J-44
6 Assumptions and calculations for child scenario	J-45
7 Exposure analysis for Site No. 1, the Tank Farm	J-56-57
8 Exposure analysis for Site No. 5, Pumphouse E	J-58-59
9 Exposure analysis for Site No. 6, the Drainage Ditch	J-60-61
10 Exposure analysis for Site No. 7, refueling hydrant, lateral No. 3	J-64
11 Exposure analysis for Site No. 8, refueling hydrant, lateral No. 7	J-65-66
12 Exposure analysis for Site No. 9, refueling hydrant, lateral No. 8	J-67-68

INTRODUCTION

This Risk Assessment (RA) for Forbes Field Air National Guard base (ANGB) in Topeka, Kansas was prepared by the Oak Ridge National Laboratory, Office of Risk Analysis. This report is part of the National Guard Bureau's Installation Restoration Program (IRP), which has been implemented to investigate and remediate contaminated sites subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) as amended. This RA is part of a Phase II investigation which has confirmed and quantified hazardous substances at locations identified as potentially contaminated in Phase I of the IRP, and evaluates the potential impact on human health. The objective of this Risk Assessment is to determine the potential for exposure to the contaminated media at Forbes Field ANGB and to evaluate the probability for potential health effects that may result from this exposure.

SITE BACKGROUND

Forbes Field ANGB is located in Shawnee County approximately 2.5 miles south of the southern boundary of Topeka, Kansas. The base is situated on 180 acres in the northeast corner of what was formerly Forbes Field Air Force Base. The area surrounding the base is light industrial, agricultural, and residential land. The unincorporated village of Pauline, Kansas lies approximately 250 feet west of the base. The Shawnee County Waste Repair Facility repairs garbage trucks and occupies a building southwest of Hangar No. 666, approximately 50 feet from the base boundary.

Forbes Field Air Force Base was opened in 1942 and closed at the end of World War II. The base was reopened from 1948 to 1949 and was used by Army Air Corps reconnaissance and geodetic survey divisions. During this time, the base was renamed Forbes Field Air Base. Forbes Field Air Base was again reopened in 1951 to train bomber crews. Operation of the facility was transferred to the U.S. Air Force in 1954 and the installation was renamed Forbes Field Air Force Base. In 1973 Air Force operations at Forbes were terminated; however, the Kansas Air National Guard 190th Air Refueling Group (190th AREFG) remained active on the base.

The facilities currently occupied by the Kansas Air National Guard (KSANG) were built between 1954 and 1959. Aerial photos taken in 1954 show

the majority of the Air National Guard Base as agricultural land with only the aboveground storage tanks in existence. At present the base is a fenced and patrolled security area.

Jet fueling and storage facilities are maintained on the base by the 190th AREFG. Facilities for jet fuel storage consist of three aboveground tanks on the west side of the base and 26 underground storage tanks near the three pumphouses (buildings No. 671, 674, and 678) at the west edge of the aircraft parking apron. The total fuel capacity of the storage facilities on the base is approximately 14 million gallons. Operational support activities on the base include aircraft retrofitting, aircraft maintenance, ground vehicle maintenance, and fire department training. These operations generate and dispose of varying quantities of waste oils, recovered fuels, spent cleaners, strippers, and solvents. Hazardous waste produced by these procedures is disposed of by the Defense Reutilization and Marketing Office.

There are over 300 full-time employees at Forbes Field ANGB. There is also a National Guard contingent of approximately 1100 people assigned to the base which is present one weekend per month and for a single two-week period during the year. National Guard personnel are on the base the duration of a standard work day while serving their commitment. No one resides on-base. The water supply for the base is Topeka public water from the Kansas River Alluvium.

REPORT ORGANIZATION

After a general introduction and site background of Forbes Field ANGB, this report will examine the site specific characterization of seven sites. A section discusses the indicator chemicals at each site, followed by an evaluation of the environmental fate and transport of these contaminants. The ensuing analysis considers the potential exposure pathways and the significance of the contamination to public health. The results of the exposure pathway analysis are summarized with a characterization of the risk from the contaminants at each site.

SITE CHARACTERIZATION

Hazardous Materials Technical Center (HMTc) conducted the Phase I investigation of the base and identified 10 potentially contaminated sites. HMTc determined that Sites No. 2, 3, 4, and 10 did not present a contaminant migration problem and that no further action was necessary. The remaining six sites (Sites No. 1, 5, 6, 7, 8, and 9) were identified as requiring further study. In addition, a groundwater contamination study by Roy F. Weston, Inc. in 1984, discovered contamination upgradient of all identified sites. This suggested that contamination was entering the base from an off-base source. The HMTc identified this area as the "Southeastern Corner of Forbes Field ANGB Property" and recommended that the area be studied in conjunction with the previous numbered sites. Therefore, seven sites are considered in the Risk Assessment of Forbes Field ANGB and are identified in Figure 1:

- Site No. 1: Tank Farm
- Site No. 5: Pumphouse E and adjacent area
- Site No. 6: drainage ditch
- Site No. 7: area adjacent to refueling hydrant, lateral No. 3
- Site No. 8: area adjacent to refueling hydrant, lateral No. 7
- Site No. 9: area adjacent to refueling hydrant, lateral No. 8
- (unnumbered site): Southeast Corner of the base

Most of these sites are part of the fuel storage and distribution system and will be discussed individually. A determination of the contamination source at the sites was made on the basis of information in the Phase I -Records Search and interviews with base personnel reported in the Phase II - Remedial Investigation.

Site No. 1, the Tank Farm

Site No. 1, the Tank Farm (Figure 1), is located at the southwest corner of the base. This site is comprised of three aboveground fuel tanks (bulk storage tank facilities No. 55122, 55123, and 55124), a spill containment area surrounded by an earthen berm, truck unloading hydrants, a pumphouse, a NASA JP-7 aboveground storage tank, and underground fuel distribution lines. This facility is currently used as a bulk jet fuel storage area. The exact date of construction of the Tank Farm Facility is not known, although the storage tanks are present in aerial photographs taken in 1954. West of the pumphouse was an above ground auxiliary wing tank from a B47 (installation date unknown), with a capacity of 600 to 700 gallons. It contained JP-4, aviation

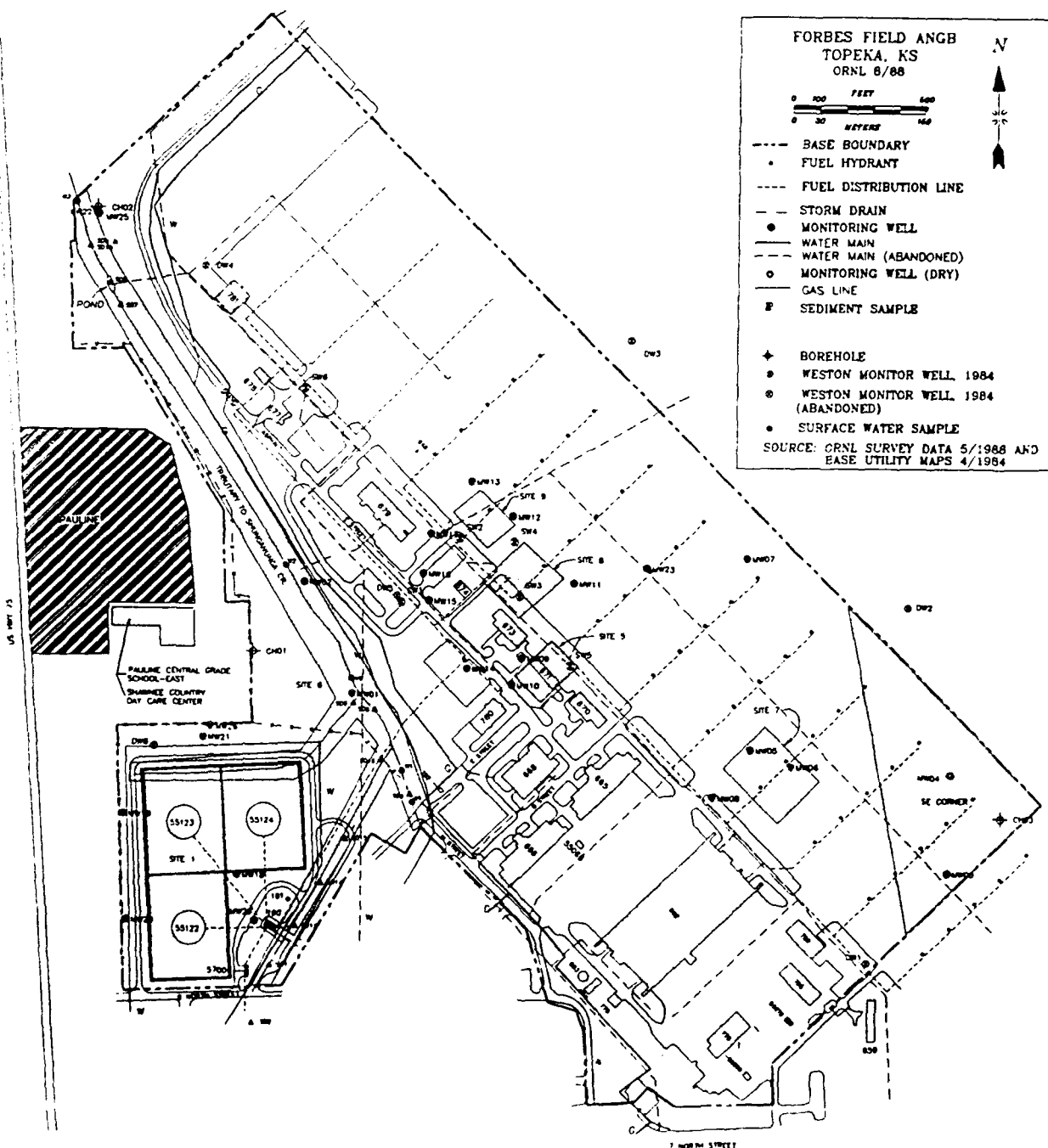


Figure 1. Site location map of Forbes Field ANGB.

gas, and the sludge from the cleaning of filters. This tank and its contents were removed in 1967 or 1968.

Two of the fuel storage tanks have a capacity of 1.98 million gallons each, and the third has a capacity of 2.42 million gallons of jet fuel (JP-4). All of the tanks have a floating roof design. An earthen dike four to five feet high enclosing each tank forms a spill containment area which is coated with a road bed surface. If an excessive amount of precipitation occurs, these containment areas are drained through a system of controlled outlets into the surface drainage ditch (Site No. 6). Otherwise, the outlets remain closed.

Fuel is received daily from trucks at several hydrants along the southeast side of the Tank Farm and is pumped by the pumphouse through underground lines to the storage tanks or to base distribution lines. The lines from the pumphouse to the storage tanks are buried at least 3.5 feet underground and the lines through which fuel is distributed to the base are approximately 8 feet below grade. Base records indicate a history of leaks and spills of jet fuel in the Tank Farm area, with the most significant leak occurring from tank No. 55122 in 1981. This leak from the southeast side of tank No. 55122 (the southernmost tank) released approximately 1200 to 1400 gallons of JP-4. None of the fuel was recovered; therefore, the entire leak either evaporated or infiltrated into the subsurface. The most recent release at the storage tank facility occurred in 1982 when approximately 300 gallons of JP-7 were released from NASA's aboveground fuel storage tank (this tank was identified as Site No. 3 in the Phase I Report). Reportedly, 95% of this spill was recovered; the remainder was lost through evaporation and/or infiltration.

Sludge removed during fuel storage tank cleaning is a secondary contaminant source in the Tank Farm area. The sludge consisted of jet fuel diluted with rusty water and soap. From the 1950's to 1978 an unknown quantity of this sludge was buried north of the storage tank facility. In 1977, 100 gallons of tank cleaning sludge were buried on the west side of the Tank Farm (this area was identified as Site No. 2 in the Phase I Report).

Site No. 5. Pumphouse E

Site No. 5 (Figure 1) is the area surrounding Pumphouse E (building no. 671), constructed between 1954 and 1959. The pumphouse (located about 130 feet southwest of the refueling apron) is a single story concrete block building surrounded by a gravel strip 30 to 50 feet wide which is encircled by grass. There are 14 underground fuel storage tanks at this site, each holding 50,000 gallons. The tanks are located to the northeast and to the southwest of the pumphouse. The depths to the top and bottom of these tanks are two and 13 feet respectively. Pumphouse E serves fuel laterals 1 through 6, pumping fuel to or from the fuel distribution lines for fueling and defueling of aircraft. Pumphouse E also pumps fuel to and from the Tank Farm facilities via underground lines. In addition, there are base utility lines buried between Pumphouse E and the aircraft parking ramp buried at depths of two to seven feet.

Only one release has been documented in the area of Pumphouse E: a spill of 2000 to 10,000 gallons of jet fuel which was accidentally discharged from the facility in 1967. The spill of JP-4 flowed onto the ground along the north side of the building. No fuel was recovered. Contamination in this area was documented in 1979 or 1980 when soil visibly contaminated with fuel was uncovered during excavation and construction activity in this area. Stressed vegetation has also been observed within this area.

Site No. 6. Surface Drainage Ditch and Storm Sewer Outflow

Site No. 6 (Figure 1) consists of the surface drainage ditch, which flows through the northwest side of the base and all of its tributaries including the base storm sewer system. Two of the drainage ditch tributaries drain the Tank Farm area. One is located north of the Tank Farm and drains the spill containment area; the second drains the area adjacent to the truck unloading hydrants. Another tributary drains the area southwest of the hangars and the Shawnee County Waste Repair Facility. Most of the overland surface water flow at the base is drained through the storm sewer system, which empties into the drainage ditch at three locations. The largest of these storm sewers drains all of the aircraft parking ramp and most of the parking lots and roads near the ramp and discharges into a small ponding of the ditch at the northwest corner of the base.

The drainage ditch is present in 1954 aerial photos; however, a large man-made pond existed between the Tank Farm and the present day pond. In a 1959 aerial photograph, the pond is gone and the drainage ditch appears to follow its present course through the base. The pond is actually a pool-sized body of water within the ditch channel created by a small dam.

The base surface drainage ditch is lined by vegetation. In the area of the Tank Farm flow has incised the ditch to a depth of approximately six feet. Where it exits the base at the north boundary the streambed is approximately 15 feet below the right bank of the ditch. As the stream travels along the northwest boundary of the base, it flows within 100 feet of several private residences and within 200 feet of U.S. Highway 75. As the stream exits the base, it enters an area of dense vegetation and travels through several areas of agricultural, industrial, and commercial lands before it flows into the South Branch of Shunganunga Creek on its way to the Kansas River.

The sources of contamination at Site No. 6 are spills or leaks (which flowed into tributaries or directly into the drainage ditch) and possibly discharge of contaminated groundwater into the ditch. It was noted in the Phase I - Records Search that an oily sheen has been observed in the ditch and on the pond on several occasions. Fuel has also been observed flowing into the storm sewer system on at least one occasion. This incident occurred during the pressurization of lateral No. 8 (Site No. 9) to locate a leak and resulted in an unknown quantity of fuel flowing into the storm sewer catch basin at the northwest corner of the base.

Aircraft Parking Apron Sites

Sites No. 7, 8, 9, and the southeastern corner of the base are all located on the aircraft parking apron. The facilities and operations at these sites are similar and, therefore, will be considered collectively. The aircraft parking apron and the fuel distribution system were constructed between 1954 and 1959. All of the facilities associated with Sites No. 7, 8, 9, and the southeastern corner of the base are currently in use. The aircraft parking apron surface consists of 18 to 22 inches of concrete with 3.5 inches of asphalt overlay. The fuel distribution system beneath the aircraft parking apron dispenses fuel to the fuel hydrants for refueling aircraft.

The pumphouses (laterals No. 1 through 6, and No. 20, are supplied by Pumphouse E; laterals No. 7 through 9 are supplied by Pumphouse G) transfer fuel through refueling headers to the fuel laterals which are buried approximately 3.5 feet under the concrete apron. The trenches in which the 700 foot laterals are bedded are filled with a coarse sand which extends to the undersurface of the apron. The fuel hydrants are joined with a tee connection to the fuel laterals and are located just beneath the parking apron where a flush mounted lid covers the connections.

Site No. 7 (Figure 1) surrounds the two southernmost refueling hydrants on fuel lateral No. 3. The site boundary is approximately 90 feet northeast of the west edge of the aircraft parking apron. The only documented leak at Site No. 7 occurred in December, 1981 and involved an undetermined quantity of jet fuel accidentally discharged from the first fuel hydrant on lateral No. 3.

Site No. 8 (Figure 1) encompasses an area surrounding the first fuel hydrant on fuel lateral No. 7. The site boundary is approximately 20 feet northeast of building No. 673. The Phase I - Records Search identified a jet fuel leak of undetermined quantity from the first fuel hydrant on lateral No. 7 in July, 1982.

Site No. 9 (Figure 1) consists of the area surrounding the first fuel hydrant on fuel lateral No. 8. The boundary of the site is approximately 30 feet east of the west margin of the aircraft parking apron. The contamination source identified by Phase I is the jet fuel leak that occurred at the first hydrant on lateral No. 8 in 1983 when a maximum of 3000 gallons of fuel was lost. The leak was detected when JP-4 was observed seeping from pavement joints adjacent to site No. 9. The lateral was pressurized to locate the leak at which time an unknown quantity of JP-4 was released under the concrete apron. The fuel that flowed onto the apron then migrated to a storm sewer catch basin at the northwest corner of the base. The storm sewer drains into the small pond (Site No. 6) at the northwest corner of the base.

The southeast corner of Forbes Field ANGB encompasses an area on the aircraft parking apron. The parking apron extends south and east of the base property line on property formerly owned by the Air Force Base and currently owned by the Metropolitan Topeka Airport Authority. There is a fuel lateral (No. 20) associated with Pumphouse E, located south of the southeastern boundary of the base. Contamination was revealed in this area during the

groundwater contamination study conducted by Roy F. Weston, Inc. in 1984, suggesting an off-base source of contamination. No spills or leaks have been reported in this area, and a source of contamination has not been identified. The source of contamination could be past leaks from fuel laterals.

CONTAMINATION CHARACTERIZATION

The indicator chemicals for the sites at Forbes Field ANGB were selected using the Superfund Public Health Evaluation Indicator Selection Process. This evaluation was undertaken to identify a manageable number of contaminants to be considered during exposure scenarios, to select contaminants representative of the most toxic, mobile, and persistent chemicals at the site, and to identify those contaminants detected in the highest concentrations.

There were 58 contaminants found in surface water, groundwater, sediment, and subsurface soil samples at the base. A complete record of the contaminants is contained in appendix E of the Remedial Investigation Report (RIR). Table 1 presents the 8 contaminants selected as indicator chemicals according to sites and media. In addition, the table provides the range in concentration, representative concentration, Applicable or Relevant and Appropriate Requirements (ARARs), the excess cancer risk (dose x cancer potency factor) associated with the carcinogenic indicator chemicals, and the representative concentration toxicity (CT= representative concentration x toxicity) for each contaminant in the various media at each site. As directed by the Superfund Public Health Evaluation guidelines, the representative concentration was calculated as an arithmetic mean of downgradient contaminated samples. The CT value is used in the Indicator Selection Process to evaluate contaminants; it is the product of the representative concentration and the toxicity of the contaminant reported by the United States Environmental Protection Agency (USEPA) in the Superfund Public Health Evaluation Manual.

In the course of selecting the indicator chemicals 50 of the contaminants identified in samples from the base were excluded from the exposure scenarios. These contaminants can be divided into four broad groups on the basis of the rationale for their exclusion: 1) contaminants which have no known on-base source and are believed to have an exogenous source 2) those that occur at concentrations below background levels 3) contaminants at concentrations that are negligible relative to adverse human health effects 4) and a group for which there is little toxicological information.

The chemicals believed to originate off-base were found in samples of ditch sediment from Site No. 6. Since there is no known source for pesticides

on base, pesticides (dieldrin, 4,4-DDT, and 4,4-DDE) found in sediment sample SD09, (taken from the ditch near the northwest boundary of the base, see Plate 1 of the RIR) were eliminated from consideration as indicator contaminants. Considering the agricultural development of the area, these pesticides most likely derive from an off-base source. Likewise, polynuclear aromatic hydrocarbons (PAHs) found in the sediment samples from the drainage ditch were also excluded from the evaluation of base contaminants. These chemicals are common by-products of the incomplete burning of fossil fuel and consequently are often found in roadside sediment. The samples containing PAHs are limited to areas in the drainage ditch that receive roadway runoff.

In addition to excluding pesticides and PAHs, lead was also eliminated at this stage of the indicator selection process. The distribution of lead observed in ditch sediment samples suggests that lead is probably associated with road dust, which is not associated with any of the sites now under investigation. Therefore, under IRP guidelines lead cannot be considered in this risk assessment.

Several studies have linked lead contamination to motor vehicle emissions. Lead concentrations as high as 0.1% were found in analyses of roadway dust performed by Hopke et al. (1980). Lagerwerff and Specht (1970) demonstrated the existence of a lead concentration gradient associated with roadway proximity. This study revealed that the amount of lead in soil decreased with distance from the road and with depth. Getz et al. (1977) ascertained that the highest lead concentrations are typically within 65 feet of roadways and that the volume of traffic has a direct effect on the levels of lead in roadside soil.

Lead is present in concentrations exceeding the regional background level in several sediment samples (SD1, SD13, SD14, SD15, and SD16, see Plate 1 of the RIR) from the drainage ditch tributary to the southeast of the Tank Farm. All of the sediment samples with anomalously high lead concentrations are associated with the road used by fuel tankers to access the Tank Farm pumphouse hydrants to download JP-4. Lead in this area is not correlated to any known spills or leaks and is hydraulically either upgradient or isolated from all potentially contaminated IRP sites. Although not a typical component, trace amounts of lead are found in JP-4 (0.09 mg/L, Chassemi et al., 1984). However, the suite of contaminants expected from JP-4

contamination are not present. Conversely, the diesel fuel used by the fuel tankers contains <0.49 to 2.0 mg/L of lead (Ghassemi et al., 1984) and contaminants associated with road dust and runoff (PAHs) are evident in this area.

The access road to the Tank Farm pumphouse hydrants is used daily by fuel tankers to download JP-4. The road provides access to the downloading hydrants, which are located west of the tributary. The road consists of an entrance lane paralleling the west side of the tributary and an exit lane paralleling the east side of the tributary. The access road crosses the tributary approximately 1600 feet downstream from the Tank Farm entrance. Samples SD1, SD13, SD14, and SD15 have the highest lead concentrations found in ditch sediment and are located inside the loop created by the fuel tanker access road, encircling the tributary.

There is clearly a decrease in lead with increased distance from the Tank Farm fuel downloading area. The samples within this area are within 50 feet of the tanker access road and had an average lead concentration of 111.25 mg/L. Sample SD16, taken approximately 650 feet downstream from the fuel tanker access road, demonstrates an appreciable decline to 38.0 mg/L in lead content. A sample (SD5) taken 1000 feet downstream of the road contained 7.0 mg/L of lead, well below the regional background of 23.8 mg/L (Fleischhauer, 1988). Drainage ditch sediment samples from the base boundary were also below background. The dependence of the lead concentration gradient on sample distance from the fuel tanker access road suggests that the source of lead is not an IRP site.

Therefore, although lead is a trace component of JP-4, the lead concentrations in the ditch sediments are most likely associated with motor vehicle exhaust from the Tank Farm access road and nearby base entrance, deposited in ditch sediment directly or via road runoff. These levels, then, may be regarded as an anomaly associated with proximity to the Tank Farm fuel downloading area and *not* reflections of effects associated with site contamination.

Most of the contaminants detected below background levels are metals, in both soil and sediment samples. Except for lead, all of the metals occur at concentrations less than regional background levels. Although many of these

metals may be trace constituents of JP-4, their concentrations are not indicative of contamination by jet fuel.

Several contaminants were removed from further consideration as potential human health hazards due to low concentrations and relatively low toxicity. These chemicals have a hazard index rating that was well below one (1): acetone, benzoic acid, bromodichloromethane, and phenol. In addition, some of these contaminants were found in only one sample.

The remaining contaminants excluded from the exposure scenarios are predominantly hexanes and pentanes. The limited quantitative toxicologic information on these chemicals inhibits attempts at evaluating their individual effects on public health. However, the concept of using indicator chemicals enables such contaminants to be represented in the exposure scenario analysis by contaminants of similar chemical properties and known toxicity (as is the case with benzene, toluene, and xylene in the present assessment).

TABLE 1. INDICATOR CHEMICALS FOR FORBES FIELD ANGB.

SITE NO. 1, GROUNDWATER INDICATOR CHEMICALS*					
<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>	<u>CT***</u>
Benzene	ND - 0.011	0.006	0.005 ^{ad}	4.97 E-06	4.60 E-05 ^{pc}
Ethylbenzene	ND - 0.003	0.003	0.680 ^{pmclg}	-	3.30 E-05
Toluene	ND - 0.001	0.001	2.000 ^{pmcl}	-	5.20 E-06
Xylene	ND - 0.110	0.055	0.440 ^{pmclg}	-	NA

SITE NO. 1, SOIL INDICATOR CHEMICALS*					
<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>	<u>CT***</u>
Benzene	ND - 0.380	0.380		3.94 E-09	1.47 E-07 ^{pc}
Ethylbenzene	ND - 1.600	0.800		-	4.46 E-07
Toluene	0.002 - 1.800	0.488		-	1.27 E-07
Xylene	ND - 31.000	4.218		-	NA

* All values are reported as ppm

** Applicable or Relevant and Appropriate Requirements

*** CT = Representative Concentration multiplied by the chemical's media specific toxicity (from the Superfund Public Health Evaluation Manual)

MCL Maximum Contaminant Level

KAL Kansas Action Level

PMCLG Proposed Maximum Contaminant Level Goal

PC Potential Carcinogen (from the Superfund Public Health Evaluation Manual)

TABLE 1. (continued)

SITE NO. 5, GROUNDWATER INDICATOR CHEMICALS*				
<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>
Benzene	ND - 0.640	0.310	0.005 ^{md}	2.57 E-04
Ethylbenzene	ND - 0.740	0.381	0.680 ^{md}	-
Toluene	0.007 - 0.010	0.009	2.000 ^{md}	-
Xylene	ND - 1.300	0.648	0.440 ^{md}	-
				<u>CT***</u>
				2.00 E-03 ^{pc}
				4.00 E-03
				4.68 E-05
				NA

SITE NO. 5, SOIL INDICATOR CHEMICALS*

<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>
Toluene	ND - 0.003	0.003		-
1,1,1-Trichloroethane	ND - 0.004	0.004		-
Xylene	ND - 2.600	2.600		-
				<u>CT***</u>
				7.80 E-10
				1.44 E-10
				NA

TABLE 1. (continued)

SITE NO. 6, SURFACE WATER INDICATOR CHEMICALS*

<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>	<u>CT***</u>
Trichloroethene	ND - 0.005	0.003	0.005 ^{mod}	9.48 E-07	1.29 E-05 ^{pc}
Vinyl Chloride	ND - 0.007	0.006	0.002 ^{mod}	3.94 E-04	2.57 E-05 ^{pc}

SITE NO. 6, SOIL INDICATOR CHEMICALS*

<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>	<u>CT***</u>
Toluene	0.001 - 0.002	0.002		-	5.20 E-10

TABLE 1. (continued)

SITE NO. 6, SEDIMENT INDICATOR CHEMICALS*				
<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>
1,1-Dichloroethane	ND - 0.006	0.006		-
Vinyl Chloride	ND - 0.002	0.002		1.64 E-09
				<u>CT***</u> 7.74 E-09 4.28 E-010*

SITE NO. 7, SOIL INDICATOR CHEMICALS*

<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>
1,1,1-Trichloroethane	ND - 0.002	0.002		-
				<u>CT***</u> 7.34 E-10

TABLE 1. (continued)

SITE NO. 8, GROUNDWATER INDICATOR CHEMICALS*

<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>	<u>CI***</u>
Toluene	ND - 0.001	0.001	2.000 ^{ppcld}	-	5.20 E-06

J-24

SITE NO. 8, SOIL INDICATOR CHEMICALS*

<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u>	<u>CI***</u>
Toluene	ND - 0.001	0.001		-	2.60 E-08

TABLE 1. (continued)

SITE NO. 9, GROUNDWATER INDICATOR CHEMICALS*				
<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u> <u>CT***</u>
Toluene	ND - 0.002	0.002	2.000 ^{µmole/g}	- 1.04 E-05
SITE NO. 9, SOIL INDICATOR CHEMICALS*				
<u>CHEMICAL</u>	<u>CONCENTRATION RANGE</u>	<u>REPRESENTATIVE CONCENTRATION</u>	<u>ARAR**</u>	<u>EXCESS CANCER RISK</u> <u>CT***</u>
Toluene	0.003 - 0.009	0.006		- 1.56 E-09

* All values are reported as ppm

** Applicable or Relevant and Appropriate Requirements

*** CT = Representative Concentration multiplied by the chemical's media specific toxicity (from the Superfund Public Health Evaluation Manual)

MCL Maximum Contaminant Level

KAL Kansas Action Level

PMCLG Proposed Maximum Contaminant Level Goal

PC Potential Carcinogen (from the Superfund Public Health Evaluation Manual)

ENVIRONMENTAL PATHWAYS

The following section is an evaluation of the environmental pathways and their site-specific characteristics which might affect contaminant migration from the seven potentially contaminated areas previously described. The pathways that have contaminants or the probability of future contamination and that have the capability of transporting their contamination to humans are groundwater, surface water, sediment, and soil. Evaluations of these pathways will include discussions of site groundwater and surface water flow and soil, sediment, and contaminant-specific characteristics which might affect the transfer and transformation mechanisms of the contaminants of concern. In addition to these discussions, a limited evaluation is made of the transport of contaminants through the air and food chain.

Groundwater

Groundwater is located in two units beneath Forbes Field ANGB: a water table aquifer composed of silty-clay glacial drift on top of unconsolidated weathered shale and limestone, and the Nodaway Coal Member of the Howard Limestone, a confined bedrock aquifer. The aquifers are separated by the confining Aarde Shale Member of the Howard Limestone Formation. The Severy Shale is located beneath the two aquifers at depths below ground level of approximately 32 feet at the southeastern corner and 16 feet at the northwest corner of the base. The permeability of the Severy Shale was below the detection limits used in packer-tests and is approximately 30 to 55 feet thick. This formation is, therefore, a plausible and considerable barrier to the vertical migration of water. Due to the impermeable nature of this formation, only the aquifers above the Severy Shale are pathways.

The potentiometric surface of the aquifer in the unconsolidated zone ranges from a depth of approximately 2.5 feet in the northwest section of the base to 19 feet in the southeast corner. The Nodaway Coal layer is approximately two feet thick and lies about 30 feet beneath the surface at the southeastern corner and 20 to 25 feet below the surface in the central area of the base. The hydraulic conductivity values obtained for the water table aquifer range from less than 0.1 feet/day to 2.0 feet/day, and the Nodaway Coal aquifer has a hydraulic conductivity of 3.2 feet/day. The groundwater flow in both aquifers is typically to the northwest.

The unconsolidated aquifer and Nodaway Coal are discrete aquifers beneath the southeastern area of the base; however, because the topography is steeper than the dip of the Nodaway Coal, this coal layer is truncated by the land surface and becomes part of the weathered bedrock in the northwest area of the base. The subsurface location at which the Nodaway Coal is incorporated into the unconsolidated aquifer is illustrated in Figure 2.11 of the RIR. This representation of the intersection of the Nodaway and the weathered bedrock is a point of discharge for the water in the coal aquifer into the water table aquifer. It has been demonstrated in the Remedial Investigation Report that the bedrock aquifer beneath the base is not in hydraulic communication with downgradient bedrock aquifers. This is based on core holes that establish the Nodaway Coal, which is the only bedrock aquifer beneath the base above the Severy Shale, as part of the unconsolidated aquifer in the northwestern section of the base. Therefore, if migration of contaminants off-base were to occur, contaminants would be confined to the unconsolidated aquifer.

Presumably most of the water in the unconsolidated aquifer is discharged into the unnamed tributary of the South Branch of Shunganunga Creek (the base drainage ditch). Discharge of the aquifer into the ditch is evidenced by the continuous flow in the ditch even during the drought endured by this area in the summer of 1988. However, it is difficult to determine if there is complete discharge of the aquifer into the ditch. Therefore, groundwater in the water table aquifer could feasibly migrate off-base. However, the low hydraulic conductivity and the discontinuous nature of the water table aquifer minimize the possibility of the migration of contaminated water in the unconsolidated aquifer. The absence of contaminants in groundwater samples taken from wells downgradient of the sites supports this contention.

Anthropogenic pathways which may increase the possibility of groundwater migrating off-base consist of the trenches for domestic water and gas lines which cross the base from north to south along the western side. These lines, buried above the fuel line trenches, are approximately six to eight feet deep at the northwestern corner of the base, at least four feet above the top of the storm sewer.

The evaluation of the extent of groundwater contamination in the aquifers beneath Forbes Field ANGB is based on the presence of contaminants

that have been determined to be a potential threat to human health at present concentrations. The examination of downgradient well samples containing these contaminants indicates that Site No. 1, the Tank Farm, and Site No. 5, the area surrounding Pumphouse E are contributing contamination to the groundwater. Lower concentrations of indicator chemicals were found in groundwater samples associated with Sites No. 8, 9 and the southeast corner.

The degree of contamination in the groundwater beneath Forbes Field ANGB may be affected by several sources which are difficult to evaluate quantitatively. These potential sources include the fuel lateral trenches beneath the aircraft parking apron at Sites No. 7, 8, 9, and the southeast corner (which could foreseeably contain fuel) and the underground storage tank pit associated with Pumphouse E. If fuel is ponding in the trenches, the silty-clay glacial soils may contain the fuel to the extent that the trenches act as conduits for the JP-4.

Another consideration arising from the probable ponding of fuel in the lateral trenches is the property of bulk hydrocarbons that produces an increase in the hydraulic conductivity of clay-rich soils (J. Dragun, 1988). This process does not permanently alter the soil permeability and is reversed when water replaces the hydrocarbons within interparticle pore spaces. The rejuvenation of the natural soil properties, however, is improbable at the base due to the inhibition of recharge by the parking apron. Regardless of the potential for this process to occur, the effect it would have on the transport of contaminants off-base would be negligible due to the excessive distance to receptors and the low hydraulic conductivity.

Although the Remedial Investigation Report suggests that contaminant transport via groundwater is unlikely, the remote possibility of future transport cannot be excluded. Therefore, in order to consider all conceivable scenarios, groundwater will be considered as a potential contaminant pathway. A comprehensive treatment of the potential adverse health effects associated with the contamination at Forbes Field ANGB is ensured by considering the off-base migration of contaminated groundwater.

Surface Water

Surface water is the most obvious route by which contaminants could be transported from the base. It is also a primary environmental pathway for the

transport of contaminated sediments and discharged groundwater. Forbes Field ANGB is located between two drainage divides that are located to the east and southwest and direct all surface runoff for the sites to an unnamed tributary of the South Branch of Shunganunga Creek (drainage ditch).

The drainage ditch begins in the vicinity of the Tank Farm and flows north-northwest exiting the base at the northwestern corner. The drainage ditch receives discharge from tributaries (which drain the Tank Farm) and the storm sewer drainage system (which drains the aircraft parking apron). It is also a point of discharge for the unconsolidated aquifer. Records indicate that the South Branch of Shunganunga Creek has experienced periods of no flow; however, the drainage ditch continually contained water during the dry summer of 1988, an indication of groundwater recharge.

The drainage ditch is a viable migration pathway for contaminated surface water and spills which occur on the base. Contamination was found in surface water samples taken from the upper section of the ditch; however, no contamination was found in samples taken at the base boundary. This restricted pattern of contaminated surface water samples indicates that the contaminants are most likely not being transported off-base in ditch flow. The ditch could receive contaminated discharge from the unconsolidated aquifer; however, the migration of contaminants in the groundwater is not substantiated. The potential also exists for the stream to transport contaminated drainage ditch sediments in suspension during periods of high-energy flow.

Drainage Ditch Sediment

Sediment samples were taken in the drainage ditch (Site No. 6) and at two downstream locations, approximately one and two miles from the base (see Plate 1 of the RIR). The high clay content of the area soils results in a high adsorption capacity, a property that may assist the migration of contaminants off-base in stream sediment. Therefore, contaminated sediments in the drainage ditch (Site No. 6) could be transported within the sediment load during periods of high flow.

The samples containing contaminants are restricted to the upper section of the ditch which drains the area to the southeast of the Tank Farm. Evidence of the migration of contaminants in the drainage ditch is not indicated by similar contaminant concentrations in downstream samples. Access

to this area is limited to base personnel and the probability of contaminated particles becoming airborne is mitigated by the grass cover and water in the ditch.

Soil

There are two soils underlying Forbes Field ANGB, Ladysmith and Pawnee. Ladysmith soils, the predominant soils on the base, consist of two types of moderately well-drained silty clay loams that occur on 0% to 1% and 1% to 3% upland slopes. These upland soils have a high capacity to hold water and extend to a depth of 58 inches. The Pawnee clay loam is a deep, well-drained soil developed on an upland glacial till occurring on 3% to 7% slopes. These soils extend to a depth of 79 inches and also have a high moisture capacity. The permeability of the soils which cover the base is within the range of 0.20 to 0.63 inch/hour.

Since surface soil samples were not taken it is not possible to assess the extent of contamination in this medium. However, the surface of the base is entirely covered by asphalt, concrete, building, gravel, and lawn. Therefore, the potential for migration of surface soil off-base is minimal.

The extent of contamination in the subsurface soil, based on the presence of contaminants that have been determined to be a threat to human health at present concentrations, is limited to a single sample (MW21, see Plate 1 of the RIR) from Site No. 1, the Tank Farm. Lower levels of indicator chemicals were present in soil samples associated with all sites except the southeast corner. The leaching of these contaminants into the groundwater is a mechanism by which the soil contaminants may enter a migration pathway, however, there is no contamination in downgradient wells to indicate that this is occurring. The subsurface soil is not considered a viable environmental pathway for the transport of these contaminants to the air or surface water unless excavated or otherwise disturbed.

Air

Air monitoring performed at the sites with a photoionization detector indicated that volatilization of JP-4 to the atmosphere is insignificant. Therefore, it was determined that more extensive air monitoring was not necessary.

There is limited potential for jet fuel which has leaked to the subsurface to volatilize into the air and subsequently migrate off-base. Approximately 75% of the base is covered by road bed, asphalt, concrete, or buildings, with the remainder covered with grass. The tight clay soils similarly impede the escape of volatiles. The drainage ditch is the only area in which soil is exposed and from which contaminants in the soil could escape.

Food Chain

The food chain is an environmental pathway that may provide an indirect route for contaminants to reach the public via biological uptake by agricultural products or game animals, but data on food chain contamination are not available for the area surrounding the base. Since contaminated groundwater appears to be confined to sites of past fuel spills, it is unlikely to migrate off-base and be used for crop irrigation. Therefore, this route is not considered to be a potential contaminant pathway.

EXPOSURE PATHWAYS

Discussion of exposure will focus on defining the current and potential routes of exposure at the base and describing the scenarios used to evaluate carcinogenic and noncarcinogenic risk. This discussion will include an explanation of the calculations used to quantify the different exposure pathways being considered and will conclude with an assessment of the probability of exposure for the receptors identified on and off the base.

Exposure Analysis

To determine if human exposure occurs as a result of contamination at Forbes Field ANGB, current and potential routes of exposure and associated receptors have been identified for each medium capable of serving as an environmental transport pathway. Environmental media considered as possible transport pathways for the Forbes Field ANGB are ground water, surface water, sediments, and subsurface soils. Each of these environmental pathways will be evaluated in terms of potential exposure both on- and off-base via three exposure routes: ingestion, inhalation, and dermal absorption. The data necessary to evaluate these pathways quantitatively are available for all media *on-base*; except for two sediment samples taken north of the base in the continuation of the drainage ditch (Site No. 6), no off-base data are available.

If an exposure pathway exists (i.e., there is a link between a contaminated environmental media and a receptor), then there is a *probability* of exposure, regardless of the concentration of contaminants in that environmental medium. However, the presence of a completed exposure pathway *does not* necessarily imply that the receptors involved will incur adverse health effects. Adverse health effects associated with exposure are dependent upon exposure factors and the concentration and toxicological properties of the chemicals involved. The likelihood of the occurrence of adverse effects will be evaluated in the Risk Characterization section.

The following discussions identify the human exposure routes associated with each of the environmental transport pathways identified in the contaminated (or potentially contaminated) areas of the base. Each exposure pathway will be discussed in light of the current or potential exposure that may result from each of these environmental transport pathways.

Groundwater. Exposure to on-base groundwater via ingestion is unlikely because the base is on a public water system and maintains no groundwater drinking wells, eliminating ingestion of contaminated ground water as an exposure pathway. Further, these circumstances also preclude the possibility of inhalation exposure to volatile constituents present in the ground water under normal base conditions. Excavation or construction projects occurring in the area of ground water contamination may result in contact with groundwater, increased volatilization, and some possibility of inhalation exposure for workers. Dermal absorption of contaminants in groundwater would also be possible in these situations. The probability of inhalation and dermal exposure during the excavation at sites where groundwater is known to be contaminated is deemed moderate.

Off-base, the chief prospect for human exposure to ground water which might be potentially contaminated is via ingestion of private well water. The available data for private wells is limited to wells installed since July 1, 1974 and registered with the Kansas Department of Health and Environment. Table 2 lists the registered domestic wells in the vicinity of the base, and Figure 3 shows their location. Registry information indicates that these wells do not involve the contaminated aquifer, thus eliminating possibility of exposure via *these* wells. In addition, these wells are isolated from the groundwater system beneath the base by divides or gradient and could not receive base groundwater. However, without comprehensive private well data and off-base groundwater data, off-base ground water exposures cannot be absolutely negated.

Surface water. Characteristics of the drainage ditch and activities which occur in its vicinity make routine contact with contaminated surface waters unlikely. Maintenance or grounds-keeping activities performed at the base provide possible opportunities for surface water exposure. Although exposure could conceivably occur through inadvertent ingestion or inhalation of volatile contaminants, probability of exposure via these pathways is extremely unlikely (primarily because of low flow in the ditch and low concentrations of contaminants in the water) and is not considered a concern. Dermal contact is somewhat more likely and could occur during various grounds-keeping activities and routine base maintenance procedures. Because surface water contamination appears only in samples taken in the ditch's upper

Table 2. Location of domestic wells within a 2.5 mile radius of Forbes Field Air National Guard Base.

<u>WELL</u>	<u>LOCATION¹</u>	<u>DIAMETER</u>	<u>DEPTH²</u>	<u>SCREENED INTERVAL</u>	<u>STATIC COMPLETION DATE</u>	<u>ESTIMATED WATER LEVEL</u>	<u>MAXIMUM YIELD</u>	<u>USE</u>
1	R16E,T13S,4,NW,NW,NW	5 in.	26 ft.	20-26 ft.	5/15/77	9 ft. (5/77)	5 gpm ³	Domestic
2	R16E,T13S,4,SW,NW,SW	5 in.	26 ft.	20-26 ft.	11/10/76	13 ft. (11/76)	3 gpm	Domestic
3	R16E,T13S,4,SW,SW,NW	Unknown	27 ft.	17-27 ft.	4/22/75	10 ft. (4/75)	1 gpm	Domestic
4	R153,T13S,12,NW,SW,SW	5 in.	40 ft.	Unknown	8/17/76	4 ft. (3/76)	1 gpm	Domestic
5	R16E,T12S,33,NW,NW,NW	5 in.	27 ft.	11-27 ft.	1977	6 ft. (7/76)	0.33 gpm	Domestic
6	R16E,T12S,20,SW,SE,SE	Unknown	10 ft.	Unknown	Unknown	Unknown	Unknown	Unknown
7	R16E,T12S,33,NW,NW,NW	Unknown	27 ft.	Unknown	Unknown	Unknown	Unknown	Domestic

¹Units are in Range, Township, Section, and Fraction.

²Feet below land surface.

³Gallons per minute.

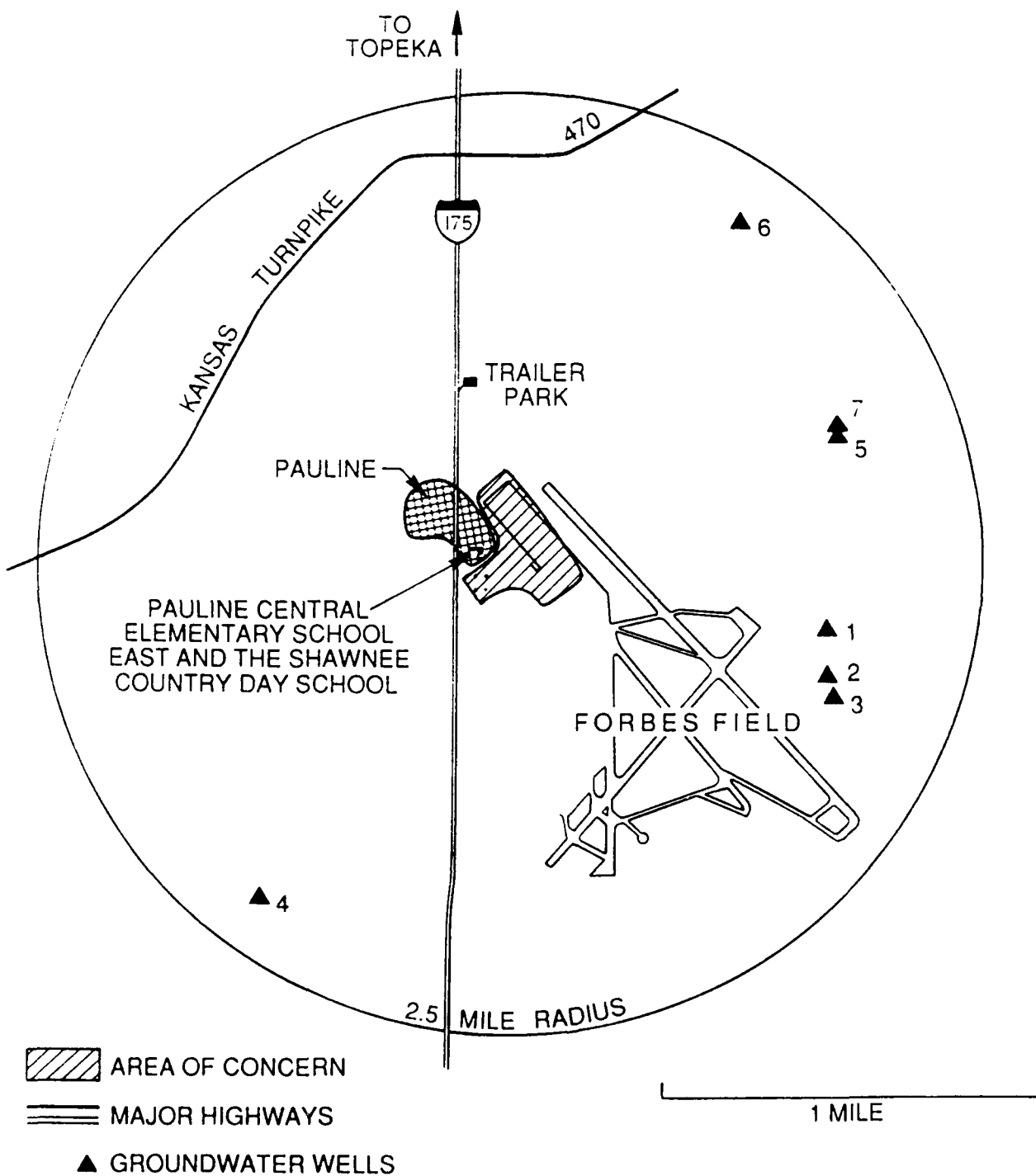


Figure 2. Location of known groundwater wells within a 2.5 mile radius of Forbes Field Air National Guard Base.

reaches, contaminants are probably not being transported off-base in ditch flow. However, the possibility of off-base migration has not been completely eliminated and should be considered. Contact with off-base surface water is most probable for children playing in the creek. As with the on-base evaluation, ingestion and inhalation exposure are possible but not likely and so are not considered to be pathways of concern. Again, exposure to contaminated surface water off-base is possible primarily through dermal absorption.

Ditch sediment. Site characteristics and conditions prevent routine contact with contaminated ditch sediments. As with exposure to contaminated surface water, on-base exposure to contaminated sediments is most likely to occur during maintenance, grounds-keeping, or other sediment-disturbing activities. Ingestion exposure is not probable during these activities. Because of fugitive dust generation and volatilization, these activities could increase the potential for inhalation exposure. However, the amount of contaminants liberated to the atmosphere from sediment by either fugitive dusts or airborne volatiles would be negligible because of the restraining nature of the grass cover and constant flow in the ditch. Particularly for sediment-disturbing activities such as grading or ditch excavation, exposure via dermal contact again presents the most likely route of human exposure.

Contact with sediment off-base is most likely to occur with children playing in the creek. Off-base exposure via either the ingestion or inhalation exposure routes is unlikely to occur. However, the probability of dermal contact by children playing in the creek is high.

Soil. Because most of the base is covered by either buildings, asphalt, tarmac, or grass, exposure to contaminated site soils is unlikely. Documented spills or leaks occurred before 1984 and involved volatile chemicals, which would not be expected to persist on the surface. Contact with any contamination remaining in the subsurface is also highly improbable under normal conditions. Contact with subsurface contamination could occur if contaminated sites were involved in construction or excavation. In these situations, the most likely routes of exposure would be inhalation of fugitive dusts or volatilized constituents and dermal absorption.

Given the hydrogeological character of the site, contaminant migration via the movement of on-base groundwater to off-base subsurface soils is not

likely to have occurred. Therefore, off-base subsurface soils are not considered in this exposure analysis.

Receptors

Based on information provided by the site characterization and the site visit, three major groups of receptors were identified: base personnel, contractors working on the base, and off-base residents in the surrounding communities. On-base personnel consist of 300 National Guard and civilian workers. An additional 1100 National Guard personnel train at the base one weekend a month and one two-week period out of each year, but do not live on the base during this time (No personnel, at any time, reside on the base). People working at the base perform a wide variety of jobs including fuel handling, plane maintenance, grounds keeping, and facility maintenance projects at various locations on-base. The significance of this human presence lies in the possible exposure of personnel to contaminated soil, groundwater, surface water and air during maintenance and excavation projects that may be occurring now or in the future.

The nearest off-base population consists of the 4000 residents of the unincorporated village of Pauline. Pauline is made up of single family residences, trailer parks, several small businesses, and schools. The Pauline Central Grade School-East and the Shawnee Country Day Care Center adjoin the northern base boundary, north of the Tank Farm (Site No. 1). Drinking water in this community is primarily supplied through the municipal water supply. The Kansas Department of Health Water Well Program registry indicates that no registered private wells are in this area (see Table 2 and Figure 3); no field verification has been conducted to identify wells not contained in the well registry. The stream (which receives the Site No. 6 drainage ditch effluent) flows within 100 feet of several private residences of this community and within 200 feet of U.S. Highway 75. Farther north of the base, several small businesses, residences, and trailer parks abut U.S. Highway 75, which leads into Topeka, Kansas approximately 2.5 miles to the north. The remaining area around the base is agricultural.

Summary

Based on an examination of site conditions, it is unlikely that routine contact with contaminated media will occur under normal conditions for

receptors either on or off Forbes Field ANGB. However, some receptors may come into contact with contamination under specific situations:

Base Workers

Base workers could be exposed to site contaminants under one of two situations: routine maintenance/grounds-keeping activities or excavation/construction activities. Grounds-keeping or maintenance activities could expose workers to contaminated surface waters via dermal absorption and to sediments via inhalation or dermal absorption. In addition, excavation or construction could expose workers to contaminated ground water and subsurface soils via inhalation or dermal contact.

Off-Base Residents

Resident exposure to base contamination is extremely unlikely unless there are private, unregistered wells which draw from the contaminated water table aquifer. Should these wells exist, then exposure could occur via ingestion, inhalation, or dermal absorption during routine domestic use.

Children Off-Base

In addition to other residents, children playing in the creek, which exits from Site 6 north of the base, could be exposed to contaminated surface water and sediments via dermal absorption.

EXPOSURE CHARACTERIZATION

In order to quantify the exposures which on-base workers and off-base adults and children might receive, a series of exposure scenarios have been developed to conservatively estimate the exposure to contaminants under the situations described in the previous section. Quantitative estimates of exposure are derived from contaminant concentrations in environmental media, assumptions about exposure frequency, and human intake estimates for the pertinent exposure pathways. The following sections present the scenarios developed for each of the receptor groups, the assumptions used in evaluating these scenarios, and the resulting estimates of exposure.

Exposure Scenarios

Exposure scenarios have been developed to represent the most likely situations, both on- and off-base, under which human exposure could occur. Since there is no receptor-specific exposure information, or where no data are available (as in the case of current off-base exposure to groundwater), an estimation of the most probable (but conservative) conditions of exposure must be made. Modeling to predict future concentration levels has not been undertaken.

For this risk characterization, estimates of contaminant concentrations at points of exposure are assumed to correspond with measured concentrations found in the nearest contaminated media. Under these conservative assumptions, any resulting absence of adverse health risks would suggest that no further action is required, provided future contaminant releases from the IRP sites is not a possibility. Alternatively, if a scenario shows a potential for adverse health effects, a more realistic assessment may be made after collection of more appropriate data. This method focuses future data collection toward those contaminated media which have the greatest potential to adversely affect human health.

For this assessment, risks faced by the receptor groups previously identified will be analyzed using the following scenarios:

- 1) a construction worker scenario to examine worker exposure to contaminated ground water and subsurface soils during excavation or construction;

- 2) a maintenance worker scenario to examine worker exposure to contaminated surface water and sediments during routine maintenance or grounds-keeping activities;
- 3) a general residential scenario to evaluate exposures to contaminated ground water in the eventuality that unregistered wells exist in the upper aquifer, and
- 4) a child scenario to evaluate effects on children exposed to contaminated surface water and sediments while playing in the creek.

Each scenario will be discussed with respect to the media and exposure factors that apply. Tables 3 through 6 outline the assumptions used in evaluating these scenarios.

Construction Worker Scenario. The construction worker scenario applies to on-base construction that might occur in the future at contaminated sites, potentially exposing base or contractor personnel to contaminated ground water or subsurface soils. There is no current possibility for exposure via these media because the base is supplied by municipal water and there are no areas of exposed subsurface soil on-base. For this analysis, we have assumed that the known concentrations in the contaminated media are the same concentrations to which workers are exposed. The actual period of exposure and contaminant concentrations that a worker may be subject to is also difficult to predict, so we have used the most conservative estimation of exposure in the construction scenario (see Table 3).

Such a worst-case-scenario should result in the most conservative risk estimates, providing a margin of safety over actual risk levels. If none of the contaminants are demonstrated to be at hazardous levels using this conservative analysis, no further action is required.

Maintenance Worker Scenario. The maintenance worker scenario analyzes exposure to contaminated surface water and sediment during routine maintenance or grounds-keeping activities. As with the construction worker scenario, conservative exposure conditions have been assumed (see Table 4), and worker exposure to contaminants is assumed to be at the same concentrations measured in surface water and sediment.

General Residential Scenario. The general residential scenario applies to exposure through ground water. This scenario considers adults who could be

living in the vicinity of the base for their entire lifetime, utilizing contaminated ground water via private wells in the water table aquifer. This scenario examines exposure through three routes: ingestion of contaminated drinking water, inhalation of volatile contaminants during showering, and dermal absorption of contaminants during showering. Exposure concentrations are assumed to equal measured concentrations in ground water. Other assumptions used in this scenario are explained in Table 5.

It should be emphasized that this scenario is *not valid* for all residents surrounding Forbes Field ANGB; rather it only applies to those residents who might be utilizing private wells drawing from the contaminated water table aquifer. Further, this scenario is a conservative estimate of risk which should be used only to determine whether additional information should be collected to confirm or negate the existence and use of such wells.

Child Scenario. The child scenario will examine the impacts of off-base exposure to contaminated surface water and sediments. While it is true that adults could also be exposed to these contaminated media, conditions at the site and characteristics of the ditch/creek make children the most likely receptors. As with the previous scenarios, conservative assumptions will be utilized to ensure that risk estimates are not underpredicted (see Table 6).

Estimation of Exposure

In order to quantitatively assess human exposure, and eventually determine the potential for adverse health effects, an estimate of exposure has been calculated using the scenarios presented in Tables 3 through 6. Calculation of the exposure dose follows a standard equation (Equation 1), which can be modified to reflect the site-specific conditions for the medium being evaluated. Values from Tables 3 through 6 are used to calculate the exposure dose for the contaminated or potentially contaminated media under each exposure scenario. Exposure calculations used for each exposure scenario are also presented in Tables 3 through 6.

Table 3 Assumptions and Calculations for Construction Worker Scenario

Assumes a one year construction project with a 70 kg adult: working eight hours per day, five days per week, 50 weeks per year, for one year out of a lifetime.

Groundwater

Ingestion: not considered

Inhalation: Inhalation Rate = $9.6 \text{ m}^3/8 \text{ hr day}$

$$\text{Exposure} = \frac{C \text{ mg/m}^3 \times 9.6 \text{ m}^3/\text{d} \times 8 \text{ hr/d} \times 5 \text{ d/wk} \times 50 \text{ wk/yr}}{70 \text{ kg} \times 24 \text{ hr/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

Dermal Absorption: Dermal Absorption Constant = $.024 \text{ l/cm}^2 \cdot \text{d}$
Exposed Skin Surface = 4000 cm^2

$$\text{Exposure} = \frac{C \text{ mg/l} \times .024 \text{ l/cm}^2 \cdot \text{d} \times 4000 \text{ cm}^2 \times 8 \text{ hr/d} \times 5 \text{ d/wk} \times 50 \text{ wk/yr}}{70 \text{ kg} \times 24 \text{ h/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

Soil

Ingestion: not considered

Inhalation: Inhalation Rate = $9.6 \text{ m}^3/8 \text{ hr day}$

$$\text{Exposure} = \frac{C \text{ mg/m}^3 \times 9.6 \text{ m}^3/\text{d} \times 8 \text{ hr/d} \times 5 \text{ d/wk} \times 50 \text{ wk/yr}}{70 \text{ kg} \times 24 \text{ hr/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

Dermal Absorption: Soil Adhered = 9400 mg/8 hr day

$$\text{Exposure} = \frac{C \text{ mg/kg} \times 9400 \text{ mg/d} \times .001 \text{ g/mg} \times .001 \text{ kg/g} \times 8 \text{ hr/d} \times 5 \text{ d/wk} \times 50 \text{ wk/yr}}{70 \text{ kg} \times 24 \text{ h/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

Table 4 Assumptions and Calculations for Maintenance Worker Scenario

Assumes a 70 kg adult working eight hours per day, five days per week, 50 weeks per year, for one year for a 40 year career

Surface water

Ingestion: not considered

Inhalation: not considered

Dermal Absorption: Dermal Absorption Constant = .024 l/cm² - d
Exposed Skin Surface = 4000 cm²

$$\text{Exposure} = \frac{C \text{ mg/l} \times .024 \text{ l/cm}^2\text{-d} \times 4000 \text{ cm}^2 \times 8 \text{ hr/d} \times 5 \text{ d/wk} \times 50 \text{ wk/yr} \times 40 \text{ yr}}{70 \text{ kg} \times 24 \text{ h/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

Sediment

Ingestion: not considered

Inhalation: Inhalation Rate = 9.6 m³/8 hr day

$$\text{Exposure} = \frac{C \text{ mg/m}^3 \times 9.6 \text{ m}^3\text{/d} \times 8 \text{ hr/d} \times 5 \text{ d/wk} \times 50 \text{ wk/yr} \times 40 \text{ yr}}{70 \text{ kg} \times 24 \text{ hr/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

Dermal Absorption: Soil Adhered = 9400 mg/d x .001 g/mg x .001 kg/g = .0094 kg/d

$$\text{Exposure} = \frac{C \text{ mg/kg} \times .0094 \text{ kg/d} \times 8 \text{ hr/d} \times 5 \text{ d/wk} \times 50 \text{ wk/yr} \times 40 \text{ yr}}{70 \text{ kg} \times 24 \text{ h/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

Table 5 Assumptions and Calculations for General Resident Scenario

Assumes a continuous, lifetime exposure for 70 kg adults.

Groundwater

Ingestion: Water Ingestion Rate = 2 l/d

$$\text{Adult Exposure} = \frac{C \text{ mg/l} \times 2 \text{ l/d}}{70 \text{ kg}}$$

Inhalation: Exposure Duration = Half-hour exposure, once a day, 70 years
Inhalation Rate = .958 m³/hr (23 m³/d 24 hr/d)

$$\text{Exposure} = \frac{C \text{ mg/m}^3 \times .958 \text{ m}^3/\text{hr} \times .5 \text{ hr/d}}{70 \text{ kg} \times 24 \text{ hr/d}}$$

Dermal Absorption: Dermal Absorption Constant = .024 l/cm² - d
Exposed Skin Surface = 4000 cm²

$$\text{Exposure} = \frac{C \text{ mg/l} \times .024 \text{ l/cm}^2\text{-d} \times 4000 \text{ cm}^2 \times .5 \text{ hr/d}}{70 \text{ kg} \times 24 \text{ h/d}}$$

Table 6 Assumptions and Calculations for Child Scenario

Assumes episodic exposure for a 30 kg child over a ten year period (ages 1-11).

Surface water

Ingestion: not considered

Inhalation: not considered

Dermal Absorption: Dermal Absorption Constant = .024 l/cm² · d
Exposed Skin Surface = 1800 cm²

$$\text{Exposure} = \frac{C \text{ mg/l} \times .024 \text{ l/cm}^2\text{-d} \times 1800 \text{ cm}^2 \times 4 \text{ hr/d} \times 5 \text{ d/wk} \times 52 \text{ wk/yr} \times 10 \text{ yr}}{30 \text{ kg} \times 24 \text{ h/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

Sediment

Ingestion: not considered

Inhalation: not considered

Dermal Absorption: Exposure Duration = 4 hr/d, 5 d/wk
Soil Adhered = 5250 mg/d x .001 g/mg x .001 kg/g = .0053 kg/d

$$\text{Exposure} = \frac{C \text{ mg/kg} \times .0053 \text{ kg/d} \times 4 \text{ hr/d} \times 5 \text{ d/wk} \times 52 \text{ wk/yr} \times 10 \text{ yr}}{30 \text{ kg} \times 24 \text{ hr/d} \times 365 \text{ d/yr} \times 70 \text{ yr}}$$

(Equation 1)

$$ED = \frac{C \times ER \times AF \times EF}{BW}$$

Where:

- ED = exposure dose
- C = concentration of contaminant in the medium being evaluated
- ER = exposure rate (ingestion rate, inhalation rate, etc.)
- AF = absorption factor (a unit-less number assumed to be 100% unless known specifically)
- EF = exposure factor (the ratio of time an individual is exposed to the standard lifetime; indicates duration and frequency of exposure period; for continuous, lifetime exposure, the EF equals 1)
- BW = body weight of exposed individual in kg.

RISK CHARACTERIZATION

To determine the health implications associated with base contamination, the Risk Characterization section integrates the toxicological properties of the chemicals of concern, the estimations of exposure, and the comparison of exposure estimates to health guidelines and standards. This integration allows analysis of the risks faced by each receptor group at each site, using the estimations presented in the Exposure Characterization section. The following sections discuss the toxicological characteristics of the contaminants of concern, the methods used to estimate risk, and the estimated risks posed by conditions at each of the seven base sites.

Toxicological Effects of Contaminants of Concern

The following contaminant-specific discussions present the noncarcinogenic and carcinogenic health effects associated with the principle contaminants of concern found at Forbes Field ANGB. Of the nine contaminants of concern at Forbes, most are volatile or semi-volatile organics associated with noncarcinogenic toxic effects. Three have been linked with carcinogenic potential: benzene and vinyl chloride are known human carcinogens (Class A compounds under the U.S. EPA Weight of Evidence Classification); trichloroethylene is a suspected human carcinogen (Class B2).

Benzene. Benzene is the simplest member of the aromatic hydrocarbon series. Although some benzene is naturally occurring, the majority of benzene released into the atmosphere is man-made. Benzene is used as an intermediate in the manufacture of numerous plastics, synthetic rubbers and fibers, and resins. Benzene also is a component of gasoline, occurring in concentrations of up to 5%. The most significant source for the release of benzene to the environment is the combustion of gasoline.

Benzene is toxic, especially to hemopoietic (blood-cell-forming) tissues. There is also evidence that it affects the immune system. Acute exposure to benzene produces drowsiness, dizziness, and headaches. Chronic exposure may affect normal blood production, possibly resulting in severe anemia and internal bleeding. Benzene may also cause spontaneous abortions and miscarriages in pregnant women.

Benzene is a human carcinogen and has been linked, in particular, to occurrences of acute myelogenous leukemia and other blood related disorders in both animals and humans. Animal bioassays have shown benzene to be a causal

agent in the development of leukemia and other cancers. Benzene is considered a human carcinogen and has been rated by the EPA as a weight-of-evidence Group A carcinogen.

1,1-Dichloroethane. 1,1-Dichloroethane (ethylidene chloride) is used as a cleaning solvent and degreaser and in the manufacture of 1,1,1-trichloroethane. The major sources of environmental concentrations of 1,1-dichloroethane are volatilization during use and in production of 1,1,1-trichloroethane.

Inhalation of 1,1-dichloroethane is known to cause liver and kidney damage. Repeated or prolonged exposure can lead to irritation of the lungs, skin, and eyes. Evidence from carcinogenicity studies of animals suggests that 1,1-dichloroethane may be a potential carcinogen. However, it has not been rated by the EPA in the carcinogenic potential classification scheme.

Ethylbenzene. Ethylbenzene occurs primarily as an intermediate in the production of styrene. It is also used in combination with xylene as a diluent in the paint industry and as an additive in gasoline and aviation fuels.

Inhalation is the predominant route of ethylbenzene exposure, resulting primarily in irritation to the skin, eyes, and upper respiratory tract. Exposure to high concentrations can lead to narcosis, dizziness, drowsiness, and general weakness. Inhalation can exacerbate the symptoms of obstructive airway diseases, and aspiration of small amounts may cause extensive edema and hemorrhaging of lung tissue. The data are insufficient to make conclusive evaluations of the toxicity of ethylbenzene in humans, but there is cause for concern over possible liver and kidney damage since these organs are the primary centers of metabolism and excretion, respectively.

Toluene. Toluene (methylbenzene) is a component of gasoline, used as a solvent base in paints, as an additive in cosmetics, and as a production agent of other chemicals. The predominant sources of toluene in the environment are emissions from motor vehicles, aircraft exhaust, and cigarette smoke.

Toluene is most readily absorbed after inhalation with as much as 60% being retained in humans. Toluene may also enter the body by dermal absorption; absorption of toluene in the gastrointestinal tract occurs less readily. Toluene is distributed in the highest concentrations to adipose tissue followed by bone marrow, adrenals, kidneys, liver, brain, and blood.

The critical target organs for toluene are those comprising the central nervous system.

Acute occupational exposure to toluene in the range of 200 to 1500 ppm has caused dose-related effects to the central nervous system. The symptoms are characterized by initial central nervous system excitative effects (euphoria and hallucinations) followed by progressive impairment of consciousness, eventually resulting in seizures and coma. Chronic exposure has resulted in some evidence of neurological effects such as encephalopathy, optic atrophy, and equilibrium disorders.

The results of inhalation, ingestion, and dermal absorption carcinogenicity studies of animals have been negative for toluene. There are no available data on the human carcinogenicity of toluene. Toluene is rated by the EPA classification as weight-of-evidence Group D, carcinogenicity unknown.

1,1,1-Trichloroethane. 1,1,1-Trichloroethane (methyl chloroform) is a volatile chlorinated hydrocarbon that is used as an industrial solvent and in consumer products. Volatilization during production and use is the primary source of 1,1,1-trichloroethane in the atmosphere. There are no known natural sources of 1,1,1-trichloroethane emissions.

Inhalation is the primary and most rapid route by which 1,1,1-trichloroethane is absorbed by the body, though it may enter the body through absorption by the gastrointestinal tract. After absorption it is distributed to all parts of the body. The lipophilic nature of 1,1,1-trichloroethane results in deposition in the brain and the colostrum of nursing mothers, as well as into the fetus during pregnancy. The amount of the chemical metabolized, unlike other chlorinated solvents, is limited to six percent of the retained dose.

The chronic exposure to 1,1,1-trichloroethane at ambient air levels commonly encountered appears to be extremely low. Acute effects produced by exposure to higher levels (>350 ppm) are symptomatic of neurological disfunction including disturbances of equilibrium, lightheadedness, and irritation of the throat. Although the liver is the primary site of 1,1,1-trichloroethane metabolism, liver damage has not been conclusively evident from exposure to the chemical. Narcosis (which may occur from exposure to levels in excess of 5000 ppm) is the major health concern associated with

exposure to 1,1,1-trichloroethane. No epidemiologic studies investigating human carcinogenicity are available, and the results of animal studies have been inconclusive. Therefore, 1,1,1-trichloroethane cannot be classified as to its human carcinogenicity.

Trichloroethene. The chlorinated hydrocarbon trichloroethene is used as a solvent in many industries, as a degreasing agent in the drycleaning industry and in the manufacture of organic chemicals. The predominant source of trichloroethene in the environment is the result of volatilization during its production. Trichloroethene can also be formed during the process of water chlorination.

The principal exposure routes to trichloroethene are inhalation and ingestion. It is readily absorbed by the skin, gastrointestinal tract, and lungs where up to 28% of the dose may be retained. A major factor in the toxicity of trichloroethene is its metabolic conversion to active intermediates (2,2,3-trichloroxirane and dichloroacetic acid) that are responsible for some of the long term effects.

Acute exposure to trichloroethene produces depression of the central nervous system (incoordination and unconsciousness) and inhibits cardiac function. Occupational subjection to chronic exposure levels of trichloroethene has been reported to cause liver damage. There is no evidence that the chemical accumulates in the body upon repeated exposure.

The carcinogenic potential of trichloroethene has been indicated in several studies performed in rats and mice. Trichloroethene exposure resulted in a significant increase in hepatocellular carcinomas, kidney tubular adenocarcinomas, and pulmonary adenocarcinomas. The information on the human carcinogenicity associated with trichloroethene exposure is limited and inconclusive; therefore, it has been designated as a weight-of-evidence Group B2 by the EPA.

Vinyl chloride. Vinyl chloride is used in the production of polyvinyl chloride (PVC). The majority of the emissions of vinyl chloride to the environment are linked to the plastic industries. There are no known natural sources of vinyl chloride emission.

Vinyl chloride is absorbed readily after inhalation or ingestion; however, animal data suggest that dermal absorption is minor. Acute exposure causes central nervous system depression and the exposed individual will

experience lightheadedness, dizziness, nausea, and a blurring of vision. Chronic vinyl chloride exposure is known to produce a number of maladies including a decreased number of platelets in the blood, an enlarged spleen and decreased pulmonary function, swelling and shortening of the fingers, and nodular growths on the bottom of the hands and forearms. Chronic exposure has also been linked to an increased rate of birth defects. Vinyl chloride disease has occurred in people occupationally exposed to high levels of vinyl chloride with complications involving the liver, central nervous system, and peripheral circulation and nerves. Vinyl chloride is acutely hepatotoxic.

The occupational exposure to vinyl chloride has also been linked to human cancer. Its carcinogenicity is most evident by the increased incidence of liver cancer associated with exposure to vinyl chloride. Other cancers associated with vinyl chloride exposure include tumors of the brain, central nervous system, the lungs and respiratory tract, the digestive tract, and the lymphocytic/hematopoietic system. Vinyl chloride is considered a human carcinogen and has been rated by the EPA as a weight-of-evidence Group A carcinogen.

Xylene. Xylene is a mixture of the ortho, meta, and para isomers. The principal uses of xylene are as a fuel additive, as a solvent, and as an intermediate in the chemical industry.

Acute exposure to xylene has narcotic effects on the central nervous system and may also effect the liver, kidneys, and the gastrointestinal tract. Symptoms produced by the exposure to 200 ppm include nausea, vomiting, abdominal pain and loss of appetite. Xylene has been reported to cross the human placenta and may retard brain development in children. Chronic exposure to xylene results in symptoms similar to those associated with acute exposure but more severe. Regular exposure to high levels of xylene vapors may produce euphoria followed by depression and characterized by paresthesia, tremors, apprehension, impaired memory, weakness, vertigo, headache, and anorexia. Due to the paucity of data on the carcinogenicity of xylene it is designated by the EPA as a weight-of-evidence Group D, carcinogenicity unknown.

Estimations of Risk

Two measures are used to quantify the noncarcinogenic and carcinogenic hazards associated with these contaminants of concern. Calculations of the U.S. EPA Hazard Index (Superfund Public Health Evaluation, 1986) have been

used to indicate the toxic potential for noncarcinogens present on the base. Estimations of lifetime excess cancer risk have been used to indicate the carcinogenic potential present at the site.

Noncarcinogenic Hazards. The Hazard Index is the ratio of exposure to a compound to the compound-specific RfD or AIC (Equation 2). The RfD is an estimate of a lifetime daily exposure (mg/kg/day) below which there is little appreciable risk of deleterious effects. For chemicals that have no RfD, EPA Acceptable Intake Chronic (AIC) values are used. These values, also expressed as daily exposure doses (mg/kg/day), are long-term acceptable intake levels below which adverse health effects are not expected. When the Hazard Index is greater than 1, there is the potential for noncarcinogenic adverse effects to occur.

(Equation 2) Hazard Index = $\frac{\text{Exposure Dose}}{\text{RfD or AIC}}$

Carcinogenic Risk. Carcinogenic risks are usually expressed in terms of the probability that an individual will develop cancer from a lifetime of exposure to a specific contaminant. This risk is termed *excess* because the estimated risk is in addition to the risk of cancer presented by other sources.

The U.S. EPA has provided quantitative estimates of the human cancer risk for some compounds. These estimates, known as Cancer Potency Factors (CPF), represent the 95% upper limit on the lifetime probability that the carcinogen will cause cancer at a dose of one mg/kg/day. The potential excess cancer risk from a lifetime of exposure can be estimated by multiplying the CPF by the estimated daily exposure (mg/kg/day):

(Equation 3)

$$\text{Excess Cancer Risk} = \text{CPF}(\text{mg/kg/day})^{-1} \times \text{Exposure} (\text{mg/kg/day})$$

The resulting value is the unitless excess cancer risk, which represents an upper limit on the probability that cancer will occur at a rate beyond that expected in the general population.

In general, excess cancer risks below 1×10^{-6} or 10^{-7} (i.e., one excess case in one million people or one in ten million people exposed) are considered insignificant. Under varying circumstances, regulators have found risks in the range of 1×10^{-7} to 1×10^{-4} to be acceptable (see Travis and Frey, 1988). Risk higher than 1×10^{-4} indicates a potential for carcinogenic effects and is of concern.

Site-specific Risk Evaluations

The noncarcinogenic and carcinogenic risks posed by the contaminants of concern at each site have been estimated using the four exposure scenarios developed in the Exposure Characterization (see Tables 3 through 6). Not all scenarios will be applied to each site. The worker construction scenario will be used at all seven sites to assess potential risks to on-base workers under future construction/excavation conditions. In addition, potential risks from surface water contamination at Site No. 6 (the drainage ditch) will be assessed using the maintenance worker scenario and the off-site child scenario. Finally, the resident scenario will be used at Sites 1, 5, 8, and 9 to characterize risks that may be present if the contamination is travelling off-base in the upper aquifer and is being utilized in off-site private wells. This scenario will be evaluated using data from on-base samples at each of the four sites (i.e., Sites No. 1, 5, 8, and 9).

Site No. 1. Exposure to contamination at Site No. 1 is likely only under the construction worker scenario. Under this scenario, workers could be exposed to four of the contaminants of concern (benzene, ethylbenzene, toluene, and xylene) via inhalation or dermal absorption of contaminants in either groundwater or subsurface soils. Estimation of possible exposures via volatilization from groundwater assumes that 100% of the concentrations found in groundwater will volatilize and be inhaled by the receptors. Estimation of dermal absorption exposures assumes a 100% absorption across the skin barrier.

Table 7 presents the results of the Site No. 1 risk characterization for each route of exposure under the construction worker and resident scenarios. Evaluation of construction worker exposures to contaminated groundwater and subsurface soil indicates a negligible probability of carcinogenic effects (range: 1.6×10^{-5} to 4.8×10^{-9}) resulting from either inhalation or dermal absorption of benzene. In addition, the hazard indices for these exposure routes are well below levels of concern (range: 5×10^{-6} to 2×10^{-2}).

Analysis of the resident scenario also shows no probability of developing carcinogenic or noncarcinogenic effects from off-base exposure to site groundwater. This scenario assumes that resident exposure in groundwater equals the concentrations currently measured on site; actual exposures, and thus, actual risks (should such off-site wells be identified) would be even lower.

Considering the conservative assumptions used, concentrations of contaminants of concern at Site No. 1 are not expected to adversely impact either workers or off-base residents under the simulated conditions.

Site No. 5. Risks presented by contamination at Site No. 5, Pumphouse E, are also evaluated using the construction worker and resident scenarios (Table 8). Benzene, ethylbenzene, toluene and xylene are the contaminants of concern present in site groundwater. In site soils, toluene, 1,1,1-trichloroethane and xylene are the contaminants of concern. Evaluation of risks posed by inhalation or dermal absorption of these contaminants under the construction worker scenario again indicates no potential for adverse effects in on-base workers.

Calculation of the hazard index for the resident scenario is well below the acceptable level and indicates no potential for noncarcinogenic effects. However, estimation of carcinogenic risks to off-base residents from exposure to contaminated groundwater does indicate an excess cancer risk (2.6×10^{-4}). This risk is only slightly outside the range of acceptability. The combined influence of regional hydrogeology, the low hydraulic conductivity and discontinuous nature of the water table aquifer, the significant effect of dilution on the concentration, and the distance to receptors makes the actual probability of exposure minimal. Further, the conservative assumptions used (in conjunction with the effects expected from distance, dilution, and dispersion) make it most likely that any actual risks would be significantly lower, and consequently, well within acceptable levels.

Site No. 6. Because conditions at Site No. 6, the Drainage Ditch, make current or future exposure most probable during routine maintenance and grounds-keeping, only the maintenance worker scenario was used to evaluate risks to on-base workers. Risks to off-base receptors from this site were evaluated using the child scenario since children playing in the creek off-base are the most likely potential receptors. Contaminants of concern are

found only in ditch surface waters and sediments. No indicator chemicals are found in the groundwater at Site No. 6, eliminating the need to evaluate exposures to this medium.

Contaminants of concern present in on-base and off-base surface waters and sediments are presented in Table 9. Trichloroethene and vinyl chloride are of concern in surface waters. On-base, sediments are contaminated with vinyl chloride and 1,1-dichloroethane. Maintenance worker contact with ditch surface water involves exposure to two carcinogens: trichloroethene and vinyl chloride. Levels of trichloroethene contained in the surface water are associated with a low excess cancer risk (10^{-6}), which is not regarded as a health concern. Risk estimates associated with dermal absorption of vinyl chloride indicate an increased potential for excess cancer risk (2.3×10^{-3}).

The actual risk incurred by workers from exposure to vinyl chloride in the surface water at Site No. 6 is mitigated by several factors which are not considered in the maintenance worker scenario. This scenario assumes 100% absorption, while in actuality vinyl chloride is poorly absorbed across the skin. In studies using rhesus monkeys Hefner et al. (1975) determined that less than 0.1% of vinyl chloride was dermally absorbed. Also, the very high volatility of vinyl chloride (Henry's Law Constant = $8.19\text{E-}02 \text{ atm}\cdot\text{m}^3/\text{mol}$) would reduce the actual exposure concentrations. The combined effect of the high volatility and low dermal absorption of vinyl chloride would reduce actual concentrations well below those used in risk calculations. However, the influence of dermal absorption and volatility on vinyl chloride exposure concentration has not been quantitatively determined for humans and thus cannot be included in the calculation of risk.

In addition, concentrations of vinyl chloride appear to decrease in downstream surface water (based on samples WS04, WS01, and WS05; vinyl chloride was not detected in WS05, see Plate 1 of the RIR). Exposure to the levels of vinyl chloride assumed in the risk calculations is limited to the headwater area of the drainage ditch. Thus, exposure to vinyl chloride may not be occurring at a frequency or intensity that would produce carcinogenic effects in workers who might come in contact with surface water.

Inherent in a worst-case-scenario is the over-estimation of risk due to the use of an excessive exposure period. The period of vinyl chloride exposure used in the maintenance worker scenario is the duration of an average

TABLE 7. EXPOSURE ANALYSIS FOR SITE 1, THE TANK FARM
GROUNDWATER (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
BENZENE	6.0E-03	7.8E+01	1.9E-02	8.6E-06				
ETHYLBENZENE	3.0E-03	1.1E+02	1.3E-02	5.8E-06				
TOLUENE	1.0E-03	9.2E+01	3.8E-03	1.7E-06	1.0E-01	2.9E-02	5.8E-05	2.5E-07
XYLENE	5.5E-02	1.1E+02	2.4E-01	1.1E-04	3.0E-01		5.6E-06	
					2.0E+00		5.3E-05	
						TOTAL	1.2E-04	2.5E-07

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
BENZENE	6.0E-03	2.7E-05				
ETHYLBENZENE	3.0E-03	1.3E-05				
TOLUENE	1.0E-03	4.5E-06	1.0E-01	2.9E-02	1.3E-04	7.8E-07
XYLENE	5.5E-02	2.5E-04	3.0E-01		1.5E-05	
			2.0E+00		1.2E-04	
				TOTAL	2.7E-04	7.8E-07

SOIL (CONSTRUCTION SCENARIO) INHALATION OF VOLATILIZED OR SUSPENDED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
BENZENE	3.8E-01	7.8E+01	1.2E+00	5.4E-04				
ETHYLBENZENE	8.0E-01	1.1E+02	3.5E+00	1.6E-03				
TOLUENE	4.9E-01	9.2E+01	1.8E+00	8.2E-04	1.0E-01	2.9E-02	1.6E-02	1.6E-05
XYLENE	4.2E+00	1.1E+02	1.8E+01	8.2E-03	3.0E-01		2.7E-03	
					2.0E+00		4.1E-03	
						TOTAL	2.2E-02	1.6E-05

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
BENZENE	3.8E-01	1.7E-07				
ETHYLBENZENE	8.0E-01	3.5E-07				
TOLUENE	4.9E-01	2.1E-07	1.0E-01	2.9E-02	3.5E-06	4.8E-09
XYLENE	4.2E+00	1.8E-06	3.0E-01		7.1E-07	
			2.0E+00		9.2E-07	
				TOTAL	5.1E-06	4.8E-09

TABLE 7. EXPOSURE ANALYSIS FOR SITE NO. 1, THE TANK FARM (CONTINUED)
GROUNDWATER (RESIDENT SCENARIO)
INGESTION

CHEMICAL	REP. CONC.	ADULT DOSE	RfD	CPF	ADULT HI	ADULT EX. CR. RSK.
BENZENE	6.0E-03	1.7E-04				
ETHYLBENZENE	3.0E-03	8.6E-05	1.0E-01	2.9E-02	8.6E-04	5.0E-06
TOLUENE	1.0E-03	2.9E-05	3.0E-01		7.9E-04	
XYLENE	5.5E-02	1.6E-03	2.0E+00		1.7E-03	5.0E-06
			TOTAL			

INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	ADULT DOSE	RfD	ADULT HI	ADULT EX. CR. RSK.
BENZENE	6.0E-03	7.8E+01	5.5E-06			
ETHYLBENZENE	3.0E-03	1.1E+02	3.7E-06			
TOLUENE	1.0E-03	9.2E+01	1.1E-06	1.0E-01	3.7E-05	3.6E-06
XYLENE	5.5E-02	1.1E+02	6.8E-05	3.0E-01	3.4E-05	7.5E-05
				2.0E+00		1.6E-07
				TOTAL		

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	ADULT DOSE	RfD	CPF	ADULT HI	ADULT EX. CR. RSK.
BENZENE	6.0E-03	1.7E-04				
ETHYLBENZENE	3.0E-03	8.6E-05	1.0E-01	2.9E-02	8.6E-04	5.0E-06
TOLUENE	1.0E-03	2.9E-05	3.0E-01		9.5E-05	
XYLENE	5.5E-02	1.6E-03	2.0E+00		7.9E-04	5.0E-06
			TOTAL		1.7E-03	

TABLE 8. EXPOSURE ANALYSIS FOR SITE NO. 5, PUMPHOUSE E
GROUNDWATER (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
BENZENE	3.1E-01	7.8E+01	9.9E-01	4.4E-04				
ETHYLBENZENE	3.8E-01	1.1E+02	1.7E+00	7.4E-04	1.0E-01		7.4E-03	1.3E-05
TOLUENE	9.0E-03	9.2E+01	3.4E-02	1.5E-05	3.0E-01		5.1E-05	
XYLENE	6.5E-01	1.1E+02	2.8E+00	1.3E-03	2.0E+00		6.3E-04	
						TOTAL	8.1E-03	1.3E-05

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
BENZENE	3.1E-01	1.4E-03				
ETHYLBENZENE	3.8E-01	1.7E-03	1.0E-01	2.9E-02	1.7E-02	4.0E-05
TOLUENE	9.0E-03	4.0E-05	3.0E-01		1.3E-04	
XYLENE	6.5E-01	2.9E-03	2.0E+00		1.4E-03	
				TOTAL	1.9E-02	4.0E-05

SOIL (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	3.0E-03	9.2E+01	1.1E-02	5.1E-06	3.0E-01		1.7E-05	
1,1,1-TRICHLOROETHANE	4.0E-03	1.3E+02	2.2E-02	9.8E-06	9.0E-02		1.1E-04	
XYLENE	2.6E+00	1.1E+02	1.1E+01	5.1E-03	1.0E-02		5.1E-01	
						TOTAL	5.1E-01	

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	3.0E-03	1.3E-09	3.0E-01		4.4E-09	
1,1,1-TRICHLOROETHANE	4.0E-03	1.8E-09	9.0E-02		1.9E-08	
XYLENE	2.6E+00	1.1E-06	1.0E-02		1.1E-04	
				TOTAL	1.1E-04	

TABLE 8. EXPOSURE ANALYSIS FOR SITE NO. 5, PUMPHOUSE E (CONTINUED)
GROUNDWATER (RESIDENT SCENARIO)
INGESTION

CHEMICAL	REP. CONC.	ADULT DOSE	RfD	CPF	ADULT HI	ADULT EX. CR. RSK.
BENZENE	3.1E-01	8.9E-03	1.0E-01	2.9E-02	1.1E-01	2.6E-04
ETHYLBENZENE	3.8E-01	1.1E-02	3.0E-01		8.6E-04	
TOLUENE	9.0E-03	2.6E-04	2.0E+00		9.3E-03	
XYLENE	6.5E-01	1.9E-02			1.2E-01	2.6E-04
				TOTAL		

INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	ADULT DOSE	RfD	ADULT HI	ADULT EX. CR. RSK.
BENZENE	3.1E-01	7.8E+01	9.9E-01	2.8E-04	1.0E-01	4.7E-03	8.2E-06
ETHYLBENZENE	3.8E-01	1.1E+02	1.7E+00	4.7E-04	3.0E-01	3.2E-05	
TOLUENE	9.0E-03	9.2E+01	3.4E-02	9.7E-06	2.0E+00	4.0E-04	
XYLENE	6.5E-01	1.1E+02	2.8E+00	8.0E-04		5.1E-03	8.2E-06
					TOTAL		

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	ADULT DOSE	RfD	CPF	ADULT HI	ADULT EX. CR. RSK.
BENZENE	3.1E-01	8.9E-03	1.0E-01	2.9E-02	1.1E-01	2.6E-04
ETHYLBENZENE	3.8E-01	1.1E-02	3.0E-01		8.6E-04	
TOLUENE	9.0E-03	2.6E-04	2.0E+00		9.3E-03	
XYLENE	6.5E-01	1.9E-02			1.2E-01	2.6E-04
				TOTAL		

TABLE 9. EXPOSURE ANALYSIS FOR SITE NO. 6, THE DRAINAGE DITCH
SURFACE WATER (MAINTENANCE SCENARIO)
DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RFD	CPF	HI	EX. CR. RSK.
TRICHLOROETHENE	2.0E-03	3.6E-04		1.1E-02		3.9E-06
VINYL CHLORIDE	5.5E-03	9.8E-04		2.3E+00		2.3E-03
				TOTAL		2.3E-03

DITCH SEDIMENTS (MAINTENANCE SCENARIO)
INHALATION OF VOLATILIZED OR SUSPENDED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RFD	CPF	HI	EX. CR. RSK.
VINYL CHLORIDE	2.0E-03	6.3E+01	5.1E-03	9.1E-05				2.1E-04
1,1-DICHLOROETHANE	6.0E-03	9.9E+01	2.4E-02	4.3E-04				2.1E-04
					1.2E-01	2.3E+00	3.6E-03	3.6E-03
						TOTAL	3.6E-03	2.1E-04

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RFD	CPF	HI	EX. CR. RSK.
VINYL CHLORIDE	2.0E-03	3.5E-08		2.3E+00		8.1E-08
1,1-DICHLOROETHANE	6.0E-03	1.1E-07	1.2E-01		8.8E-07	8.8E-07
				TOTAL		8.1E-08

TABLE 9. EXPOSURE ANALYSIS FOR SITE NO. 6, THE DRAINAGE DITCH (CONTINUED)
 SURFACE WATER (CHILD SCENARIO)
 DERMAL ABSORPTION

CHEMICAL	REP. CONC.	CHILD DOSE	RFD	CPF	CHILD HI	CHILD EX. CR. RSK.
TRICHLOROETHENE	2.0E-03	2.0E-06		1.1E-02		2.2E-08
VINYL CHLORIDE	5.5E-03	5.6E-06		2.3E+00		1.3E-05
				TOTAL		1.3E-05

work life. Although this period of exposure is excessive, the actual duration of worker contact with surface water in this area of the ditch is difficult, if not impossible, to determine. Certainly the period of actual worker exposure to vinyl chloride in surface water would be less than the average work life. Therefore, the actual worker risk associated with exposure to vinyl chloride would be less than that predicted from the exposure scenario.

The actual risk associated with dermal absorption of vinyl chloride in surface water at Site No. 6 is less than the estimate for excess cancer risk (2.3×10^{-3}). The exposure scenario applied is mitigated by several factors which greatly reduce the actual risk from exposure to vinyl chloride: the low dermal absorption and high volatility of vinyl chloride, the limited area of contamination, and the excessive exposure duration used in risk calculations.

Evaluation of the maintenance worker scenario for contact with ditch sediments also indicates a low possibility of adverse health effects via inhalation; contact via dermal absorption is not associated with any adverse effects. Inhalation of suspended sediment particles is associated with a slight increase in excess cancer risk (2.1×10^{-4}) from exposure to vinyl chloride. However, these findings must be considered in light of mitigating site conditions. Vinyl chloride (the carcinogenic agent) was detected in only *one* sediment sample. The absence of vinyl chloride in other sediment samples and its appearance in decreasing concentrations in the surface water reduce the likelihood that workers could contact it at a level and a frequency which would induce adverse effects.

Evaluation of off-base risks posed by Site No. 6 is limited to the child scenario. This scenario evaluates risks posed by dermal contact with either ditch surface water or sediment. Regardless of the exposure route considered, no adverse carcinogenic or noncarcinogenic effects are associated with children playing in the ditch/creek after its exit from the base.

Site No. 7. Because of the site's location in the interior of the base and the nature of the contaminants present, only the construction worker scenario was evaluated for this site, the Refueling Hydrant, lateral number 3 (Table 10). Analysis of construction worker exposure to both groundwater and subsurface soil for both inhalation and dermal absorption pathways indicates no potential for either noncarcinogenic or carcinogenic effects.

Site No. 8. Exposure at Site No. 8, Refueling Hydrant, lateral no. 7, is possible under either the construction worker or off-base resident scenarios. At this site, under either scenario, receptors could be exposed to only one contaminant of concern (toluene, a noncarcinogen). Under the construction worker scenario, exposure could occur via either inhalation or dermal absorption of contaminated groundwater or surface water; under the resident scenario, exposure could occur via ingestion, inhalation, or dermal absorption of groundwater. Hazard indices for all routes of exposure for both scenarios indicate no potential for adverse health effects from this site (Table 11).

Site No. 9. Exposure at Site No. 9, Refueling Hydrant, lateral no. 8, is possible under the construction worker and off-base resident scenarios. As with Site No. 8, exposure at this site is limited to a single compound, toluene. Calculation of hazard indices for both worker and resident scenarios indicates that site concentrations of toluene are not expected to produce adverse health effects in either receptor group (Table 12).

The Southeast Corner. No contaminants of concern were detected in environmental media at the southeast corner. Consequently, there is no potential for carcinogenic or noncarcinogenic health effects from exposure to contaminated media at the southeast corner.

TABLE 10. EXPOSURE ANALYSIS FOR SITE NO. 7, REFUELING HYDRANT, LATERAL NO. 3
GROUNDWATER (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	1.0E-03	9.2E+01	3.8E-03	1.7E-06	6.0E-02	TOTAL	2.8E-05	2.8E-05

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	1.0E-03	4.5E-06	6.0E-02	TOTAL	7.5E-05	7.5E-05

SOIL (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED OR SUSPENDED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
1,1,1-TRICHLOROETHANE	1.0E-03	1.3E+02	5.5E-03	2.4E-06	9.0E-02	TOTAL	2.7E-05	2.7E-05

SOIL (CONSTRUCTION SCENARIO)
DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
1,1,1-TRICHLOROETHANE	1.0E-03	4.4E-10	9.0E-02	TOTAL	4.9E-09	4.9E-09

TABLE 11. EXPOSURE ANALYSIS FOR SITE NO. 8, REFUELING HYDRANT, LATERAL NO. 7
GROUNDWATER (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	1.0E-03	9.2E+01	3.8E-03	1.7E-06	3.0E-01	TOTAL	5.6E-06	5.6E-06

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	1.0E-03	4.5E-06	3.0E-01	TOTAL	1.5E-05	1.5E-05

SOIL (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	1.0E-03	9.2E+01	3.8E-03	1.7E-06	3.0E-01	TOTAL	5.6E-06	5.6E-06

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	1.0E-03	4.4E-10	3.0E-01	TOTAL	1.5E-09	1.5E-09

TABLE 11. EXPOSURE ANALYSIS FOR SITE NO. 8, REFUELING HYDRANT, LATERAL NO. 7, (CONTINUED)
GROUNDWATER (RESIDENT SCENARIO)
INGESTION

CHEMICAL	REP. CONC.	ADULT DOSE	RfD	CPF	ADULT HI	ADULT EX. CR. RSK.
TOLUENE	1.0E-03	2.9E-05	3.0E-01	TOTAL	9.5E-05	9.5E-05

INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	ADULT DOSE	RfD	CPF	ADULT HI	ADULT EX. CR. RSK.
TOLUENE	1.0E-03	9.2E+01	3.8E-03	1.1E-06	3.0E-01	TOTAL	3.6E-06	3.6E-06

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	ADULT DOSE	RfD	CPF	ADULT HI	ADULT EX. CR. RSK.
TOLUENE	1.0E-03	2.9E-05	3.0E-01	TOTAL	9.5E-05	9.5E-05

TABLE 12. EXPOSURE ANALYSIS FOR SITE NO. 9, REFUELING HYDRANT, LATERAL NO. 8
GROUNDWATER (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	2.0E-03	9.2E+01	7.5E-03	3.4E-06	3.0E-01		1.1E-05	
						TOTAL	1.1E-05	

DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	2.0E-03	8.9E-06	3.0E-01		3.0E-05	
				TOTAL	3.0E-05	

SOIL (CONSTRUCTION SCENARIO)
INHALATION OF VOLATILIZED OR SUSPENDED CONTAMINANTS

CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	6.0E-03	9.2E+01	2.3E-02	1.0E-05	3.0E-01		3.4E-05	
						TOTAL	3.4E-05	

SOIL (CONSTRUCTION SCENARIO)
DERMAL ABSORPTION

CHEMICAL	REP. CONC.	DOSE	RfD	CPF	HI	EX. CR. RSK.
TOLUENE	6.0E-03	2.6E-09	3.0E-01		8.8E-09	
				TOTAL	8.8E-09	

TABLE 12. EXPOSURE ANALYSIS FOR SITE NO. 9, REFUELING HYDRANT, LATERAL NO. 8 (CONTINUED)
GROUNDWATER (RESIDENT SCENARIO)

CHEMICAL	REP. CONC.	ADULT DOSE	RFD	CPF	ADULT	
					HI	EX. CR. RSK.
TOLUENE	2.0E-03	5.7E-05	3.0E-01	TOTAL	1.9E-04	1.9E-04

INHALATION OF VOLATILIZED CONTAMINANTS						
CHEMICAL	REP. CONC.	MOL. WT.	mg/m ³	ADULT DOSE	RFD	ADULT EX. CR. RSK.
TOLUENE	2.0E-03	9.2E+01	7.5E-03	2.1E-06	3.0E-01	7.2E-06
					TOTAL	7.2E-06

DERMAL ABSORPTION						
CHEMICAL	REP. CONC.	ADULT DOSE	RFD	CPF	ADULT HI	ADULT EX. CR. RSK.
TOLUENE	2.0E-03	5.7E-05	3.0E-01	TOTAL	1.9E-04	1.9E-04

CONCLUSIONS

Consideration of all factors evaluated in this risk assessment generally indicates that contamination found at Forbes Field ANGB poses little, if any, risk of adverse health effects to either on- or off-base human receptors. Analysis of the environmental and human exposure pathways associated with the seven sites at the base shows that contamination is relatively localized and is generally confined to the base itself. Although contamination does occur in base groundwater (the most likely medium for off-base transport), environmental conditions at the base suggest that:

- 1) the potential migration of contaminants in groundwater to off-base areas appears to be confined to the unconsolidated aquifer, and
- 2) the probability of contaminants migrating off-base within the unconsolidated aquifer to an exposure point (at levels adverse to human health) is reduced by the confining hydrologic nature of the unconsolidated aquifer (contaminant movement has not been evidenced by contaminated samples from wells downgradient from the sites), the effect of dilution on contaminant concentrations, and the absence of registered private wells in the vicinity of the base.

In addition to confinement of base contamination and limited potential for migration, this analysis also suggests that base conditions limit the potential for exposure under both current and future conditions. Under these simulations, we can conclude with a reasonable margin of safety that Sites No. 1, 7, 8, 9 and the Southeast Corner pose no adverse health effects from current or future exposure to the pathways considered. These conclusions will not apply to these sites if exposure occurs in a manner inconsistent with the exposure scenarios evaluated.

Further, the risks associated with exposures to contamination at Sites No. 5 and 6 are very likely overestimates of actual risks present. At Site No. 5, the excess cancer risk associated with off-base ingestion and dermal absorption of contaminated groundwater must be qualified by the following factors:

- 1) The excess cancer risk associated with off-base ingestion and dermal absorption of potentially contaminated groundwater is only slightly outside the range of acceptability.
- 2) There are no known off-base wells drawing from the contaminated aquifer, thus eliminating a point of exposure.
- 3) Estimations of the off-base risk assume exposure at the point of contact is equal to concentrations measured in the groundwater on-base. Actual exposure concentration should be much lower, greatly reducing the risk.
- 4) There is no evidence that benzene is moving in the groundwater at Site No. 5 and may, in fact, be confined on-base due to the nature of the aquifer.

Thus, the probability of carcinogenic effects in off-base receptors from this site is unlikely.

Risks estimated from worker exposure to contaminated surface water and sediment at Site No. 6 are mitigated by a similar set of qualifying factors:

- 1) Carcinogenic effects are linked to dermal absorption of vinyl chloride-contaminated surface water.
- 2) Simulation of surface water exposure assumes 100% absorption across the skin barrier. In actuality, vinyl chloride is poorly absorbed dermally and is highly volatile, and exposure concentrations would, therefore, be much lower.
- 3) The period of actual worker exposure to vinyl chloride in surface water would be less than the duration of the average work life used to estimate risk.

Thus, consideration of these factors make it unlikely that significant risks are posed by Site No. 6 to on-base workers performing routine maintenance around the site.

Finally, estimations of exposure and risk for all sites at Forbes Field ANGB have been made using the most cautious assumptions possible. This conservatism makes it extremely unlikely that conditions present at the base pose risks which exceed those estimated here and provide a more than adequate margin of safety for concluding that contamination at Forbes Field ANGB is unlikely to pose significant human health risks.

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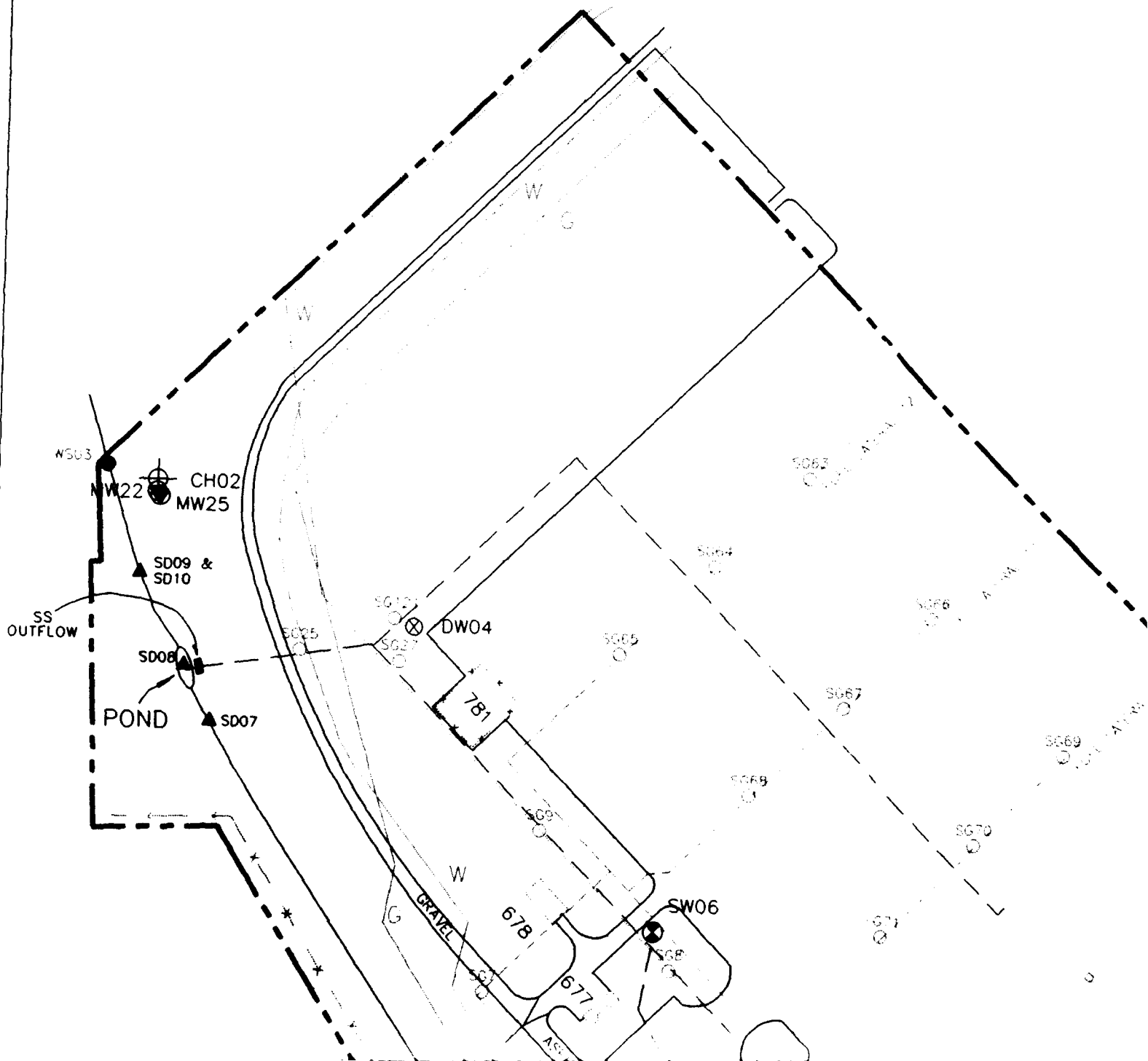
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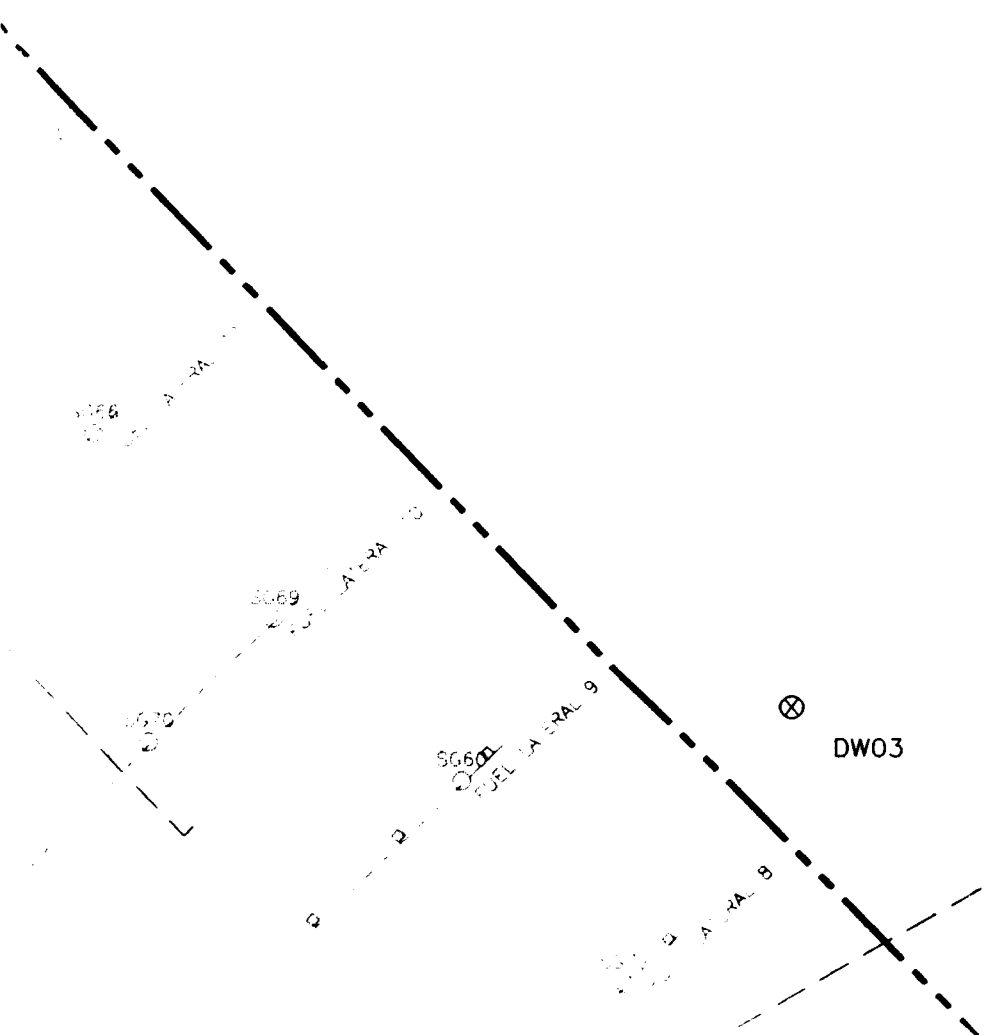
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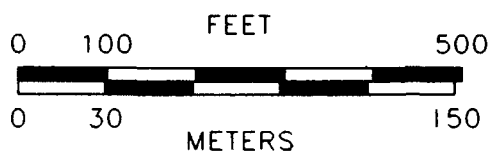


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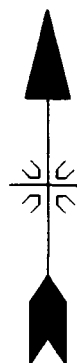
SC

PLATE 1

FORBES FIELD ANGB
TOPEKA, KS
ORNL 1/89

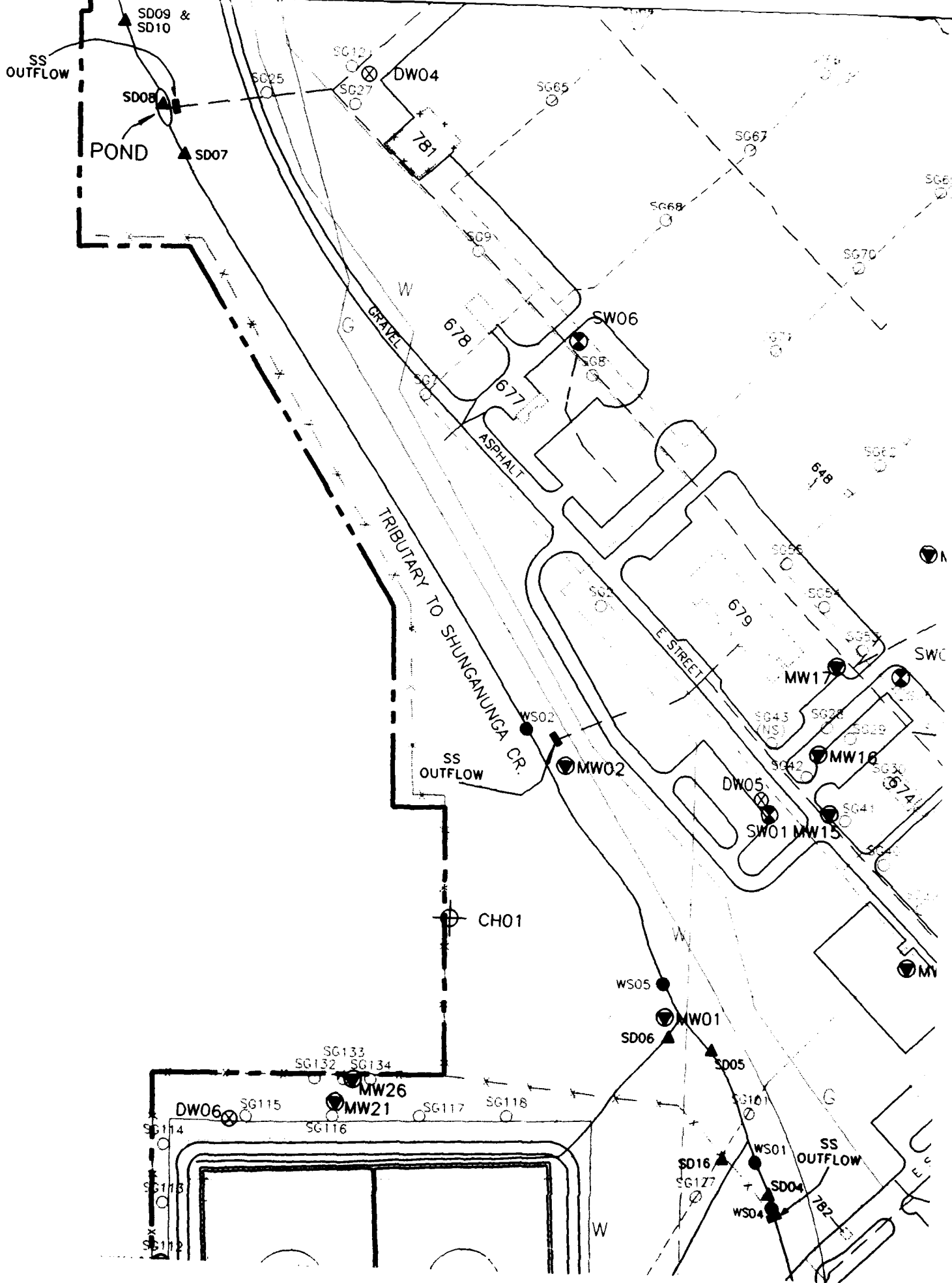


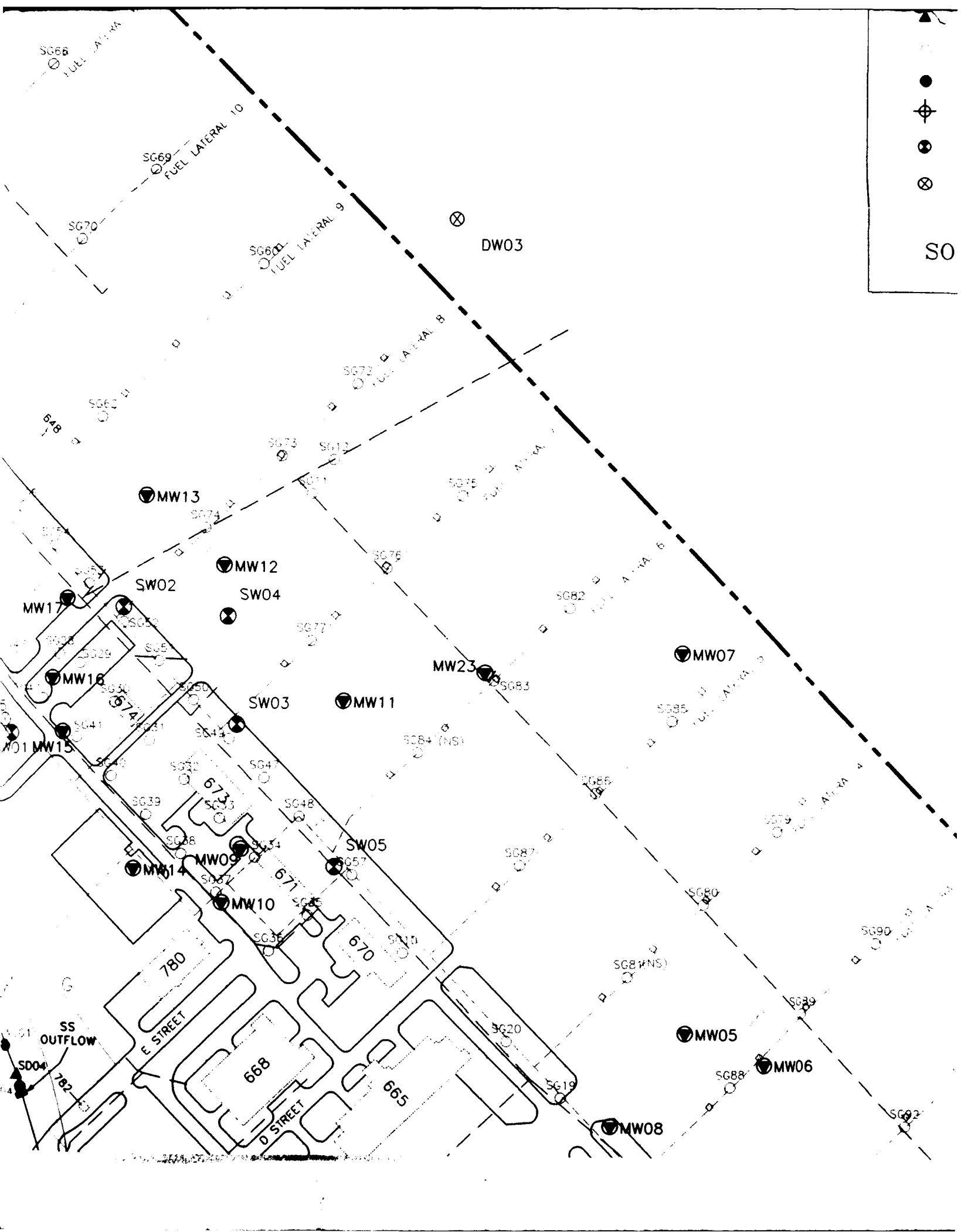
N



- BASE BOUNDARY
- 760 BUILDING OR FACILITY
I.D. NUMBER
- FUEL HYDRANT
- FUEL DISTRIBUTION LINE
- STORM DRAIN
- G GAS LINE
- W WATER MAIN
- W WATER MAIN (ABANDONED)
- ⊙ OAK RIDGE MONITORING WELL (DRY)
- OAK RIDGE MONITORING WELL
- ▲ SEDIMENT SAMPLE
- SOIL-GAS SAMPLE (NG = NO SAMPLE)
- SURFACE WATER SAMPLE
- ⊕ OAK RIDGE COREHOLE
- ⊗ WESTON MONITORING WELL, 1984
- ⊗ WESTON MONITORING WELL, 1984
(ABANDONED)

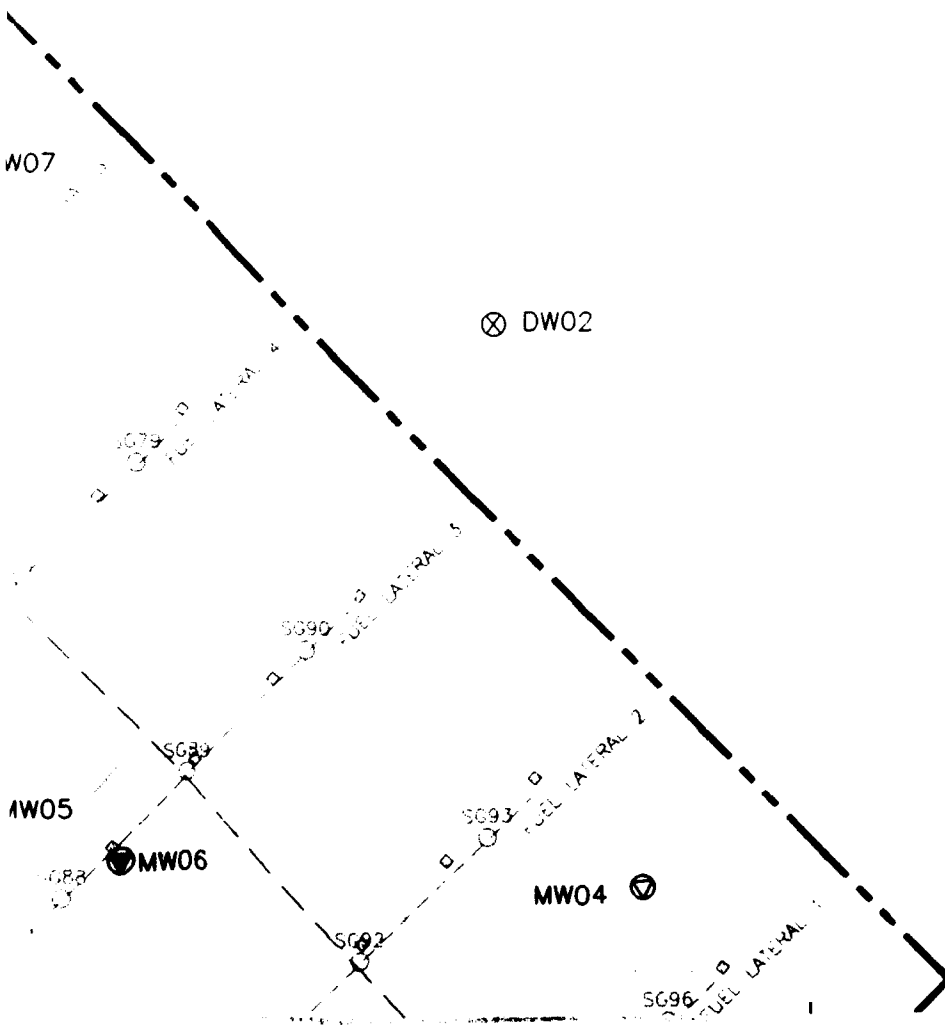
SOURCE: ORNL DATA 5/88, 7/88, 11/88
AND BASE UTILITY MAPS 4/84



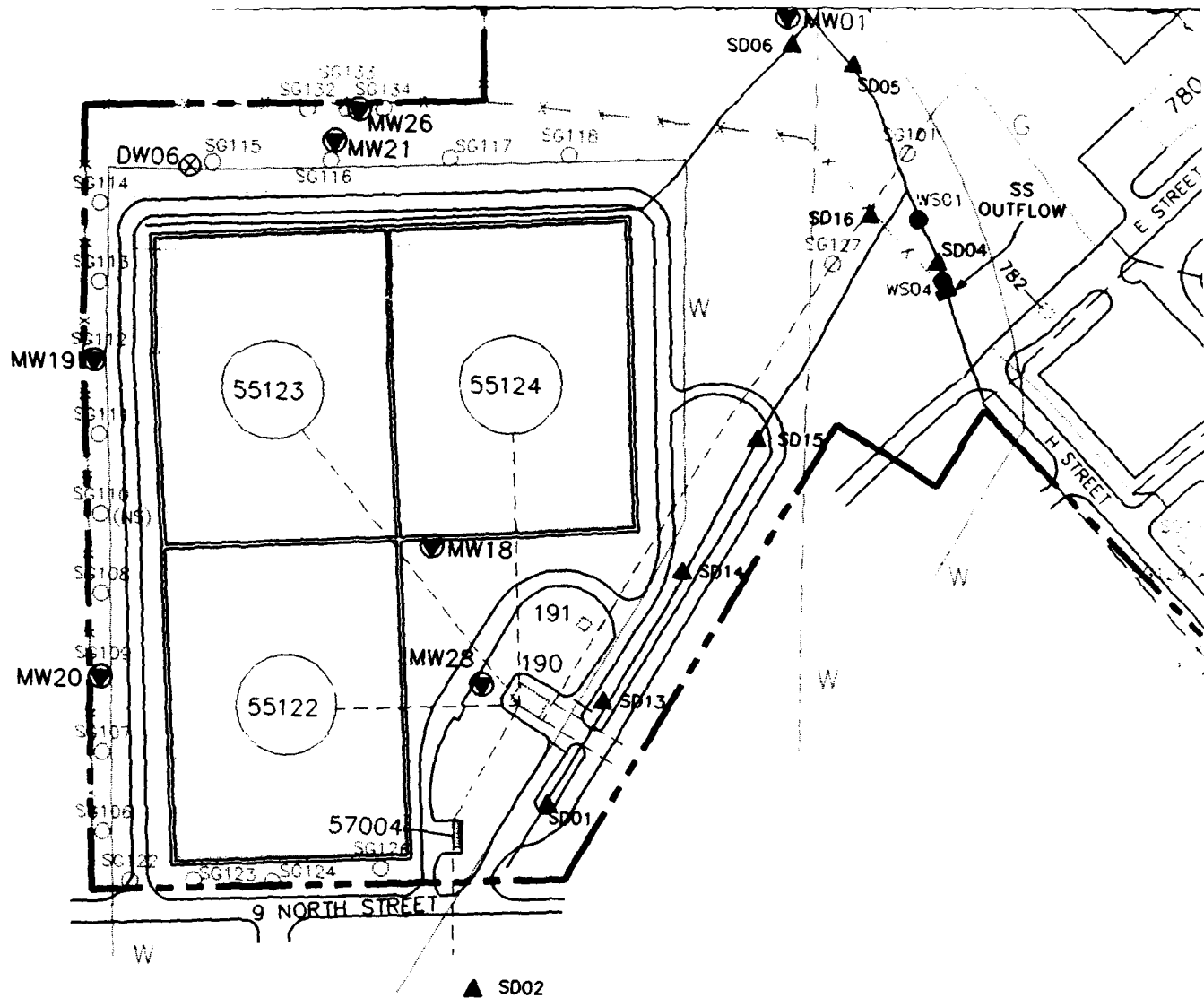


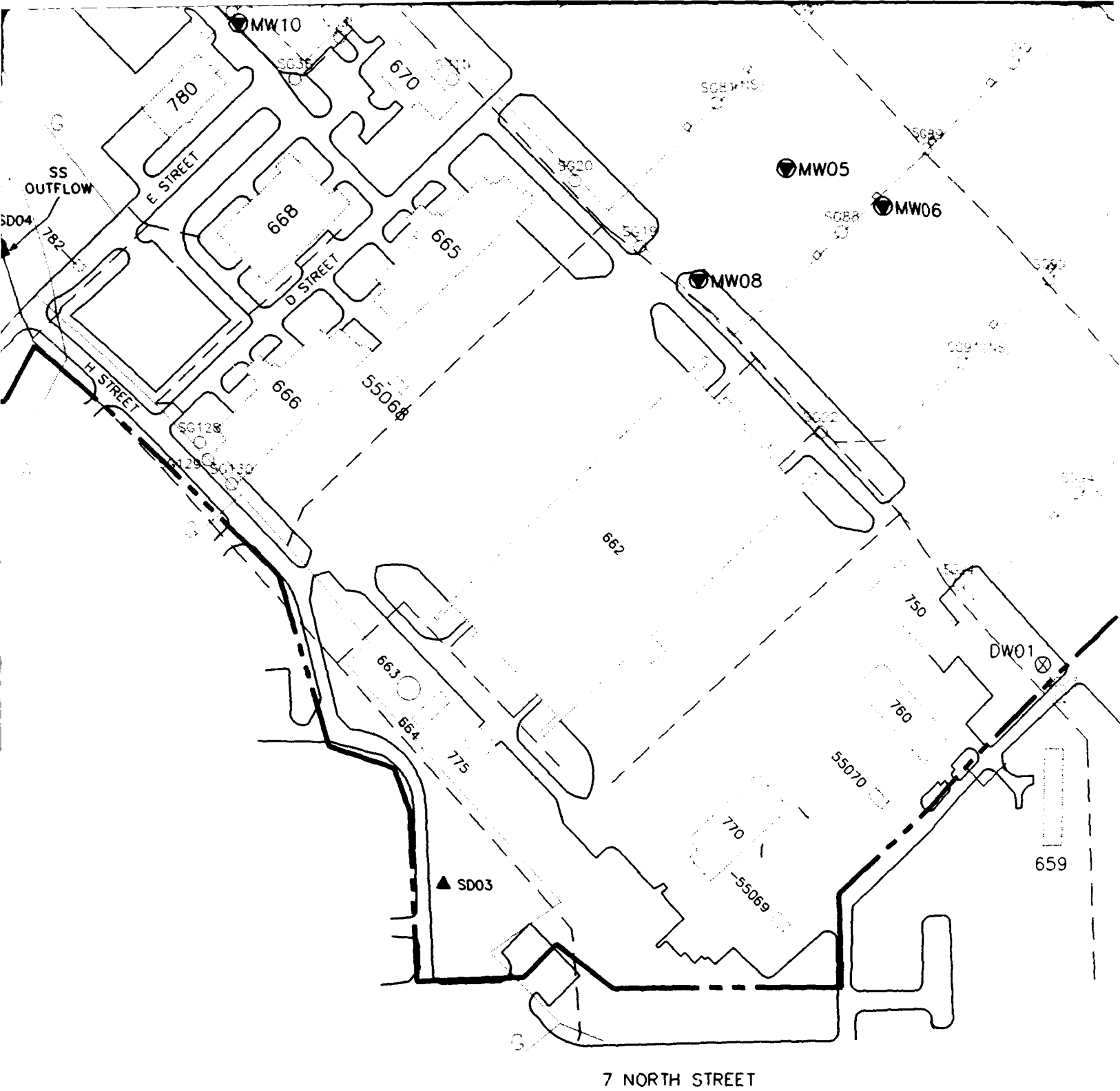
- ▲ SEDIMENT SAMPLE
- SOIL-GAS SAMPLE (NS = NO SAMPLE)
- SURFACE WATER SAMPLE
- ⊕ OAK RIDGE COREHOLE
- ⊗ WESTON MONITORING WELL, 1984
- ⊗ WESTON MONITORING WELL, 1984 (ABANDONED)

SOURCE: ORNL DATA 5/88, 7/88, 11/88
AND BASE UTILITY MAPS 4/84



US HWY 75





W05

MW06

MW04

CH03

MW27

MW03

MW24

DW01

659

750

760

35070

SG93
L.A. - RAL 2

SG96
L.A. - L.A.

SG91 (NS)

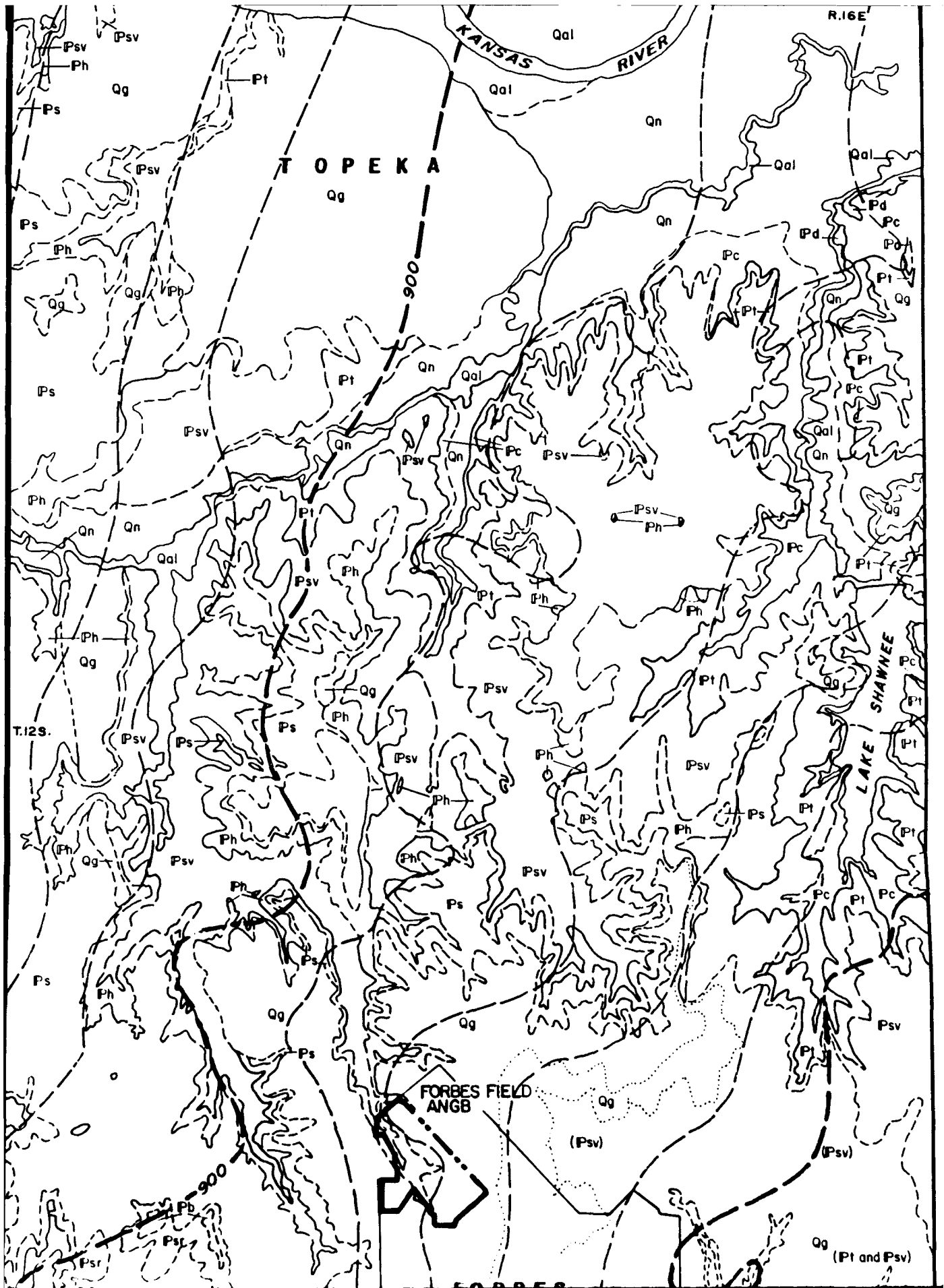
SG94
(NS)

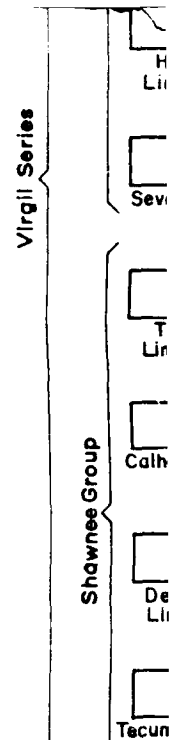
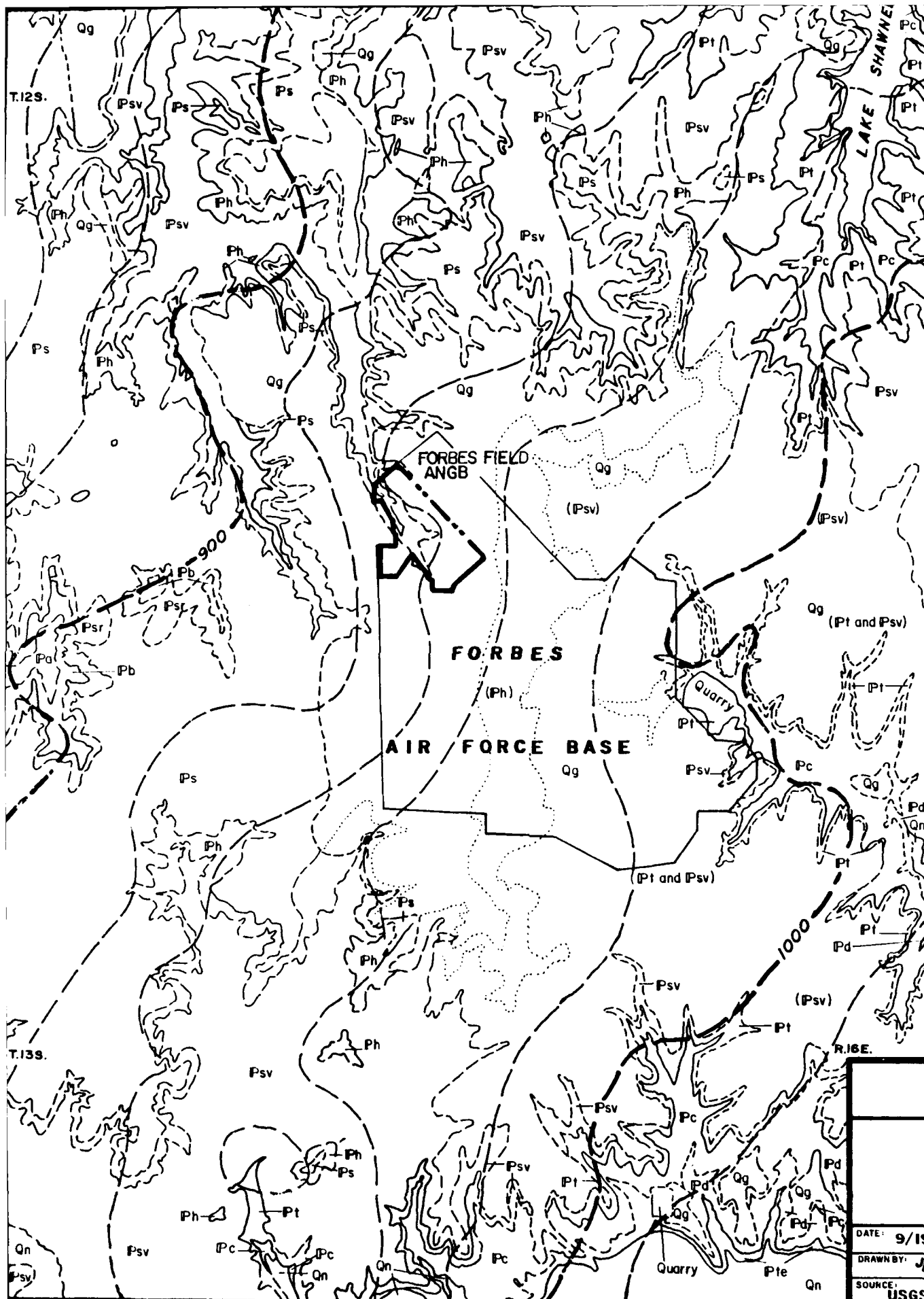
SG97
(NS)

SG95

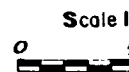
SG92

SG89





STRUCTURE
CONTOUR IN'
Drawn on base of To,
where approximate
where datum is sea
level.



PLATE

**FORBES FIELD
TOPEKA, KAN.**

ORNL 9/

DATE: 9/19/88

DRAWN BY: JDB DRAFTING

SOURCE: USGS BULLETIN 1215A

