

AD-A274 679



92156R01
VOLUME I of II
ORIGINAL

①



PROGRAM MANAGER
FOR ROCKY MOUNTAIN ARSENAL

U.S. ARMY
MATERIEL COMMAND

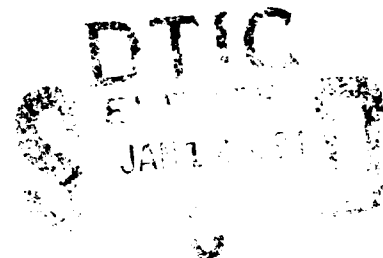
— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

Offpost Operable Unit
Remedial Investigation

Final Addendum

Volume I of II

March 30, 1992
Contract Number DAAA15-88-0021



Harding Lawson Associates

Environmental Science And Engineering, Inc.

94-01567



REQUESTS FOR COPIES OF THIS DOCUMENT
SHOULD BE REFERRED TO THE PROGRAM MANAGER
FOR ROCKY MOUNTAIN ARSENAL
AMXRM-PM, COMMERCE CITY, COLORADO 80022

This document complies with the
National Environmental Policy Act of 1969.

ROCKY MOUNTAIN ARSENAL • COMMERCE CITY, COLORADO • 80022-2180

94 1 13 045

**Best
Available
Copy**



92156R01
ORIGINAL
VOLUME I of II

TECHNICAL SUPPORT FOR ROCKY MOUNTAIN ARSENAL

DTIC QUALITY INSPECTED 8

**Offpost Operable Unit
Remedial Investigation**

Final Addendum

Volume I of II

**March 30, 1992
Contract Number DAAA15-88-0021**

Accession For	
NTIS CRA&I	☒
DTIC TAB	☐
Unannounced	☐
Justification	
By <i>Pec A274641</i>	
Distribution	
Dist	<i>A-1</i>

PREPARED BY

**Harding Lawson Associates
Environmental Science and Engineering**

PREPARED FOR

PROGRAM MANAGER FOR ROCKY MOUNTAIN ARSENAL

**THIS DOCUMENT IS INTENDED TO COMPLY WITH THE NATIONAL
ENVIRONMENTAL POLICY ACT OF 1969.**

**THE INFORMATION AND CONCLUSIONS PRESENTED IN THIS REPORT REPRESENT
THE OFFICIAL POSITION OF THE DEPARTMENT OF THE ARMY UNLESS EXPRESSLY
MODIFIED BY A SUBSEQUENT DOCUMENT. THIS REPORT CONSTITUTES THE
RELEVANT PORTION OF THE ADMINISTRATION RECORD FOR THIS CERCLA
OPERABLE UNIT.**

TABLE OF CONTENTS

	<u>Page</u>
LIST OF TABLES	vi
LIST OF FIGURES	viii
1.0 INTRODUCTION	1
1.1 PURPOSE	1
1.2 SUMMARY OF THE TECHNICAL APPROACH	2
1.3 REPORT ORGANIZATION	4
2.0 DATA COLLECTION AND ANALYSES	5
2.1 GROUNDWATER MONITORING PROGRAM	5
2.1.1 Groundwater Monitoring Network and Rationale	5
2.1.1.1 Monitoring Well Installation Methods	8
2.1.2 Water-Level Monitoring and Groundwater Sampling	9
2.1.3 Field Sampling Methodology	10
2.1.4 Analytical Program	10
2.2 SURFACE-WATER MONITORING PROGRAM	11
2.2.1 Surface-Water Sampling Network and Rationale	11
2.2.2 Field Sampling Methodology	12
2.2.3 Analytical Program	12
2.3 STREAM-BOTTOM SEDIMENT MONITORING PROGRAM	12
2.3.1 Stream-Bottom Sediment Sampling Network and Rationale	13
2.3.2 Field Sampling Methodology	13
2.3.3 Analytical Program	13
2.4 SOIL MONITORING PROGRAM	14
2.4.1 Surficial and Subsurface Soil Monitoring Network and Rationale	14
2.4.2 Field Sampling Methodology	16
2.4.3 Analytical Program	17
2.5 BIOTA MONITORING PROGRAM	17
2.5.1 Criteria for Target Analyte Selection and Biota Sampling Rationale	18
2.5.2 Field Sampling Methodology for Ecological Characterization	18
2.5.2.1 Methods for Ecological Characterization of Aquatic Systems in the Offpost OU	19
2.5.2.2 Methods for Ecological Characterization of the Terrestrial System in the Offpost OU	19
2.5.3 Methods of Sample Collection for Contaminant Analyses	20

TABLE OF CONTENTS (Continued)

	<u>Page</u>
2.5.3.1 Aquatic Sampling Methodology	20
2.5.3.2 Terrestrial Biota Sampling Methodology	21
2.5.3.3 Agricultural Sample Collection	22
2.5.4 Analytical Program for Biological Samples	23
3.0 GROUNDWATER MONITORING RESULTS AND ASSESSMENT	24
3.1 GEOLOGY AND HYDROGEOLOGY	24
3.1.1 Geology	25
3.1.2 Hydrogeology	26
3.1.3 Groundwater Flow	26
3.1.3.1 Unconfined Flow System	27
3.1.3.2 Arapahoe Formation	28
3.2 WATER QUALITY DATA	29
3.2.1 Nature and Extent of Unconfined Flow System Contamination	32
3.2.1.1 Unconfined Flow System Organics	32
3.2.1.1.1 Semivolatile Organic Compounds	33
3.2.1.1.2 Other Semivolatile Organic Compounds	37
3.2.1.1.3 Organochlorine Pesticide Compounds	38
3.2.1.1.4 Nitrogen Phosphorous Pesticides	39
3.2.1.1.5 Organosulfur Compounds	40
3.2.1.1.6 Volatile Organic Compounds	41
3.2.1.1.7 Other Volatile Organic Compounds	48
3.2.1.2 Unconfined Flow System Inorganics	48
3.2.2 Nature and Extent of Arapahoe Formation Contamination	54
3.2.2.1 Arapahoe Formation Organics	55
3.2.2.2 Arapahoe Formation Inorganics	56
3.2.3 Summary of Gas Chromatography/Mass Spectroscopy Results	58
3.2.4 Summary of Quality Assurance/Quality Control Results	59
3.2.5 Comparison of Offpost RI Results and RI Addendum Results	61
3.3 CONCLUSIONS	62
4.0 SURFACE-WATER MONITORING RESULTS AND ASSESSMENT	64
4.1 NATURE AND EXTENT OF SURFACE-WATER CONTAMINATION	64
4.1.1 Organic Compounds	65
4.1.2 Inorganic Constituents	70
4.2 SUMMARY OF GAS CHROMATOGRAPHY/MASS SPECTROSCOPY RESULTS	72
4.3 SUMMARY OF QUALITY ASSURANCE/QUALITY CONTROL RESULTS ...	73

TABLE OF CONTENTS (Continued)

	<u>Page</u>
4.4 COMPARISON OF OFFPOST REMEDIAL INVESTIGATION AND REMEDIAL INVESTIGATION ADDENDUM RESULTS	73
4.5 CONCLUSIONS	76
5.0 STREAM-BOTTOM SEDIMENT MONITORING RESULTS AND ASSESSMENT	79
5.1 NATURE AND EXTENT OF STREAM-BOTTOM SEDIMENT CONTAMINATION	79
5.1.1 Organic Compounds	80
5.1.2 Inorganic Constituents	84
5.2 SUMMARY OF GAS CHROMATOGRAPHY/MASS SPECTROSCOPY RESULTS	86
5.3 SUMMARY OF QUALITY ASSURANCE/QUALITY CONTROL RESULTS ...	86
5.4 COMPARISON OF REMEDIAL INVESTIGATION RESULTS AND REMEDIAL INVESTIGATION ADDENDUM RESULTS	87
5.5 CONCLUSIONS	87
6.0 SURFICIAL AND SUBSURFACE SOIL MONITORING RESULTS AND ASSESSMENT	89
6.1 NATURE AND EXTENT OF SURFICIAL AND SUBSURFACE SOIL CONTAMINATION	89
6.1.1 Surficial Soil	89
6.1.1.1 Organic Compounds	90
6.1.1.2 Inorganic Constituents	93
6.1.2 Subsurface Soil	94
6.1.2.1 Organic Compounds	94
6.1.2.2 Inorganic Constituents	94
6.1.3 Background Surficial Soil Samples	95
6.1.3.1 Site-specific Data	95
6.1.3.2 Literature Data	96
6.2 SUMMARY OF GAS CHROMATOGRAPHY/MASS SPECTROSCOPY RESULTS	98
6.3 SUMMARY OF QUALITY ASSURANCE/QUALITY CONTROL RESULTS ...	99
6.4 COMPARISON OF REMEDIAL INVESTIGATION ADDENDUM RESULTS AND COLORADO DEPARTMENT OF HEALTH RESULTS	99
6.5 CONCLUSIONS	100

TABLE OF CONTENTS (Continued)

	<u>Page</u>
7.0 BIOTA MONITORING RESULTS AND ASSESSMENT	102
7.1 ECOLOGICAL CHARACTERIZATION STUDY RESULTS	102
7.1.1 Aquatic Characterization	102
7.1.1.1 RMA to the Impoundment	102
7.1.1.2 First Creek Impoundment	103
7.1.1.3 First Creek Impoundment to Highway 2	103
7.1.2 Terrestrial Characterization	104
7.2 NATURE AND EXTENT OF BIOTA CONTAMINATION	106
7.2.1 Target Analytes in Biological Samples	106
7.2.2 Comparison of Onpost and Offpost Contaminant Data	107
7.2.3 Comparison of Biota Contaminant Levels with Concentrations in Surface Soil and Water	109
7.2.4 Threatened and Endangered Species in the Offpost OU	110
7.3 QUALITY ASSURANCE AND QUALITY CONTROL FOR CHEMICAL ANALYSES	110
7.4 SUMMARY AND CONCLUSIONS OF CHARACTERIZATION AND CONTAMI- NANT STUDIES	111
8.0 REMEDIAL INVESTIGATION ADDENDUM SUMMARY AND CONCLUSIONS ...	112
8.1 GROUNDWATER	112
8.2 SURFACE WATER	113
8.3 STREAM-BOTTOM SEDIMENT	114
8.4 SURFICIAL AND SUBSURFACE SOILS	115
8.5 BIOTA	116
9.0 GLOSSARY	118
10.0 LIST OF REFERENCES	122

TABLE OF CONTENTS
(Continued)

APPENDIXES

- A LITHOLOGIC LOGS, CONSTRUCTION SUMMARIES, COMPLETION REPORTS
AND SURVEY DATA
- B GROUNDWATER ANALYTICAL DATA
- C SURFACE-WATER ANALYTICAL DATA
- D STREAM-BOTTOM SEDIMENT ANALYTICAL DATA
- E SURFICAL AND SUBSURFACE SOIL ANALYTICAL DATA
- F BIOTA ANALYTICAL DATA
- G COLORADO DEPARTMENT OF HEALTH SURFICAL SOIL ANALYTICAL
DATA
- H ANALYTICAL RESULTS FOR ADDITIONAL OFFPOST SURFICIAL SOIL
SAMPLES COLLECTED BY WOODWARD-CLYDE FEDERAL SERVICES,
MAY 1991
- I COMMENTS AND RESPONSES TO THE OFFPOST OPERABLE UNIT REMEDIAL
INVESTIGATION, DRAFT FINAL ADDENDUM, NOVEMBER 1991

LIST OF TABLES

Table No.

1.1	Data Needs in Each Offpost Operable Unit Medium Addressed in RI Addendum
2.1	Aquifer Designations and Sampling Dates for Wells in Offpost Operable Unit
2.2	Technical Justification for Monitoring Wells Installed Under Remedial Investigation Addendum Program
2.3	Completion Data for New Monitoring Wells
2.4	Target Analyte List
2.5	Analytical Methods and Certified Reporting Limits
2.6	Biota Samples Collected in the Offpost Operable Unit During Remedial Investigation Addendum Program
2.7	Summary of Certified Biota Analysis Methods
3.1	Unconfined Flow System Groundwater Elevations Used to Construct Potentiometric Surface Map
3.2	Groundwater Field Quality Assurance/Quality Control Samples
3.3	Groundwater Duplicate Sample Agreement
3.4	Tentatively Identified Compounds in Groundwater Samples
4.1	Surface-Water Duplicate Sample Agreement
5.1	Metal Concentrations Commonly Found in Uncontaminated Fresh-Water Sediments
5.2	Stream-Bottom Sediment Duplicate Sample Agreement
6.1	Arithmetic Mean and Upper 95th Percentile Concentrations for Selected Organic Compounds in Offpost Operable Unit Background Surficial Soil
6.2	Residue Levels for Selected Insecticides in Soil
6.3	Surficial Soil Duplicate Sample Agreement
6.4	Summary of Compounds Detected in Collocated Harding Lawson Associates and Colorado Department of Health Surficial Soil Samples from the 96th Avenue Residential Area in Offpost Operable Unit

LIST OF TABLES
(Continued)

Table No.

- | | |
|-----|--|
| 7.1 | Aquatic Vertebrates and Invertebrates Found in First Creek Impoundment |
| 7.2 | Comparisons of Target Analytes Detected in Biota Samples with Analytes Detected in Samples from Nearby Soil and Surface-Water Sample Locations |

LIST OF FIGURES

Figure No.

- | | |
|-----|---|
| 1.1 | Location Map of Onpost Operable Unit, Rocky Mountain Arsenal |
| 1.2 | Offpost Operable Unit, Rocky Mountain Arsenal |
| 2.1 | Offpost Operable Unit Unconfined Flow System Monitoring Well Network |
| 2.2 | Offpost Operable Unit Arapahoe Formation Well Monitoring Network |
| 2.3 | Offpost Operable Unit Surface-Water Sampling Locations |
| 2.4 | Offpost Operable Unit Stream-Bottom Sediment Sampling Locations |
| 2.5 | Offpost Operable Unit Soil Sampling Locations in the 96th Avenue Residential Area, February 1989 |
| 2.6 | Offpost Operable Unit Subsurface and Surficial Soil Sampling Locations, June-July 1990 and May 1991 |
| 2.7 | Offpost Operable Unit Background Soil Sampling Locations Near Brighton, CO |
| 2.8 | Offpost Operable Unit Biota Habitat Map |
| 2.9 | Offpost Operable Unit Biota Sampling Locations |
| 3.1 | Potentiometric Surface Map of the Unconfined Flow System in the Offpost OU |
| 3.2 | Distribution of Diisopropylmethylphosphonate (DIMP) in the Offpost Unconfined Flow System |
| 3.3 | Distribution of Dicyclopentadiene (DCPD) in the Offpost Unconfined Flow System |
| 3.4 | Distribution of Dieldrin in the Offpost Unconfined Flow System |
| 3.5 | Distribution of Endrin in the Offpost Unconfined Flow System |
| 3.6 | Distribution of Chloroform in the Offpost Unconfined Flow System |
| 3.7 | Distribution of Chlorobenzene in the Offpost Unconfined Flow System |
| 3.8 | Distribution of Dibromochloropropane (DBCP) in the Offpost Unconfined Flow System |
| 3.9 | Distribution of Trichloroethene (TRCLE) in the Offpost Unconfined Flow System |

LIST OF FIGURES
(Continued)

Figure No.

- | | |
|------|---|
| 3.10 | Distribution of Tetrachloroethene (TCLEE) in the Offpost Unconfined Flow System |
| 3.11 | Distribution of Arsenic in the Offpost Unconfined Flow System |
| 3.12 | Distribution of Chloride in the Offpost Unconfined Flow System |
| 3.13 | Distribution of Fluoride in the Offpost Unconfined Flow System |
| 4.1 | Distribution of Organic Compounds, Arsenic, and Mercury Detected in Offpost Operable Unit Surface Water, November 1988 |
| 4.2 | Distribution of Organic Compounds, Arsenic, and Mercury Detected in Offpost Operable Unit Surface Water, May-June 1990 |
| 5.1 | Distribution of Organic Compounds, Arsenic, and Mercury Detected in Offpost Operable Unit Stream-Bottom Sediment, November 1988 |
| 5.2 | Distribution of Organic Compounds, Arsenic, and Mercury Detected in Offpost Operable Unit Stream-Bottom Sediment, May-June 1990 |
| 6.1 | Distribution of Organochlorine Pesticides, Arsenic, and Mercury Detected in 96th Avenue Residential Area Offpost Surficial Soil, February 1989 |
| 6.2 | Distribution of Organochlorine Pesticides Detected in Offpost Soil, June-July 1990 and May 1991 |
| 6.3 | Distribution of Arsenic and Mercury Detected in Offpost Surficial Soil, June-July 1990 |
| 6.4 | Distribution of Organochlorine Pesticides, Arsenic, and Mercury Detected in 96th Avenue Residential Area Offpost Subsurface Soil, February 1989 |
| 6.5 | Distribution of Organochlorine Pesticides, Arsenic, and Mercury Detected in Offpost Background Surficial Soil near Brighton, CO |
| 7.1 | Distribution of Organic Compounds, Arsenic, and Mercury in Offpost Operable Unit Agricultural Biota |
| 7.2 | Distribution of Organic Compounds, Arsenic, and Mercury in Offpost Operable Unit Aquatic Biota |
| 7.3 | Distribution of Organic Compounds, Arsenic, and Mercury in Offpost Operable Unit Terrestrial Biota |

1.0 INTRODUCTION

This Addendum to the Rocky Mountain Arsenal (RMA) Offpost Operable Unit (OU) Remedial Investigation (RI) report has been prepared by Harding Lawson Associates (HLA) for the Program Manager for Rocky Mountain Arsenal (PMRMA). This document presents the results of additional data collection activities and interpretive efforts conducted in the Offpost OU north of RMA after the Offpost OU RI report (Final RI) (Environmental Science and Engineering, Inc. [ESE], 1988a) was completed. The Offpost OU RI Addendum investigation consisted of additional data collection programs and evaluations for offpost environmental media, including groundwater in the unconfined flow system (UFS) and Arapahoe Formation, surface water, stream-bottom sediment, soil, and biota. The results and interpretations presented in this report are being used to prepare a revised Draft Final Offpost OU Endangerment Assessment/Feasibility Study (EA/FS) report (ESE, 1989a). The locations of the RMA Onpost OU and the Offpost OU are shown in Figures 1.1 and 1.2, respectively.

1.1 PURPOSE

The purpose of the RI Addendum activities described in this report was to further characterize the nature and extent of RMA-derived contaminants offpost in groundwater, surface water, sediment, soil, and biota. RI Addendum activities included collecting and evaluating physical and chemical data and, where necessary, updating interpretations of contaminant distributions offpost. Data presented and discussed in this report include the results of analyses for samples collected under the RI Addendum program for groundwater, surface water, stream-bottom sediment, soil, and biota. Additionally, data collected under the RMA Comprehensive Monitoring Program (CMP) for groundwater and surface water were used in performing the evaluations of the nature and extent of contamination for those media. Appropriate information collected by the Colorado Department of Health (CDH) for soil was also considered in this report.

The general nature of the data collection activities conducted for the Offpost OU RI Addendum investigation was discussed among the U.S. Department of the Army (Army), Shell Oil

Company (Shell), the U.S. Environmental Protection Agency (EPA), the State (CDH), and the U.S. Fish and Wildlife Service (USFWS) during preparation of the Draft Final Work Plan for the Offpost OU RI/EA/FS. The specific activities performed for this effort were developed largely on the basis of comments received on the Final RI from the Organizations and the State (OAS). The review and comment process conducted on the Offpost OU RI report and the Offpost OU EA/FS report identified the need for additional data collection and evaluation of the extent of contamination in various media offpost.

1.2 SUMMARY OF THE TECHNICAL APPROACH

The technical approach used to complete the Offpost OU RI Addendum investigation and report consisted of (1) reviewing existing data, (2) designing a field sampling program to address identified data needs, and (3) collecting and interpreting additional field data.

The field sampling program conducted to collect data for the RI Addendum was designed to generate information necessary to address identified data needs. A summary of the data needs for each medium within the Offpost OU is provided in Table 1.1. The program was developed following review of (1) the OAS comments and (2) RMA reports that contain more recent data or data for media that were not sampled during the offpost RI program. The following RMA reports were reviewed:

1. Final Offpost OU RI report (ESE, 1988a)
2. CMP Annual Groundwater Report for 1988 (R. L. Stollar Associates [RLSA], 1989)
3. CMP Annual Groundwater Report for 1989 (RLSA, 1990a)
4. CMP Annual Groundwater Report for 1990 (RLSA, 1991a)
5. CMP Final Surface-Water Data Assessment Report for 1988 (RLSA, 1990b)
6. CMP Final Surface-Water Data Assessment Report for 1989 (RLSA, 1991b)
7. RMA Water RI report (Ebasco, 1989)
8. RMA Biota RI report (ESE, 1989b)

The reviews assisted in assessing the distribution of selected organic compounds and inorganic constituents in various media in the Offpost OU and provided a basis from which to select areas for additional sample collection.

Sample collection and data evaluation procedures followed during RI Addendum activities were consistent with those approved by the Army and are specified in the following planning documents prepared by HLA to address specific objectives for the task:

- Draft Final Work Plan (Work Plan), Offpost Operable Unit Remedial Investigation/Endangerment Assessment/Feasibility Study, December 1989 (HLA, 1989a)
- Offpost Interim Response Action and Remedial Investigation/Feasibility Study, Draft Final Field Operations Procedures Plan (FOP) (HLA, 1989b)
- Offpost Operable Unit, Draft Final Quality Assurance Plan (QAP), August 1989 (HLA, 1989c)
- Offpost Interim Response Action and Remedial Investigation/Feasibility Study, Draft Final Health and Safety Plan (HSP), August 1989 (HLA, 1989d)
- Offpost Interim Response Action and Remedial Investigation/Feasibility Study, Draft Final Data Management Plan (DMP), August 1989 (HLA, 1989e)
- Surficial Soil Sampling Plan, April 1990 (HLA, 1990)

The Work Plan described specific data collection objectives to be incorporated in the RI Addendum report. Within the Work Plan are detailed sampling procedures and proposed sampling locations for offpost media that required further characterization. The QAP describes sample collection procedures and guidelines, analytical methods, recordkeeping, and other procedures designed to ensure the quality of the data generated during the RI Addendum activities. The FOP presents the procedures for conducting the field activities, including procedures for drilling and installation, sampling of various media, hydraulic testing, and decontamination.

The HSP describes health and safety guidelines implemented to protect personnel, equipment, materials, and property during the RI Addendum field investigations. The DMP describes field sample custody, data tracking, database management, and quality assurance/quality control (QA/QC) procedures for creating and maintaining the computerized database. The Surficial Soil Sampling Plan describes field procedures, proposed sample locations, and rationale for additional

offpost surficial soil sampling. Offpost OU RI Addendum field, laboratory, and data evaluation activities were performed in accordance with the procedures described in the planning documents.

1.3 REPORT ORGANIZATION

Data collection, analysis, and monitoring programs conducted to address data needs for each medium are described in Section 2.0. The results of monitoring activities and data assessment, by medium, are provided in Sections 3.0 through 7.0. The results and conclusions of the Offpost OU RI Addendum Investigation are summarized in Section 8.0. Geologic and analytical data discussed in this report are contained in Appendixes A through H.

Geologic and groundwater analytical data are contained in Appendixes A and B. Appendix A contains lithologic data and well completion diagrams, including survey data for monitoring wells installed during RI Addendum activities. Groundwater analytical data, including results for analyses of investigative gas chromatography/mass spectroscopy (GC/MS), QA/QC, and duplicate samples, are presented in Appendix B. Appendixes C through F contain similar data for samples of other media also collected during RI Addendum activities. Appendix G contains analytical data for surficial soil samples collected by CDH in the area immediately north of RMA. Analytical results for additional surficial soil samples collected from the offpost OU in May 1991 are presented in Appendix H. Responses to OAS comments on the Draft Final RI Addendum report are presented in Appendix I.

2.0 DATA COLLECTION AND ANALYSES

The data collection programs described in this section were designed to address data needs for each Offpost OU medium identified by the Army on the basis of review comments received from the OAS following their review of the Final RI report (ESE, 1988a) and the Draft Final EA/FS report (ESE, 1989a). Additionally, data collection activities were proposed for the offpost program on the basis of OAS comments made during various working meetings. Data that required additional data collection are summarized in Table 1.1.

The following subsections describe monitoring networks, sampling methods and procedures, and analytical programs used for additional data collection from Offpost OU environmental media. The following subsections describe the field and analytical activities conducted during the RI Addendum for each medium and include the sampling locations, number of samples collected, sampling procedures, and analyses performed.

2.1 GROUNDWATER MONITORING PROGRAM

This section describes the *groundwater monitoring network*, *groundwater sampling events*, *sampling methodology*, and *analytical program* used to assess groundwater flow and contamination in the Offpost OU. Results of the groundwater monitoring program are presented and discussed in Section 3.0.

The data collected during the RI Addendum were assessed, together with the data collected during the RI, to accomplish the objectives described in the Work Plan. The objectives of the additional data collection for groundwater assessment were (1) to collect additional data required to assess contaminant plume boundaries adequately and to address the interpreted contaminant plumes and isolated detections of contaminants in some wells and (2) to collect the data necessary to supplement assessment of migration pathways.

2.1.1 Groundwater Monitoring Network and Rationale

The network of groundwater monitoring wells sampled during the Offpost OU RI Addendum investigation was selected to provide data to evaluate groundwater flow and contamination in

Offpost OU groundwater in the UFS. Groundwater samples were also collected from wells in the Arapahoe Formation to assess the occurrence of contaminants in that confined groundwater zone.

Data presented in the Final RI demonstrated that contamination in the Denver Formation generally exhibited a trend of decreasing contaminant concentrations with depth. The highest contamination concentrations in the Denver Formation were generally observed in samples from wells completed within sandy zones of the upper Denver Formation. These zones are in direct contact with the base of the alluvium. Most of the organic contaminants observed in the Denver Formation are generally present in the overlying alluvium nearby. Downward gradients from the alluvium to the Denver Formation and relatively low lateral velocities in the Denver Formation suggest that a component of vertical migration in the offpost was present. Lateral migration of mobile contaminants within the Denver Formation that move at a rate similar to that of groundwater is expected to be relatively slow as compared to the alluvial aquifer. Based on these conclusions, additional characterization of the nature and extent of contamination in the Denver Formation is not necessary for conducting and EA/FS for the Offpost OU.

Groundwater in the UFS is present in the unconsolidated alluvial sediments overlying the Denver Formation and in the weathered upper portion of the Denver Formation. The majority of the groundwater movement and groundwater contaminant migration in the Offpost OU occurs in the UFS. As noted above, groundwater monitoring in the Denver Formation was not necessary for this addendum report because the Final RI report adequately characterized the extent of contamination in the Denver Formation for the purposes of conducting an EA and FS for the Offpost OU. Additionally, the Final RI identified the mechanisms of contaminant migration through the Denver Formation. The Army presented the conceptual model for interaction between the Denver Formation and the UFS to the OAS on October 16, 1991. Contaminant migration to the Denver Formation, which in some areas is part of the UFS, occurs where subcropping sands are in contact with contaminated groundwater in the UFS. Groundwater flow in the Denver Formation is considerably slower than in the UFS. Given the relatively slow groundwater velocities in the Denver Formation, contaminants observed in the Denver Formation

in the Offpost OU must have entered the Denver Formation flow system locally. The subcropping sands of the Denver Formation, particularly those sand units that have detectable levels of contaminants, generally discharge to the UFS primarily in areas upgradient of the O'Brian Canal. Considering the relationships between contaminant migration in the Denver Formation and the UFS, additional characterization of the Denver Formation was not considered necessary in this RI Addendum.

The groundwater monitoring network sampled during RI Addendum activities consisted of existing and new monitoring wells in locations that were selected to provide sufficient data to address the groundwater program objectives. The sampling events and locations are described below.

The RI Addendum groundwater monitoring network consisted of 124 wells, including 65 existing monitoring wells and piezometers, 25 domestic-use wells, and 34 new monitoring wells and piezometers installed as part of the Groundwater Intercept and Treatment System North of RMA Interim Response Action (IRA A) and RI Addendum activities. The existing monitoring wells were sampled as part of the CMP offpost monitoring network. The domestic-use wells and new monitoring wells were sampled during IRA A and RI Addendum activities.

The locations of offpost monitoring wells completed in the UFS and domestic wells completed in the UFS or Arapahoe Formation are shown in Figures 2.1 and 2.2. Unconfined flow system wells include wells completed in saturated alluvium and wells completed in permeable Denver Formation strata that are hydraulically connected to the alluvium (ESE, 1988a). The aquifer designations assigned to wells and listed in Table 2.1 are consistent with those adopted under the CMP.

Thirteen new UFS monitoring wells and 5 Arapahoe Formation wells were installed under the RI Addendum program during 1989 and 1990. The technical justification for installing these wells was presented in the Work Plan (HLA, 1989a) and is summarized in Table 2.2.

2.1.1.1 Monitoring Well Installation Methods

The new UFS monitoring wells were installed between November 1989 and February 1990 under the RI Addendum program. They were completed in saturated alluvium with total depths ranging from 30 to 56 feet below ground surface. The lithology of each monitoring well was logged, and reference samples were obtained at 5-foot intervals using a pilot boring with a 3.25-inch-inside-diameter (ID) hollow-stem auger (HSA). The pilot boring was terminated when depth to bedrock was confirmed and was reamed to the well completion depth using an 8.25-inch-ID HSA. Monitoring wells were installed with 8.25-inch-ID HSAs that were drilled from 1 to 2 feet into bedrock.

Monitoring wells were constructed of 4-inch-diameter Schedule 40 PVC, flush-threaded casing and 0.020-inch slot screens. Each well was designed to screen the interval from the interface between competent bedrock and alluvium or weathered bedrock to an elevation above the highest seasonal groundwater fluctuation. The monitoring wells were developed before sampling using a surge and pump method with a 3-inch-diameter submersible pump. Well installation and development procedures and documentation protocol are described in the Work Plan (HLA, 1989a) and in the FOP (HLA, 1989b). Well construction details are summarized in Table 2.3. Lithologic logs and well construction summary diagrams are included in Appendix A.

Three wells were drilled and completed in the Arapahoe Formation. These wells provide groundwater quality data for the Arapahoe Formation. Each well was drilled using rotary methods and was triple-cased to minimize the potential for cross-contamination of the Arapahoe Formation. For each well, a 15- or 15-1/4-inch-diameter hole was drilled through alluvium and into the upper few feet of Denver Formation bedrock. This interval was sealed by installing and pressure grouting a 12-inch-ID steel conductor casing in place.

After a minimum of 24 hours curing time, the cement plug was drilled out and the hole was advanced to approximately the top of the Upper Arapahoe Formation using an 11-7/8-inch-diameter bit. The interval, down to that depth, was sealed off by installing and pressure grouting an 8-inch-ID steel conductor casing in place. After a minimum of 24 hours curing time, the plug

was drilled out and an acoustic bond log was run to assess the casing bond. After a positive assessment of the bond log, the hole was advanced to total depth using a 7-7/8-inch bit. Upon reaching a clean, productive Arapahoe Formation sand, the drill string was removed, and the hole was geophysically logged using natural gamma, self-potential, and resistivity tools. The completion intervals were selected on the basis of these logs.

Final completion of the well was achieved using 4-inch-ID stainless-steel wire-wound well screen (0.020-inch slot size), 4- or 5-inch steel welded riser pipe, and an 8-12 or 10-20 silica sand filter pack from total depth to the top of the Lower Arapahoe Formation water-producing interval. A bentonite pellet seal was placed via tremie pipe on top of the sand-filter pack and the remaining annulus between the final casing, and the 8-inch conductor casing was grouted to the surface. After a minimum of 24 hours curing time, the well was developed by a combination of air lifting and pumping. Each well was disinfected using sodium hypochlorite according to the requirements of the State of Colorado's Engineer's Office.

2.1.2 Water-Level Monitoring and Groundwater Sampling

Water-level monitoring and groundwater quality sampling were performed in 1989 and 1990 during RI Addendum, IRA A, and CMP activities. Samples were collected from all offpost UFS monitoring and domestic wells and 10 Arapahoe Formation wells. Data from these sampling events were combined to create a comprehensive, temporally consistent database to evaluate the nature and extent of contamination in groundwater in the UFS and Arapahoe Formation.

The offpost CMP wells were sampled between October 25 and November 28, 1989, during the annual CMP sampling event. New wells installed during IRA A and RI Addendum activities were sampled during several events between September 1989 and March 1990. Most of the monitoring wells were sampled more than once during the RI Addendum. The domestic-use wells were sampled between January and April 1989. Water levels were measured in monitoring wells during the February 1990 CMP monitoring event. As further discussed in Section 3.0, groundwater-quality data from the Winter 1990-1991 CMP sampling event were also evaluated in this report.

2.1.3 Field Sampling Methodology

Sampling and field documentation procedures used during sampling and water-level measurements are described in the FOP (HLA, 1989b) and are briefly summarized here. Upon arrival at the sampling site, sampling personnel used a photoionization detector (PID) to measure background and casing head space concentrations, and readings were recorded. The aboveground casing height, depth-to-water, and total well depth were measured and recorded. The decision to pump or bail a well was made on the basis of the relative efficiency of either method with respect to the amount of purge water to be removed.

A minimum of five casing volumes of water was removed from each well before sampling. Sample bottles were rinsed with well water before filling. A chain-of-custody form and sample data sheet were completed for each sample and signed by the field team leader. All sample bottles were placed on ice and stored at 4 degrees Celsius (°C) in a sample cooler immediately after filling. All data collected during the groundwater monitoring program were recorded on preprinted field data sheets and in bound field notebooks, as described in the QAP (HLA, 1989c).

Groundwater samples were also collected from private residential wells. These samples were collected from the tap nearest the well. The tap was allowed to flow at the maximum rate for 45 minutes prior to sample collection. The approximate flow rate was measured during purging and was recorded on the field sampling data sheet. Field parameters were monitored during purging as specified in the FOP. The field parameters were also recorded in the field sheets and are used to verify that groundwater quality was stable prior to sampling. The flow rate from the individual taps was reduced during sample collection to reduce agitation of the samples. Sample handling, labeling, and chain-of-custody procedures for residential tap samples are consistent with requirements in the FOP and QAP.

2.1.4 Analytical Program

The analytical program for groundwater conducted during RI Addendum activities is consistent with the analytical program followed during the Final RI. Two additional analytes, caprolactam and bis(2-ethylhexyl)phthalate, were added to the target analyte list for the RI

Addendum. Groundwater samples were analyzed for the volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and inorganic constituents listed in Table 2.4.

Analytical methods and target analyte certified reporting limits (CRLs) for the groundwater analytical program are listed in Table 2.5.

The analytical program included analyses by GC/MS for purposes of confirming GC results and as part of the QA/QC protocol. The analytical program, including the analytical policies and organization, methodologies, and QA/QC procedures and protocol used during RI Addendum activities, is described in the QAP (HLA, 1989c). All analytical activities were performed in accordance with the PMRMA Chemical QAP (CQAP) (PMRMA, 1989).

2.2 SURFACE-WATER MONITORING PROGRAM

This section describes the surface-water sampling conducted during RI Addendum activities. The sampling events, sampling locations and methods, and analytical program used during the RI Addendum are described in this section. Results from surface-water samples collected under the CMP, concurrent with samples collected during the RI Addendum, are addressed in Section 4.0.

2.2.1 Surface-Water Sampling Network and Rationale

Surface-water sampling events were performed during November 1988 and from May to June 1990. Surface-water sampling locations are shown in Figure 2.3. In November 1988, six surface-water samples were collected along First Creek between 96th Avenue and the First Creek Impoundment and directly from the First Creek Impoundment. On the basis of evaluation of these data and surface-water results reported in the Offpost OU RI report, 10 additional surface-water samples were collected, and surface-water flows were estimated from May to June 1990. Samples were collected from May to June 1990 from along First Creek, the O'Brian Canal, Burlington Ditch, and Barr Lake. The sampling events and locations are described below.

Six surface-water samples were collected along First Creek in November 1988. From May to June 1990, surface-water samples were collected from First Creek between the First Creek

Impoundment and O'Brian Canal and from along Burlington Ditch, O'Brian Canal, and Barr Lake (Figure 2.3).

2.2.2 Field Sampling Methodology

The sampling methodology employed during RI Addendum surface-water sample collection was similar to the methodology previously used during the Final RI. Surface-water samples were obtained by integrating samples over the cross-sectional area of the stream. Where the stream was too small to permit integration samples were collected from the center of the channel immediately below the water surface. Stream discharges were estimated at each sampling location at the time of sampling. The specific procedures for surface-water sample collection are outlined in the FOP (HLA, 1989b).

2.2.3 Analytical Program

The analytical program for surface-water analyses conducted during RI Addendum activities is consistent with the analytical program conducted during the Final RI. The analytical program included sampling VOCs, SVOCs, and inorganic constituents. RI Addendum surface-water target analytes were selected on the basis of target analyte lists used during previous RMA investigations. Caprolactam was added to the surface-water target analyte list for the RI Addendum investigation.

The analytical methods and CRLs used for the surface-water analytical program are shown in Table 2.5. The analytical program, including the analytical policies and organization, methodologies, and QA/QC procedures and protocol, used during RI Addendum is described in the QAP (HLA, 1989c). All analytical activities were performed in accordance with the PMRMA CQAP (PMRMA, 1989).

2.3 STREAM-BOTTOM SEDIMENT MONITORING PROGRAM

This section describes the stream-bottom sediment sampling conducted during Offpost OU RI Addendum activities. The sampling events, sampling locations and methodology, and

analytical program are described below. The results of analyses of stream-bottom sediment samples are presented and discussed in Section 5.0.

2.3.1 Stream-Bottom Sediment Sampling Network and Rationale

Stream-bottom sediment samples were collected during November 1988 and from May to June 1990. The stream-bottom sediment sampling locations for the November 1988 and May to June 1990 sampling events are shown in Figure 2.4. The November 1988 sampling event included five sampling locations along the First Creek channel and near-channel areas between 96th Avenue and the First Creek Impoundment. Stream-bottom sediment samples were collocated with surface-water samples.

On the basis of evaluation of November 1988 analytical data and stream-bottom sediment results reported in the Offpost OU RI, a second sediment sampling event was performed from May to June 1990. Eleven samples were collected from locations along First Creek, the O'Brian Canal, Burlington Ditch, and in Barr Lake.

2.3.2 Field Sampling Methodology

The sample collection methodology that was followed during the RI Addendum investigation was consistent with the methodology previously followed during the Final RI. Stream-bottom sediment samples were collected with a stainless-steel trowel from the stream or pond bottom. The material collected was placed in widemouthed glass jars and was stored on ice in insulated coolers. The specific procedures followed for stream-bottom sediment sampling are described in the FOP (HLA, 1989b).

2.3.3 Analytical Program

The analytical program for sediment analyses conducted during RI Addendum activities is consistent with the analytical program conducted during the Final RI. Sediment samples were analyzed for organochlorine pesticides, organosulfur compounds, DBCP, DIMP, inductively coupled argon plasma (ICAP) spectrometry metals, arsenic, and mercury. RI Addendum sediment target analytes were selected on the basis of target analyte lists used during previous RMA

investigations including the Final RI. The target analytes for sediment are listed in Table 2.4. The analytical methods and CRLs used for the sediment analytical program are listed in Table 2.5. The analytical program, including analytical policies and organization, methodologies, and QA/QC protocol and procedures used during the RI Addendum, are described in the QAP (HLA, 1989c). All analytical activities were performed in accordance with the PMRMA CQAP (PMRMA, 1989).

2.4 SOIL MONITORING PROGRAM

This section describes soil sampling conducted during the RI Addendum investigation. The sampling events, sampling locations, methodology, and the analytical program used during the Offpost OU RI Addendum soil monitoring program are described below. The results of analyses of soil samples are presented and discussed in Section 6.0.

2.4.1 Surficial and Subsurface Soil Monitoring Network and Rationale

The soil monitoring program was designed to assess the nature and extent of contamination in offpost soil. Soil monitoring and assessment were not included in the Final RI, but they were added to the RI Addendum investigation to provide data on the nature and extent of contamination in soil.

Soil samples were collected during several sampling events. In February 1989, surficial and subsurface soil samples were collected from residential properties in the 96th Avenue residential area north of the RMA boundary, as shown in Figure 2.5. On the basis of evaluation of the data from February 1989 and onpost surficial soil data collected by Ebasco and Morrison-Knudsen Engineers, Inc. (MKE), from September to October 1989, additional sampling was conducted from June and July 1990. Locations of soil samples collected from the Offpost OU during this period are shown in Figure 2.6. In July 1990, background surficial soil samples were collected from an area near Brighton, Colorado. The locations of these background samples are shown in Figure 2.7.

After the analytical data were received from the laboratories for the sampling events noted above, an additional sampling event was conducted. The purpose of this final sampling event was to address anomalously high concentrations of selected target analytes. The samples were collected

in May 1991 by Woodward-Clyde Federal Services (WCFS). The locations of these samples are shown in Figure 2.6.

Soil sampling conducted in February 1989 included six subsurface soil samples collected from four locations and an additional 11 surficial soil samples, as shown in Figure 2.5. Samples were located along the southern boundary of Sections 13 and 14 outside of the suspected First Creek floodplain and irrigated areas to assess potential soil contamination from windblown transport mechanisms.

Samples were collected from the 0- to 1-foot interval at two locations (HA0986SO and HA0988SO) near the current First Creek drainage course. Samples from the 0- to 1-foot and 4- to 5-foot intervals were collected in two locations. Samples HA0985SO and HA0985SO45, collected from the 0- to 1-foot and 4- to 5-foot intervals, respectively, were collected outside of the current drainage course but within the suspected floodplain north of First Creek in Section 13. Water was encountered at a depth of 4.5 feet in this boring within the suspected floodplain. Samples HA0987SO and HA0987SO50, collected from the 0- to 1-foot and 4- to 5-foot intervals, respectively, were collected outside the suspected floodplain north of First Creek in Section 14.

CDH collected 12 surficial soil samples from locations north of RMA in February 1989. Eight of these samples were collected near the locations where HLA collected samples in February 1989. As shown in Figure 2.5, four collocated samples were also collected by CDH at sampling locations HA0989WB, HA0990WB, HA0993WB, and HA0997WB. A duplicate sample, HA0995WB, was collected at sampling location HA0994WB.

Surficial soil sampling conducted by HLA from June to July 1990 included samples from an additional 43 locations in the Offpost OU. The sampling locations are shown in Figure 2.6. The 43 samples were collected to further assess soil contamination by windblown mechanisms. The sampling locations were selected on the basis of the February 1989 offpost soil sample results for samples collected by HLA and CDH and an assessment of the onpost surficial soil results for samples collected by MKE and Ebasco, as previously described. The onpost data were evaluated regarding the prevailing and high-event wind patterns (RLSA, 1990c and ESE, 1988b) to estimate

the approximate distance and direction of windblown transport of soil and, potentially, of contamination. The surficial soil sampling grid represents the estimated maximum areal extent of potential windblown soil. Surficial soil samples were collected from 43 approximately uniformly distributed sampling locations. As depicted in Figure 2.6, six duplicate samples were collected.

The May 1991 sampling event conducted by WCFS consisted of collecting 17 surficial soil samples. This sampling episode had two major objectives. The first objective was to provide additional data about the lateral distribution of organic compounds north of the existing sample locations. A second objective was to provide data to confirm the anomalously high analytical results for two samples.

Background soil samples were collected from an area northeast of Brighton, Colorado, which was selected on the basis of comments from CDH about this area's appropriateness as a background area for the CDH Pilot Exposure Study. Four samples and one duplicate sample were collected from this background area (Figure 2.7).

The Army selected surficial soil sampling locations on the basis of review of surficial soil analytical data in the RMA database and other data available from CDH. The sample locations identified by the Army were selected to provide adequate data to permit assessment of the extent of contamination in surficial soil in the Offpost OU. The sampling locations covered an area of approximately 18 square miles. The locations were also selected on the basis of anticipated distribution of contaminants associated with windblown transport from RMA sources and from farmland irrigation in selected areas in the Offpost OU.

2.4.2 Field Sampling Methodology

Soil sampling was divided into surficial and subsurface soil samples on the basis of the depth of sample collection. Surficial soil samples were collected by the Army from a composite of the top 2 inches of soil from six equally spaced locations along the circumference of a 30-foot-diameter circle. Subsurface soil samples were collected from the 0- to 1-foot interval and the 4- to 5-foot interval using an 18-inch split-barrel sampler lined with 2-1/2-inch-diameter polybuterate tubes. The specific procedures for soil sample collection are provided in the FOP

(HLA, 1989b). Based on the CDH proposed surficial soil sampling plan (CDH, 1990), surficial soil samples collected by CDH were apparently collected using procedures similar to those used by the Army.

2.4.3 Analytical Program

Subsurface soil samples were analyzed for VOCs, SVOCs, and trace metals. Surficial soil samples were analyzed for arsenic, mercury, OCPs, and selected SVOCs, DBCP, and dimethyldisulfide (DMDS) as listed in Table 2.4. A percentage of the samples were also analyzed for ICP metals. Analytical methods and CRLs used for the soil analytical program are listed in Table 2.5. The analytical program, including analytical policies and organization, methodologies, and QA/QC protocol and procedures, is described in the QAP (HLA, 1989c). All analytical activities were performed in accordance with the PMRMA CQAP (PMRMA, 1989).

2.5 BIOTA MONITORING PROGRAM

The offpost biota monitoring program was designed to collect sufficient data to assess the nature and extent of contamination of the biotic community offpost. The Offpost OU for the Biota Monitoring Program is bound by 96th Avenue on the south, Colorado State Highway 2 on the west, 108th Avenue on the north, and Potomac Street on the east. This portion of the Offpost OU was chosen for study (1) because of its potential for contamination of biota, (2) because of its proximity to RMA sources, and (3) because of the sizes of the home range of wildlife known to exist in the RMA and Offpost OU. The Offpost OU for biota was designed to phase biological sampling locations, with some locations very close to RMA, some locations at intermediate distances, and a few sampling locations near the study area's perimeter. The goals of the Biota Monitoring Program for the RI Addendum follow:

- Select target analytes for offpost biota
- Characterize the terrestrial and aquatic ecosystems of the Offpost OU and select species to sample for contaminant analysis
- Describe the varieties and concentrations of target analytes in offpost biological samples

These objectives were presented as described in the Work Plan (HLA, 1989a) and were discussed with the OAS before finalizing the sampling program. The methods of study used to fulfill the objectives of the Biota Monitoring Program are presented in this section. The results of these investigations are presented in Section 7.0, Biota Monitoring Results and Assessment.

2.5.1 Criteria for Target Analyte Selection and Biota Sampling Rationale

Target analytes for biota were selected in a process described in the Final Biota RI (ESE, 1989b). The selected analytes are a subset of the chemicals known to occur in the RMA onpost and offpost environment. The target analytes were rated as at least moderately toxic, with volumes and persistence indicating that the chemical was present in the environment in sufficient quantity and for a long enough time to pose a potential hazard to biota. The target analytes for the Offpost OU RI Addendum are consistent with those from the Final Biota RI. The selected target analytes for biota were aldrin, arsenic, dieldrin, endrin, mercury, DDE, and DDT, as shown in Table 2.4.

A list of species to be analyzed for the target analytes was developed, in part using a food chain pathways approach; species were representative of several trophic levels that were likely to come in contact with contaminated media, which predominantly included soil and surface water. Species were also selected on the basis of their having been previously studied as a component of the Biota RI and CMP. To the extent practicable, biota sample locations were collocated with soil and water sampling locations to provide an integrated sampling approach. Finally, an ecological characterization provided additional information that was used in selecting offpost species for sampling and analyses.

2.5.2 Field Sampling Methodology for Ecological Characterization

The offpost biota sampling was conducted following an ecological characterization of terrestrial and aquatic environments. The results of the ecological characterization provided additional information used to select offpost species for sample collection and analyses. The following subsections describe the methods of investigation for ecological characterization of the

Offpost OU. The methods employed were designed to yield qualitative and quantitative data on the ecological condition of the Offpost OU.

2.5.2.1 Methods for Ecological Characterization of Aquatic Systems in the Offpost OU

The objectives of ecological characterization of aquatic and wetland portions of the Offpost OU follow:

- Describe the species and distribution of submergent and emergent vegetation
- Document and estimate relative abundance of vertebrates and invertebrates present in aquatic and adjacent wetland areas
- Record data on surface-water quality, depth, degree of disturbance, use by cattle, and any observed effects potentially attributable to RMA contamination

Studies of First Creek were performed during aquatic and terrestrial sample collection. Field reconnaissance of First Creek, from the RMA boundary to Highway 2, was conducted on December 1, 1989. Characterization of the ecology of the First Creek Impoundment was performed concurrently with sample collection on September 22 and October 27, 1989. Vegetation, invertebrate, and vertebrate species were identified in the field; voucher specimens were collected; relative abundance was recorded; and water quality data were gathered. Biota specimens were preserved by freezing, and were identified by genus and species when possible.

2.5.2.2 Methods for Ecological Characterization of the Terrestrial System in the Offpost OU

The objectives of the ecological characterization of the terrestrial systems in the Offpost OU follow:

- Describe the species and distribution of terrestrial vegetation
- Categorize vegetation into distinct habitats
- Document and estimate the potential occurrence of vertebrate and invertebrate species on the basis of available habitat
- Assess human disturbance of the area and any observed effects potentially attributable to RMA contamination

The ecological characterization of terrestrial systems consisted of literature and available data review and limited field studies. The habitat map in Figure 2.8 was constructed for the

Offpost OU using geobotanical methods consistent with the Biota RI (ESE, 1989b). The map was drawn from aerial photographs and delineated areas of aquatic and terrestrial habitat including wetlands, riparian woodland, grassland, fence rows, weedy areas, and other habitats of biological significance.

Field visits were made to the area on September 7 and October 27, 1989; to confirm the validity of the habitat map, record any changes in land use or condition, and note dominant vegetation in each habitat. Wildlife observations were performed during these visits, and wildlife location and habitat were recorded. Dominant plant species in each habitat type were recorded, and voucher specimens were collected and later keyed to genus and species according to Weber (1976) and Harrington (1964). Human land uses (e.g., residential) and areas of disturbance (e.g., plowed fields, trash dumps) were also indicated. Additional verification procedures and wildlife observations were performed during the sample collection periods described below. An inventory of terrestrial vertebrate species and important invertebrate groups was prepared for the Offpost OU.

2.5.3 Methods of Sample Collection for Contaminant Analyses

Samples for contaminant analyses were collected in the fall of 1988 and 1989. Sample locations for aquatic, agricultural, and terrestrial biota are presented in Figure 2.9. All samples collected are summarized in Table 2.6. The methods below were implemented to assess the nature and extent of contamination in biota offpost.

2.5.3.1 Aquatic Sampling Methodology

Samples of aquatic biota were obtained from the First Creek Impoundment. Fish samples were collected by seine, gill net, and hand net. Aquatic plants were collected by hand, while aquatic invertebrates were collected in a dip net or by hand.

Aquatic sampling for larger organisms using 3-meter (m) seine nets was performed on September 22, 1989. The seine extended from bank to bank and was held by a biologist on each bank. The seine was pulled through the pond to a shallow area where samples were collected.

Several passes were often required to obtain an adequate sample. The First Creek Impoundment was seined in two distinct sections. One section consisted of approximately 20 m at the north end of the pond, and the other section consisted of approximately 50 m at the extreme south end of the pond extending from the inlet to the south bank. In an effort to ensure collection of large fish (if present), further sampling using two 15 m gill nets was performed on October 27, 1989. Gill nets were set concurrently at the north and south ends of the pond. Nets were checked after one hour, reset and checked again after three hours. No large fish were observed or collected from the First Creek Impoundment.

Samples were prepared and preserved according to procedures established by the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), including homogenization of samples with dry ice and storage in cryogenic freezers. Samples were stored in freezers in the ESE laboratory in Denver for subsequent analyses. Voucher specimens were collected and analyzed by ESE personnel. Plant species were identified using Weber (1976) and Harrington (1964), while invertebrate and fish species were identified according to Needham and Needham (1977). Aquatic samples collected are listed in Table 2.6.

2.5.3.2 Terrestrial Biota Sampling Methodology

Pheasant roosters and hens (Phasianus colchicus) were collected between November 29, 1989, and January 23, 1990, roughly corresponding to open pheasant season in Colorado, by hunting with shotguns loaded with steel shot. Two to six collectors equipped with shotguns traversed all available pheasant habitat in the Offpost OU and a section of Second Creek just north of the study area. When pheasants were flushed from cover by dogs, they were shot and collected following all applicable laws regulating pheasant hunting in Colorado.

Earthworms (Apporectodea sp.) were collected from September 11 to 13, 1989, by excavating the first 25 centimeters (cm) of top soil and collecting all worms present. Samples consisted of between three and five composite samples collected within a 10 m radius of a known soil or groundwater sample location or easily identifiable landmark.

Grasshoppers (mostly Melanoplus sanguinipes) were collected from September 7 to 13, 1989, by sweep netting in all available grasshopper habitat within a 100 m radius of known soil or water sample locations or easily identifiable landmarks. Grasshopper and worm samples were collected from the same locations when possible.

Small mammal samples consisted of deer mice (Peromyscus maniculatus) and prairie dogs (Cynomys ludovicianus). Deer mice were collected between September 23 and October 30, 1989. Live traps were baited and placed in probable deer mouse habitat at earthworm and/or grasshopper sampling locations. Traps were checked daily until a composite sample consisting of two deer mice of the same sex was collected from each location. Two locations did not provide adequate deer mouse habitat, and house mice (Mus musculus) were substituted (These two samples were not subsequently analyzed.). Nontarget species caught in live traps were released. Small mammals were identified to genus and species according to Burt and Grossenheider (1976) and Hall (1981).

Three distinct prairie dog towns exist within the Offpost OU (Figure 2.8), and prairie dogs were collected from each town. Prairie dogs were trapped using live traps, and samples were collocated with soil or water samples to the maximum extent practicable. In the vicinity of the First Creek Impoundment, cattle consistently disturbed live traps, and prairie dogs were collected from this area by shooting them with a .22 rifle. Nontarget species caught in live traps were released.

All samples were collected under Scientific Collecting License Nos. 89-0298 and 90-0298 issued by the Colorado Division of Wildlife (CDOW). All biota samples were prepared and preserved according to procedures established by USATHAMA and were stored in freezers in the ESE laboratory in Denver for subsequent analyses.

The number and species of terrestrial samples collected are listed in Table 2.6.

2.5.3.3 Agricultural Sample Collection

Samples were taken from cow (Bos bovis) and chicken (Gallus domesticus) tissues. These samples were taken from a farm located immediately north of 96th Avenue, as shown in

Figure 2.9. These samples were analyzed in a manner similar to the wildlife samples and were collected to assess the possible contamination of domestic animals. Concerns were raised by the OAS and local residents about possible dibromochloropropane (DBCP) contamination of cattle, which led to collecting milk samples at the farm. These samples were only analyzed for DBCP because no other certified methods were available for this matrix.

2.5.4 Analytical Program for Biological Samples

Three analytical protocols were used for the analysis of biological samples: Graphite Furnace Atomic Adsorption (Methods B-6-A & B-6-P), Cold Vapor Atomic Adsorption (C-6-A & C-6-P), and Gas Chromatography (Methods M-6 & QH-01). A summary of methods used to analyze biota samples is presented in Tables 2.5 and 2.7.

Because of insufficient sample size for one sample of earthworms (HA1246B) collected on September 11, 1989, a dilution factor for this sample was calculated by taking the usual sample size (8.00 grams) and dividing this value by the actual sample size (6.24 grams) to generate a dilution factor of 1.27. This dilution factor was reported in the PMRMA database for this sample and resulted in slightly elevated detection limits.

3.0 GROUNDWATER MONITORING RESULTS AND ASSESSMENT

This section presents a discussion of hydrogeologic and groundwater quality data developed under the RI Addendum program for the Offpost OU. The principal purpose of this section is to present (1) the current understanding of the hydrogeologic system and (2) the nature and extent of groundwater contamination in the UFS offpost.

This section is organized to first present a brief overview of interpretations contained in the Final RI (ESE, 1988a). Refinements made to interpretations contained in the Final RI report are then presented and discussed. Following this overview is a discussion of new water-level data and an interpretation of groundwater gradients and flow directions. The major focus of this section is the refinement of the nature and extent of unconfined groundwater contamination. Figures show the extent of contamination in the UFS and are compared to previous interpretations. Data used in this assessment are contained in Appendixes A and B.

3.1 GEOLOGY AND HYDROGEOLOGY

The Final RI contained detailed discussions and interpretations of the geology and hydrogeology of the Offpost OU, and this section presents a general overview of the geologic and hydrogeologic setting offpost. This section provides the reader with a general understanding of the physical setting for interpretation of contaminant distribution in offpost groundwater. Because most of the information presented here is based on data contained in the Final RI report, appropriate sections of that report are referenced.

Sediments at the land surface in the Offpost OU consist of unconsolidated alluvial and eolian deposits of Pleistocene and Holocene age. The composition of the unconsolidated sediments varies from clays to coarse gravels, and the thickness varies from less than 10 feet to approximately 100 feet. The thickest deposits of unconsolidated sediments occur in paleochannels eroded into the underlying Denver Formation.

The Denver Formation is of late Cretaceous to early Tertiary age, and consists of 250 to 300 feet of interbedded clayshale, claystone, siltstone, and sandstone with a regional dip of one-

half to one degree to the southeast. The uppermost bedrock unit was subjected to erosion before deposition of the overlying unconsolidated units. Paleochannels incised into the bedrock surface are present in many areas offpost and generally contain the greatest thicknesses of unconsolidated sediments.

The presence of paleochannels in the Denver Formation surface has a significant impact on the fate and direction of groundwater flow in the UFS. Two such major paleochannels, the First Creek and Northern Paleochannels, are present north of the North Boundary Containment System (NBCS). An additional paleochannel, the Northwest Paleochannel, is present west of the Northwest Boundary Containment System (NWBCS). Coarse, unconsolidated materials commonly found within these paleochannels provide the pathway for preferential groundwater movement in the UFS. Groundwater contaminant plumes that have historically flowed across the RMA boundaries to the Offpost OU are generally confined to these paleochannels.

The Arapahoe Formation lies conformably beneath the Denver Formation at depths of 230 to 300 feet at the RMA north boundary and has a regional dip of one-half to one degree to the southeast. The Arapahoe Formation consists of 350 to 650 feet of interbedded conglomerate, sandstone, siltstone, and shale. The upper portion consists predominantly of blue to gray shale that ranges in thickness from approximately 100 to 200 feet, while the lower portion consists largely of sandstones and conglomerate. This lower portion is a completion interval for many water-supply wells in the area.

3.1.1 Geology

The geology of the Offpost OU consists of unconsolidated surficial deposits underlain by consolidated units of the Denver and Arapahoe Formations. Alluvial deposits form much of the ground surface in the Offpost OU. At some locations, generally northwest of Burlington Ditch, Denver Formation units crop out at the ground surface. The Arapahoe Formation is the oldest geologic unit present beneath the site that was investigated in the offpost RI programs. The Arapahoe Formation is not present at the ground surface anywhere in the Offpost OU.

3.1.2 Hydrogeology

The hydrogeology of the Offpost OU was described in detail in the Final RI. Additionally, the Final RI also discussed the interactions between the various aquifers present in the area and presented an assessment of the boundary containment systems' effect on the rate of contaminant migration from the Onpost OU.

The principal water-bearing units of interest in the Offpost OU are the unconsolidated, unconfined alluvial deposits, the Denver Formation, and the Arapahoe Formation. The hydrogeologic properties of these units, including hydraulic conductivity and groundwater flow velocities, are distinctly different. Hydraulically, these units generally behave as distinct hydrostratigraphic units, except for some areas of the uppermost weathered Denver Formation that are both unconfined and saturated. The Arapahoe Formation is confined at all locations investigated in the RI Addendum.

The hydrogeology of the Offpost OU consists of a UFS overlying a confined flow system (CFS). The UFS includes groundwater present in the unconsolidated alluvial materials overlying the Denver Formation and the weathered upper portion of the Denver Formation. The CFS includes the deeper portions of the Denver Formation. A detailed discussion of hydrogeologic conditions in the Denver Formation is given in the Final RI report and generally will not be further developed in this report. Conditions in the Arapahoe Formation will be briefly discussed below.

3.1.3 Groundwater Flow

The following sections present water-level information for the UFS and the Arapahoe Formation. From an evaluation of the distribution of contaminant plumes in the Offpost OU, the UFS is considered the principal migration route for groundwater contaminants from the Onpost OU to the Offpost OUs. Thus, the discussions of the potentiometric data and groundwater flow directions presented below are largely focused on the UFS, with some additional brief discussions of the conditions in the Arapahoe Formation.

3.1.3.1 Unconfined Flow System

Water-level data for the UFS were collected from all offpost monitoring wells during several separate monitoring events and for different programs. Water levels were measured several times between December 1989 and June 1990 in all wells installed under the Offpost OU RI Addendum program. Wells installed north of RMA in the First Creek and Northern Paleochannels in support of the offpost IRA A program also were monitored several times between September 1989 and June 1990. Water levels in the remaining offpost wells, which are monitored routinely as part of the offpost CMP, were measured in February 1990. Considering all of these sources of information, the most comprehensive set of water-level data was from the period of February 12 to 14, 1990. Table 3.1 presents the water-level information used to construct the potentiometric surface map for the UFS, as discussed below.

Figure 3.1 shows the potentiometric surface for the UFS on the basis of the February 1990 data set, as described above. The UFS potentiometric surface slopes predominantly toward the northwest, indicating groundwater flow in that direction, which is consistent with the interpretation that the South Platte River is a regional discharge point for the groundwater system in the Offpost OU. Hydraulic gradients in the Offpost OU range from 0.003 to 0.020 foot per foot (ft/ft) and average approximately 0.004 to 0.005 ft/ft. The hydraulic gradients are highest in the area immediately downgradient of the NBCS and in the vicinity of O'Brian Canal and Burlington Ditch. The observed hydraulic gradients are consistent with those observed in the Final RI report.

The level of the potentiometric surface is basically unchanged from that presented in the Final RI report, although water levels in a few areas have changed. In the area downgradient of the western portion of the NBCS, the water level is approximately 5 feet higher than presented in the Final RI report. This difference is interpreted to be a result of increased groundwater recharge using the recharge trenches. In the First Creek Paleochannel, increased control from wells installed under the IRA A program has resulted in a refinement in the potentiometric surface in that area. Water levels are slightly higher immediately downgradient of the NWBCS than those presented in the Final RI report. These changes are considered to be the result of

seasonal fluctuation in water levels and changes in recharge-well flow rates at the northeastern end of the NWBCS (Shell, 1992).

The nature of the paleochannels north of RMA is considered an important component to understanding the migration routes of contaminants offpost. Additional hydrogeologic data collected during the installation of numerous test borings, monitoring wells, and piezometers under the RI Addendum and IRA A programs were evaluated to refine the understanding of the geometry of the paleochannels in this area. On the basis of these evaluations, the extent of unsaturated alluvium depicted on Figure 3.1 has been modified from that presented in the Final RI report.

The area covered by the IRA A program includes offpost Sections 11, 12, 13, and 14. In this area, the major pathway generally follows the course of the creek; minor flow pathways located adjacent to the First Creek Paleochannel were also delineated on the basis of new geologic and potentiometric information.

The understanding of the geometry of the Northern Paleochannel was also refined, particularly on its eastern and western boundaries. The location of the western boundary of the Northern Paleochannel has been reinterpreted slightly farther west than that presented in the Final RI. The potentiometric surface in the Northern Paleochannel has remained largely unchanged in relation to previous interpretations.

3.1.3.2 Arapahoe Formation

Water-level data were collected from three Arapahoe Formation wells installed under the RI Addendum program. The locations of these wells are shown on Figure 2.2. Water levels were measured at the time of installation. The wells installed in the Arapahoe Formation and their associated water levels follow:

<u>Well</u>	<u>Installation Date</u>	<u>Water Level (below ground surface [bgs]) (feet)</u>	<u>Water Elevation (feet)</u>
37431	09/12/89	134	4987.9
37445	08/28/90	179	4898 (est.)
37446	10/09/90	188	4876 (est.)

Because these potentiometric surface elevations are above the top of the formation, the Arapahoe Formation is a confined aquifer in these areas. Although groundwater withdrawals from the Arapahoe have locally lowered the potentiometric surface, the information from these new wells is consistent with the regional water-level conditions in the Arapahoe Formation. Data from these three wells do not permit a definitive assessment of the flow directions in the Arapahoe Formation. However, the data from these three wells are consistent with the northerly to northwesterly regional groundwater flow direction, as presented in the Final RI report.

3.2 WATER QUALITY DATA

This section presents and discusses the results of groundwater quality sampling and analyses. The principal focus of this section is the distribution of contaminants in UFS groundwater. The distribution of contaminants in samples from Arapahoe Formation wells is also presented and discussed.

Data and interpretations presented in the following sections are from groundwater samples collected from all offpost UFS monitoring wells and three Arapahoe wells. Several sampling events were used to develop a groundwater quality database sufficient for interpreting the distributions of contaminants in the Offpost OU. As previously noted in Section 2.1 and shown in Table 2.3, 14 new UFS monitoring wells were installed during the RI Addendum program. Two samples were collected from each of these wells as shown in Table 2.1. Samples from these wells were analyzed for the compounds presented in Table 2.4. In addition, 14 other offpost UFS monitoring wells were installed immediately north of RMA in support of the IRA A program. These wells were primarily installed in the First Creek and Northern Paleochannels. Samples were collected from these wells in the fall of 1989 under the IRA A program.

Three Arapahoe Formation monitoring wells installed under the RI Addendum program were analyzed for the compounds shown in Table 2.4. In addition, samples from 23 alluvial or Arapahoe Formation wells were collected and analyzed for the target analytes listed in Table 2.4.

Wells not installed during the RI Addendum or IRA A programs were sampled in the offpost CMP program. These wells were sampled in the fall of 1989, as shown in Table 2.1. The analyses performed on the samples collected under the CMP include the target analytes for the RI Addendum program. The analytical results for analysis performed under the CMP are available in the RMA database.

Distribution maps for selected compounds detected in the UFS wells are presented and discussed in the following sections. Distribution maps for the Arapahoe Formation were not necessary because detectable levels of organic compounds were only sporadically found in Arapahoe Formation wells. These sporadic occurrences appear to represent false positives or localized effects, possibly due to well construction problems, and are not considered representative of Arapahoe Formation groundwater contamination.

Data developed under the CMP, the RI Addendum, and IRA A programs have undergone a rigorous QA/QC review consistent with PMRMA CQAP (PMRMA, 1989). Those data that passed QA/QC review have been accepted in the PMRMA database. Data collected during the RI Addendum activities that did not pass the QA/QC review are flagged in the attached appendixes.

Analytical data used in generating plume maps of the UFS include (1) monitoring wells and domestic wells sampled under the RI Addendum and IRA A programs and (2) CMP data collected during the fall of 1989 and winter of 1990-1991 sampling rounds. RI Addendum analytical data and fall of 1989 CMP data were combined to provide a comprehensive database that was used to contour the plume maps shown in Figures 3.2 through 3.13.

More recent data collected during the winter of 1990-1991 CMP Sampling Round was, in general, used to verify previous CMP and RI Addendum results. The verification consisted of qualitatively comparing the more recent Winter 1990-1991 CMP data with historical data, including data collected during RI Addendum activities. This qualitative comparison permitted an

assessment of the current data relative to the historical range of concentration for contaminants in the Offpost OU wells. The actual winter of 1990-1991 CMP data results were, however, used for plume map generation for those recently installed RI Addendum wells where data did not pass QA/QC assessments.

No wells were sampled under both the RIFS1 Offpost program and the fall of 1989 CMP. However, multiple rounds of data were collected at wells 37429 through 37444 and at several domestic wells sampled during the RI Addendum program. When two or more results were present in the database for a given well, the numerical average of the results was used for contouring provided that at least one result was above the CRL for the compound being contoured. The purpose of averaging the data was to provide equal weight to available data for these newly installed wells.

In a few instances, fall of 1989 CMP analytical results were highly anomalous when compared to historical CMP results and to subsequent winter of 1990-1991 CMP results at a given monitoring well. In these instances, an approximate average result was used for plume map contouring taking into consideration the historical and subsequent CMP data. Data recognized as anomalous were not used in contouring.

In a few instances, fall of 1989 CMP analytical results were either missing, rejected, or not collected for a monitoring well within the Offpost OU that had been previously and/or subsequently sampled under the CMP. In these instances, historical and subsequent CMP data collected at the monitoring well in question were evaluated and qualitatively assessed while preparing the plume maps in this report.

QA/QC sample results including sample duplicates and GC/MS conformational samples collected under the RI Addendum and CMP programs were used in a qualitative manner to assess investigative GC results. QA/QC sample results were not, however, averaged with investigative results nor were they used to determine analyte concentrations for plume map contouring.

3.2.1 Nature and Extent of Unconfined Flow System Contamination

This section presents interpretations of the organic and inorganic analytes detected in groundwater samples collected from wells in the UFS. Contaminant distribution maps for nine organic and three inorganic analytes have been prepared and are discussed. These 12 contaminants represent the target analytes detected consistently and are considered the most widespread of the analytes for which analyses were performed.

The distribution maps and general descriptions presented in this section are contrasted with the results and interpretations contained in the Final RI report. Significant changes in the distribution of contaminants in the UFS are noted. Because some improvements have been made to the analytical methods certified by PMRMA, CRLs have been lowered for some target analytes. In some cases, use of lower CRLs has resulted in an apparent increase in the distribution of selected analytes. Where a change in the CRL has contributed to an apparent significant increase in the distribution of a particular contaminant, a brief discussion of the influence of this change is presented.

Background concentrations for inorganic compounds were evaluated in the Final RI report, Table 3.3-3 (ESE, 1988a). Because recent sampling of the wells listed in that table indicate no substantial changes in inorganic concentrations in those wells, background concentrations were not revised on the basis of data presented in this report. The background values contained in the Final RI report are considered representative of current site conditions.

3.2.1.1 Unconfined Flow System Organics

The distributions of organic analytes in UFS groundwater are discussed in the following sections. Distributions for the most widespread contaminants are shown on plume maps. The distributions of other contaminants with limited extent or sporadic detections in groundwater samples are described in the following text. The nature and extent of contamination presented below is compared to the interpretations presented in the Final RI report and the Final CMP report for fiscal year (FY) 1990 (RLSA, 1991a).

3.2.1.1.1 Semivolatile Organic Compounds

The four semivolatile contaminants, (1) diisopropylmethylphosphonate (DIMP), (2) dicyclopentadiene (DCPD), (3) dieldrin, and (4) endrin, represent the most widespread and consistently detected of the semivolatile compounds for which analyses were performed. Plume maps for these compounds are presented in Figures 3.2 through 3.5. An additional 10 semivolatile compounds are also discussed, but, because of their relatively limited distributions, the data are not presented in figures.

Diisopropylmethylphosphonate

The most widespread organic contaminant detected in the Offpost OU is DIMP. In the Final RI report, DIMP was interpreted as occurring in two elongated plumes emanating from the RMA north boundary and following the First Creek and Northern Paleochannels. The DIMP plume along the Northern Paleochannel was not shown to extend past O'Brian Canal, while the DIMP plume along the First Creek Paleochannel extended nearly to the South Platte River. The maximum concentration reported was 5390 micrograms per liter ($\mu\text{g/l}$) at well 37396 in the First Creek Paleochannel. The maximum concentration in the Northern Paleochannel was reported as greater than 2030 $\mu\text{g/l}$ at well 37391.

The distribution of DIMP based on data collected during RI Addendum activities is shown in Figure 3.2. As Figure 3.2 illustrates, DIMP is distributed in a continuous plume extending from the RMA north and northwest boundaries to the South Platte River. Samples from 89 monitoring wells were analyzed for DIMP. Of these 89 samples, DIMP was reported in 71 samples. Domestic well data were also used to characterize the plume. DIMP was found in 14 of 16 domestic wells sampled. The highest observed level was 5800 $\mu\text{g/l}$ in monitoring well 37418 located in the First Creek Paleochannel. This well is within about 200 feet of well 37396, which had the highest level of DIMP for the Offpost OU reported in the Final RI report. In the Northern Paleochannel, the highest level of DIMP detected in samples from the RI Addendum program was 830 $\mu\text{g/l}$ found in well 37409. The maximum concentration of DIMP in wells sampled under the CMP and reported in this report was 860 $\mu\text{g/l}$ reported in well 37391.

Concentrations of DIMP in the Northwestern Paleochannel are considerably lower than the levels reported north of the RMA northern boundary. Concentrations in the Northwestern Paleochannel are generally below 10 $\mu\text{g/l}$. The maximum concentration of DIMP in the Northwestern Paleochannel is about 80 $\mu\text{g/l}$ in a domestic-use well located approximately 2 miles northwest of the RMA boundary.

The shape and extent of the DIMP plume presented in this report is considerably different from that presented in the Final RI report. However, the principal reason for the observed changes is a considerably lower CRL used in this report. For the Final RI, the CRL for DIMP was 11 $\mu\text{g/l}$. For this report, the CRL is 0.392 $\mu\text{g/l}$, representing a CRL lower by a factor of nearly 30 from that used in the Final RI. However, considerable decreases in the concentration of DIMP has occurred over the past several years, as described in the CMP report for FY 1990. Maximum concentrations of DIMP have decreased from over 10,000 $\mu\text{g/l}$ in 1980 to a maximum of 5800 $\mu\text{g/l}$ in a sample collected from well 37418, located in the First Creek Paleochannel. Additionally, decreases in concentrations along 96th Avenue appear to be related to operation of the NBCS.

Dicyclopentadiene

DCPD was reported in the Final RI report only in samples collected from wells located in the First Creek Paleochannel. The maximum concentration of DCPD reported in the Final RI was 539 $\mu\text{g/l}$ in well 37309. The distribution of DCPD, on the basis of data collected during RI Addendum activities, is shown in Figure 3.3. The maximum concentrations of DCPD were detected in samples collected from wells located in the First Creek Paleochannel including 560 $\mu\text{g/l}$ in well 37420 and 596 $\mu\text{g/l}$ in well 37309. DCPD was also detected in samples collected from wells located in the Northern Paleochannel. The highest DCPD concentrations in the Northern Paleochannel was approximately 15 $\mu\text{g/l}$ in both well 37344 and well 37409.

Overall, the distribution and range of concentrations for DCPD reported in this RI Addendum are similar to those reported in the Final RI. DCPD is generally confined to a plume located along the First Creek Paleochannel with concentrations up to 600 $\mu\text{g/l}$.

Dieldrin

Dieldrin was reported in the Final RI in samples collected in the vicinity of the northern and northwestern RMA boundaries. The maximum concentration of dieldrin reported in the Final RI was 1.62 $\mu\text{g/l}$ in well 37312 located in the First Creek Paleochannel. The maximum concentration of dieldrin reported in the Final RI for well 37338 was 0.108 $\mu\text{g/l}$. As shown in the monitoring well location map, Figure 2.1, these wells are located immediately north of the RMA northern boundary and approximately 500 feet north of the NBCS. The Final RI also reported dieldrin offpost of the RMA northwestern boundary, with a maximum concentration of 1.02 $\mu\text{g/l}$ in well 37332.

The distribution of dieldrin, on the basis of data collected during RI Addendum activities, is shown in Figure 3.4, which also shows that dieldrin occurs offpost of the northern and northwestern RMA boundaries, consistent with the distribution shown in the Final RI. The highest concentrations of dieldrin are found in wells located in the First Creek Paleochannel. The highest concentrations of dieldrin were detected in wells 37308, 37369, 37373, and 37420. These four wells are located along the interpreted axis of the First Creek Paleochannel. Concentrations of dieldrin in these four wells are generally 5 to 10 times higher than concentrations found in other offpost wells. The maximum concentration of dieldrin (0.891 $\mu\text{g/l}$) was detected in samples collected from well 37420.

A dieldrin plume is also interpreted along the Northern Paleochannel. The interpreted distribution of dieldrin in this area is controlled by wells 37338 and 37378. Concentrations in these wells are approximately 0.1 $\mu\text{g/l}$.

Dieldrin occurs offpost of the northwestern RMA boundary, in two apparently distinct plumes. Both plumes are generally oriented to the northwest, consistent with the direction of groundwater flow in the area. Concentrations of dieldrin in this area range from slightly above the CRL (0.05 $\mu\text{g/l}$) to approximately 0.1 $\mu\text{g/l}$.

The distribution and range of concentration of dieldrin offpost is generally the same as that reported in the Final RI. However, the concentration of dieldrin in the First Creek Paleochannel

is slightly larger than previously reported in the Final RI. Offpost of the northwestern RMA boundary, dieldrin has apparently decreased in areal extent. In both areas, the maximum concentrations of dieldrin are generally highest nearest the RMA boundaries.

Endrin

Endrin was reported in the Final RI in samples collected in the First Creek and Northern Paleochannels. Endrin was detected in only five wells offpost of the northern RMA boundary. All of these wells were within approximately one-half mile of the northern boundary. Concentrations in this area reportedly ranged from below the CRL of $0.060 \mu\text{g/l}$ to a maximum of $1.51 \mu\text{g/l}$ in well 37312 located approximately 500 feet north of the NBCS. Endrin was not reported in samples from offpost of the northwestern RMA boundary, except in one sample collected from well 37386. The concentration in well 37386 was $0.067 \mu\text{g/l}$, only slightly above the CRL of $0.060 \mu\text{g/l}$.

The distribution of endrin, based on RI Addendum data, is shown in Figure 3.5. As shown in Figure 3.5, the highest concentrations of endrin are found in the area immediately north of the RMA northern boundary. Additionally, endrin was generally not detected in samples collected from wells located offpost of the RMA northwestern boundary, except in a single sample collected from well 37345. The concentration of endrin at this location is $0.0706 \mu\text{g/l}$, slightly above the CRL of $0.05 \mu\text{g/l}$. Endrin detected in this well is considered an isolated occurrence and not indicative of an endrin plume in that area. The extent of endrin along the First Creek Paleochannel is slightly larger than the distribution reported in the Final RI, with detectable levels of endrin in the vicinity of wells 37396 and 37418 located near the confluence of First Creek and O'Brian Canal.

Endrin was detected in samples collected from wells located in the Northern Paleochannel. The levels of endrin in well 37392 are consistent with levels reported in the Final RI. Samples from wells 37367 and 37383 also had detectable levels of endrin. However, endrin was not detected in samples from wells 37367 and 37383. These three wells are interpreted as defining a

plume in the central portion of the Northern Paleochannel. Near the RMA northern boundary, endrin was detected in well 37338 at a concentration of 0.0621 $\mu\text{g/l}$.

In general, the range of concentrations and distribution of endrin in the Offpost OU are similar to those reported in the Final RI. Although concentrations in a few wells have increased slightly, and detectable levels of endrin were found in a few wells in which endrin was not found historically, the distribution of endrin is generally similar to that reported in the Final RI. The maximum concentration of endrin found in the Offpost OU during the RI Addendum program was 0.748 $\mu\text{g/l}$ in well 37309, approximately 1000 feet north of the NBCS. This finding is consistent the interpretations presented in the Final RI, which showed that the highest levels of endrin occurred within the area approximately 500 to 1000 feet north of the NBCS.

3.2.1.1.2 Other Semivolatile Organic Compounds

This section describes the distribution of other selected SVOCs detected in groundwater samples from the Offpost OU. Several other SVOCs were detected in the Offpost OU during RI Addendum activities. SVOCs detected include certain organochlorine pesticides (OCPs), nitrogen phosphorous pesticides, and organosulfur compounds, which are discussed in the following paragraphs.

Additionally, a few other SVOCs were detected, but only sporadically or in isolated areas. The SVOCs found in these isolated cases include bicycloheptadiene (BCHPD), hexchlorocyclopentadiene (CL6CP), vapona (DDVP), 1,4-dithiane (DITH), dimethylmethylphosphonate (DMMP), and 1,4-oxathiane (OXAT). Because of their infrequent occurrence and relatively limited distribution and because their extent was adequately described in the Final RI, these SVOCs are not discussed further.

The additional SVOCs discussed below include the following:

- Aldrin, isodrin, chlordane, 2,2-bis(parachlorophenyl)-1,1-dichloroethene (DDE), and 2,2-bis(parachlorophenyl)-1,1-trichloroethane (DDT) (OCPs)
- Atrazine, malathion, and parathion (nitrogen phosphorous pesticides)
- 4-Chlorophenylmethyl sulfoxide (CPMSO) and 4-Chlorophenylmethyl sulfone (CPMSO₂) (organosulfur compounds)

In general, the frequency of detection and the relative distribution for these SVOCs was found to be considerably less than for the SVOCs discussed in the preceding sections.

3.2.1.1.3 Organochlorine Pesticide Compounds

The distribution of five additional OCPs (aldrin, isodrin, chlordane, DDE, and DDT) is similar to the distribution of the OCPs dieldrin and endrin, as previously discussed. The maximum concentrations of these compounds generally occur in the First Creek Paleochannel, in the area 500 to 1000 feet north of the NBCS. Only sporadic, isolated occurrences of these compounds are observed offpost of the RMA northwestern boundary.

Aldrin was detected in a number of wells in the First Creek Paleochannel. The highest concentration of aldrin was 0.354 $\mu\text{g/l}$ in well 37419, which is located in the vicinity of the confluence of First Creek and O'Brian Canal. However, historical data show that aldrin has not been previously detected in samples collected from this well. Samples from a few other wells in this area also had detectable concentrations of aldrin. Concentrations in these other wells were approximately 0.15 to 0.3 $\mu\text{g/l}$. Only two wells in the Northern Paleochannel had detectable levels of aldrin. The maximum concentration of aldrin in the Northern Paleochannel was 0.25 $\mu\text{g/l}$ in well 37368. Aldrin was not detected in samples collected from wells located downgradient of the canals, except in well 37345, which is located adjacent to Burlington Ditch offpost of the northwest RMA boundary.

The distribution of isodrin is similar to that of the other OCPs. The highest concentration of isodrin was 0.260 $\mu\text{g/l}$ in well 37396. As was the case for aldrin, this well is also located in the vicinity of the confluence of First Creek and O'Brian Canal. Isodrin was detected in a few other wells in the First Creek and Northern Paleochannels. Concentrations in these wells ranged from approximately 0.08 to 0.2 $\mu\text{g/l}$. Offpost of the northwestern RMA boundary, isodrin was detected in a single sample collected from well 37442. This detection is considered an isolated occurrence and is not indicative of an isodrin plume in this area.

DDT and DDE, which is a degradation product of DDT, were detected in samples collected from wells located offpost of the northern RMA boundary. These compounds were not detected in wells offpost of the northwestern RMA boundary nor in wells located downgradient of the canals. The range of concentrations and distribution of DDE and DDT were generally similar. However, DDE was found at slightly higher concentrations in two wells than was DDT. The maximum concentration of DDE was 6.90 $\mu\text{g/l}$ in well 37309, whereas the maximum concentration of DDT was 0.838 $\mu\text{g/l}$, also in well 37309. This well is located approximately 1500 feet downgradient of the NBCS. A review of historical offpost data and more recent data for the wells in which chlordane was detected, as indicated above, shows that chlordane is generally not detected in Offpost OU wells.

Chlordane was detected in samples collected from a few wells located offpost of the northern RMA boundary. Chlordane was not detected offpost of the northwestern RMA boundary nor downgradient of the canals. The highest concentrations of chlordane were found in five wells located in the First Creek and Northern Paleochannels where values slightly exceeded 1 $\mu\text{g/l}$. Chlordane at concentrations slightly exceeding 1 $\mu\text{g/l}$ were detected in samples collected from wells located near the downgradient extreme of the paleochannels, in the vicinity of the canals, and in well 37309, which is located approximately 1500 feet downgradient of the NBCS.

The distributions of the five OCPs discussed above are consistent with the distribution of other contaminants that have migrated offpost of the northern RMA boundary, including the principal OCPs, dieldrin and endrin. The highest concentrations are found in samples collected north of the northern RMA boundary. Only sporadic, isolated occurrences of these compounds are detected offpost of the northwestern RMA boundary or downgradient of the canals.

3.2.1.1.4 Nitrogen Phosphorous Pesticides

The nitrogen phosphorous pesticides (NPPs), atrazine, malathion, and parathion, were detected in samples collected offpost of the northern RMA boundary. Atrazine was the most frequently occurring NPP and was detected at the highest concentration. Parathion and malathion were detected in only a few wells, all of which are located in the First Creek and Northern Paleo-

channels. Occurrences of malathion and parathion within this area do not appear to constitute a well-defined plume offpost. The five occurrences of malathion range from 0.7 to 1.7 $\mu\text{g/l}$. The three occurrences of parathion range from 0.986 to 5.43 $\mu\text{g/l}$. The NPP compounds were not target analytes for the Final RI. Additionally, these compounds were not reported as tentatively identified compounds (TICs) in the Final RI.

The distribution of atrazine offpost is similar to that of the OCPs. Atrazine was detected in 21 offpost wells, with the maximum concentrations occurring in the First Creek and Northern Paleochannels. Atrazine is generally not detected in samples collected offpost of the northwestern RMA boundary, except for two isolated occurrences in wells 37336 and 37337, located approximately 1 mile offpost. The maximum concentration of atrazine was 72.9 $\mu\text{g/l}$ found in a sample from well 37406 located at the northern end of the Northern Paleochannel. The highest concentration of atrazine found in the First Creek Paleochannel was 46.0 $\mu\text{g/l}$ in well 37418. In general, the highest levels of atrazine were found in the extreme northwestern and northern ends of the First Creek and Northern Paleochannels, respectively. Atrazine was not detected in offpost wells located in the immediate vicinity of the northern RMA boundary.

3.2.1.1.5 Organosulfur Compounds

In the Final RI, CPMSO was reportedly the most commonly detected organosulfur compound for offpost groundwater samples. The highest levels of CPMSO were found in samples collected from wells in the Northern Paleochannel. The highest concentration of CPMSO reported in the Final RI was 148 $\mu\text{g/l}$ in well 37391. The Final RI also reported that CPMSO₂ was detected in offpost groundwater north of RMA. The maximum concentration of CPMSO₂ reported in the Final RI was 39.3 $\mu\text{g/l}$ in well 37309. The compound 4-chlorophenylmethyl sulfide (CPMS) was the least frequently detected organosulfur compound reported in the Final RI. The highest concentration of CPMS was 4.16 $\mu\text{g/l}$ detected in well 37367, located about 1 mile north of the RMA boundary. The Final RI reported that the organosulfur compounds were not detected in any samples collected downgradient of O'Brian Canal.

For the RI Addendum program, the organosulfur compounds CPMSO and CPMSO₂ were detected at a number of locations offpost of the northern RMA boundary. CPMS was not detected in any offpost groundwater samples presented in this report. The CPMSO and CPMSO₂ distributions are distinctly different from each other. CPMSO was only found in samples collected from wells installed in the Northern Paleochannel, whereas CPMSO₂ was only found in samples collected from wells located in the First Creek Paleochannel. CPMSO was generally found at levels higher than those reported for CPMSO₂.

Detectable levels of CPMSO were reported for 9 wells located in the Northern Paleochannel. The highest concentrations of CPMSO were detected in samples collected from wells located at the northern end of the Northern Paleochannel. Concentrations of CPMSO ranged from 12.6 µg/l to a maximum concentration of 82.2 µg/l found in a sample collected from well 37344.

Detectable levels of CPMSO₂ were reported for 5 wells located in the First Creek Paleochannel. These concentrations ranged from 7.75 µg/l to a maximum concentration of 21.0 µg/l found in a sample collected from well 37420, which is located at the northwestern end of the First Creek Paleochannel.

The organosulfur compounds were not detected in samples collected from offpost wells located immediately north of the northern RMA boundary or in wells located downgradient of O'Brian Canal. The concentrations of these compounds are generally similar to those levels reported in the Final RI. Concentrations may be slightly lower for some wells. CPMS, which was detected in samples reported in the Final RI, was not detected in samples collected during RI Addendum activities. The distribution of these compounds is similar to the distributions reported in the Final RI and the CMP report for fiscal year 1990.

3.2.1.1.6 Volatile Organic Compounds

VOCs were reported in the Final RI as occurring in offpost groundwater. The most commonly occurring VOCs reported in the Final RI were chloroform, chlorobenzene, DBCP, tetrachloroethene (TCLEE), trichloroethene (TRCLE), and 1,2-dichloroethene (12DCLE). The

following sections describe the distribution of these principal VOCs, plus some additional VOCs that exhibit a lower frequency of detection, which were also reported in the Final RI.

Problems were encountered in the VOC data for samples collected from wells installed under the RI Addendum program. Several rounds of sampling of these wells were conducted between late-1989 and mid-1990. Samples collected between January 25 and March 2, 1990, exhibited anomalously high concentrations for a number of VOCs, including chloroform, TCLEE, TRCLE, carbon tetrachloride (CCL₄), benzene, chlorobenzene, DBCP, toluene, and xylenes. The wells sampled under the RI Addendum program and their sampling dates are shown in Table 2.1. The results reported by the laboratories for these affected samples were considerably higher than historical results and are not considered representative of groundwater conditions offpost. The anomalous data contained in tables presented in Appendix B of this report have been clearly identified with a coded footnote.

On the basis of a review of field documentation for the sampling period in question, the source of the problem associated with these anomalous results appears to be related to improper or inadequate field decontamination procedures. The high results for the VOCs identified above can be related to the use of a particular sampling pump. This pump has a significant length of tubing that requires decontamination. It appears that inadequate decontamination of the tubing was the source of the contamination observed in the groundwater samples collected during the period between January 25 and March 2, 1990. Corrective actions consistent with the FOP have been implemented.

To provide a complete database for assessing groundwater contamination in the UFS, data from a CMP sampling round conducted in the first quarter of 1991 were used to augment the database where anomalous data could not be used. These data have been accepted into the PMRMA database as final data and were used qualitatively in assessing plume configurations for VOCs offpost. Data used in this assessment are available in the PMRMA database.

Chloroform

As shown in the Final RI, chloroform occurs primarily downgradient of the NWBCS and in the Northern Paleochannel. Chloroform was generally not found in the First Creek Paleochannel. Concentrations found in the chloroform plume emanating from the northern RMA boundary are considerably higher than concentrations offpost of the northwestern RMA boundary. The highest concentration of chloroform reported in the Final RI was 1370 $\mu\text{g/l}$ in well 37344 located at the northern end of the Northern Paleochannel. Concentrations in the Northern Paleochannel are generally above 50 $\mu\text{g/l}$. Offpost of the NWBCS, chloroform was detected in approximately seven wells. The highest concentration of chloroform was 25.8 $\mu\text{g/l}$ in well 37331, which is located at the northwestern RMA boundary approximately 1000 feet downgradient of the NWBCS.

The current distribution of chloroform on the basis of data collected during RI Addendum activities and the CMP is shown on Figure 3.6. Chloroform in the UFS occurs in two principal plumes offpost. This chloroform distribution is similar to that presented in the Final RI. Chloroform is also detected offpost of the northwestern RMA boundary but at concentrations generally considerably lower than those found in the Northern Paleochannel.

Chloroform was detected in a few wells in the First Creek Paleochannel. Maximum concentrations detected in samples collected from wells located in the First Creek Paleochannel were approximately 2 $\mu\text{g/l}$ in well 37381. However, higher concentrations of chloroform, as well as other VOCs discussed below, were encountered in samples collected in June 1990 from wells 37418 and 37420. These values were compared to historical data for this area and more recent CMP data for wells in this area. On the basis of these assessments, the high chloroform values detected in the samples collected in June 1990 are considered anomalous and are not representative of groundwater conditions.

The highest concentrations of chloroform occur at the north end of the Northern Paleochannel. Maximum concentrations of chloroform ranged from 200 to 400 $\mu\text{g/l}$ in wells 37344 and 37409. This concentration range is lower than concentrations reported in the Final RI, as noted above but follow a general trend of decreasing concentrations for chloroform in well 37344. The

southern end of the chloroform plume is interpreted as occurring about 1000 feet north of the NBCS, which is in contrast to the interpreted extent of the southern end of the plume in the Final RI that showed the plume extending to the NBCS for data collected in the fall of 1987. More recent CMP data for the first part of 1991 also support this interpretation.

The extent of the chloroform plume offpost of the northwestern RMA boundary is also similar to the interpretation presented in the Final RI. However, the installation of several new monitoring wells located in this area has shown that the chloroform plume extends approximately 2 miles northwest of the northwestern RMA boundary. Concentrations detected in groundwater samples collected from wells offpost in this area are similar to levels previously reported in the Final RI. Concentrations range from below the CRL to a maximum of 19.8 $\mu\text{g/l}$ in well 37330 located immediately downgradient of the NWBCS. In general, the highest levels of chloroform occur at the northwestern RMA boundary. The range of concentrations for chloroform offpost is generally the same as that reported in the Final RI.

Chlorobenzene

Chlorobenzene was reported in the Final RI offpost of the northern and northwestern RMA boundaries. The highest concentration of chlorobenzene was 27.3 $\mu\text{g/l}$ detected in samples collected from well 37370, located in the First Creek Paleochannel. According to interpretations in the Final RI, the distribution of chlorobenzene did not appear to be consistent with the distribution onpost. Chlorobenzene was also sporadically detected in samples collected from wells located offpost of the northwestern RMA boundary and in wells located downgradient of the canals. In the Final RI, these data were not interpreted as indicative of a chlorobenzene plume offpost.

The distribution of chlorobenzene on the basis of data collected during RI Addendum activities and the CMP is shown in Figure 3.7. Chlorobenzene was detected in samples collected from several wells located in the Offpost OU. The highest concentrations of chlorobenzene were found in samples collected from north of RMA in the First Creek and Northern Paleochannels. The maximum concentration of chlorobenzene was 38.2 $\mu\text{g/l}$ in well 37397, which is located at the

northern end of the Northern Paleochannel. The highest concentration of chlorobenzene in the First Creek Paleochannel was 9.56 $\mu\text{g/l}$ in a sample collected from well 37370. Additionally, sporadic occurrences of chlorobenzene northwest of the canals were also found. In general, the distribution of chlorobenzene is similar to that presented in the Final RI. Concentrations of chlorobenzene and the apparent distribution offpost have not considerably changed since the Final RI.

DBCP

The Final RI presented a discussion of the distribution of DBCP in offpost groundwater. In the Final RI, DBCP was shown to occur offpost of the northern RMA boundary. DBCP is primarily confined to the Northern Paleochannel and was not detected in groundwater samples from other Offpost OUs. The maximum concentration of DBCP was 13.3 $\mu\text{g/l}$ in well 37344. DBCP was historically detected in samples collected from offpost wells located downgradient of the Irondale Boundary Containment System (IBCS). However, the Final RI reported that DBCP was not detected in wells located in that area. The location of the IBCS is shown in Figure 1.2.

The distribution of DBCP on the basis of data collected during the RI Addendum and the CMP is shown in Figure 3.8. As shown in Figure 3.8, DBCP was generally only found in samples from wells completed in the Northern Paleochannel. A few isolated occurrences of DBCP were observed in the First Creek Paleochannel and immediately downgradient of O'Brian Canal near the northern end of the Northern Paleochannel. The maximum concentration of DBCP was 6.67 $\mu\text{g/l}$ in a sample collected from well 37344. DBCP was not detected in samples collected from wells located downgradient of Burlington Ditch nor offpost of the northwestern RMA boundary. The extent of DBCP contamination offpost has decreased slightly from levels reported in the Final RI. The maximum reported concentrations in this report are lower than those presented in the Final RI. Additionally, considerable decreases in the concentration of DBCP immediately north of the NBCS are evident. As a result of these decreases, the DBCP plume offpost of the northern RMA boundary appears to not extend to the NBCS, as was previously reported in the Final RI.

DBCP data from the early 1991 CMP sampling round for wells 37402, 37403, and 37404 were reviewed to confirm the eastern arm of the DBCP plume in the Northern Paleochannel. Data for the subsequent samples collected from these three wells show that DBCP was not detected. These subsequent data suggest that the extent of DBCP may be less than presented in Figure 3.8. Subsequent data will be evaluated under the Groundwater CMP to assess the distribution of DBCP over time.

Trichloroethene and Tetrachloroethene

The distributions of TRCLE and TCLEE reported in the Final RI are similar to the distribution of chloroform. The highest concentrations of these compounds are found at the northern end of the Northern Paleochannel. The maximum concentrations of TRCLE and TCLEE were 7.71 and 115 $\mu\text{g/l}$, respectively. As in the case of chloroform, the highest levels were found in well 37344.

The current distributions of TRCLE and TCLEE on the basis of data collected during RI Addendum activities and the CMP are presented in Figures 3.9 and 3.10, respectively. TRCLE and TCLEE occur in the First Creek and Northern Paleochannels. These compounds were generally not found offpost of the northwestern RMA boundary, except in a well 37355, located approximately 2 miles offpost. The concentrations of TRCLE and TCLEE in this well, have each been in the range of approximately 3 to 8 $\mu\text{g/l}$ over the past several years.

The highest concentrations of TRCLE and TCLEE in the southwestern corner of the Offpost OU were detected in well 37359. TRCLE and TCLEE have also been detected in well SAC18 located approximately 1500 feet east of well 37359. The sources of TRCLE and TCLEE in these wells are likely associated with contamination originating at the Chemical Sales Company (CSC) site located southeast of the intersection of East 48th Avenue and Ivy Street. Additional sources of these contaminants upgradient of RMA, including Stapleton Airport, are suggested by their distribution onpost (RLSA, 1990a). The RI/FS for CSC OUs 1, 2, and 3 showed that significant levels of TRCLE and TCLEE are originating at the CSC site.

The concentrations of TRCLE and TCLEE in the First Creek and Northern Paleochannels are similar to those levels reported in the Final RI. The highest concentrations of these compounds were detected in samples collected from wells located at the northern end of the Northern Paleochannel, which is consistent with distributions reported in the Final RI. The maximum concentration of TCLEE was 108 $\mu\text{g/l}$ in well 37344 located in the Northern Paleochannel. The highest concentrations of TRCLE in the area north of RMA ranged from approximately 5 to 7 $\mu\text{g/l}$. In general, the distributions of TRCLE and TCLEE are similar to those presented in the Final RI. Concentrations of both of these contaminants have decreased slightly from those reported in the Final RI, as evidenced by the extent of the 1 $\mu\text{g/l}$ contour for TRCLE and the 10 $\mu\text{g/l}$ contour for TCLEE, as depicted on Figures 3.9 and 3.10, respectively.

1,2-Dichloroethane

The distribution of 12DCLE was shown in the Final RI. According to the information presented in the Final RI, 12DCLE is generally found offpost of the northern RMA boundary. However, unlike chloroform, TCLEE, and TRCLE, the highest concentrations of 12DCLE are found in First Creek Paleochannel. The maximum concentration of 12DCLE was 15.2 $\mu\text{g/l}$ in well 37396, which is located at the northwestern end of the First Creek Paleochannel. The concentrations of 12DCLE reported in the Final RI were considerably lower in the fourth quarter of FY 1987 than those reported in the third quarter of FY 1987.

The distribution of 12DCLE was assessed on the basis of data collected during the RI Addendum activities and the CMP. The compound 12DCLE was detected in wells located in the First Creek Paleochannel at concentrations similar to those presented in the Final RI. As was reported in the Final RI, the only detectable level of 12DCLE in the Northern Paleochannel was in well 37391. The concentration in that well was 2.61 $\mu\text{g/l}$ and was consistent with levels reported in the Final RI.

3.2.1.1.7 Other Volatile Organic Compounds

In the Final RI, several other VOCs, including 1,1,1-trichloroethane, 1,1-dichloroethane, trans-1,2-dichloroethene, carbon tetrachloride, and benzene were detected in UFS groundwater. Benzene was detected primarily in samples collected from wells located in the Northern Paleo-channel. A few samples from the First Creek Paleochannel and offpost of the northwestern RMA boundary had detectable levels of benzene. The highest concentration of benzene reported in the Final RI was 15.1 $\mu\text{g/l}$ in well 37392, located approximately 2500 feet north of the northern RMA boundary. Benzene was not detected downgradient of the canals except for one isolated occurrence in well 37361, located approximately 1.5 miles northwest of the northwestern RMA boundary. The remaining other VOCs were detected sporadically in only one or two groundwater samples.

Several other VOCs were also detected in the Offpost OU during RI Addendum activities. VOCs detected include benzene, carbon tetrachloride, 1,1,1-trichloroethane, 1,1-dichloroethane, 1,2-dichloroethene, toluene, and xylenes. These compounds were generally found in only a few groundwater samples collected from wells installed in the UFS. Of these compounds, benzene was the most frequently detected. The remaining detections are considered isolated occurrences and not necessarily indicative of contaminant plumes that migrated from onpost.

Carbon tetrachloride was reported in six samples. The highest concentration of carbon tetrachloride was 8.04 $\mu\text{g/l}$ in a sample from well 37404. Carbon tetrachloride was reported in the First Creek Paleochannel at a concentration of 6.98 $\mu\text{g/l}$ in well 37407.

3.2.1.2 Unconfined Flow System Inorganics

This section describes the distribution of selected inorganic constituents in UFS groundwater. The inorganics presented below include arsenic, mercury, chloride, and fluoride. These analytes were selected based on their distribution, range of concentration and considering their toxicity, except chloride. Virtually all of the inorganics discussed below are naturally occurring constituents in groundwater. The inorganic data presented are compared to background concentrations established in the Final RI and CMP report for FY 1990 (RLSA, 1991a). The

following discussions present data generated under the RI Addendum program and are compared to the distribution of the inorganic constituents presented in the Final RI.

Arsenic

The distribution of arsenic was presented in the Final RI. Arsenic was reported in groundwater samples from wells located in the First Creek Paleochannel, with isolated occurrences in the Northern Paleochannel and offpost of the northwestern RMA boundary. In general, arsenic was not detected in wells downgradient of the canals, except in well 37364 located 3 miles downgradient of RMA on the west side of the South Platte River, outside of the Offpost OU.

The highest concentration of arsenic in wells located near RMA was 5.80 $\mu\text{g/l}$ in well 37332, located immediately downgradient of the NWBCS. In the area north of RMA, As was detected somewhat sporadically in a number of wells at concentrations slightly above the CRL of 2.5 $\mu\text{g/l}$ to a maximum of 3.65 $\mu\text{g/l}$ in well 37373 located along the First Creek Paleochannel. The background value for As reported in the Final RI was below the CRL of 2.50 $\mu\text{g/l}$, indicating that arsenic was not detected in the upgradient wells selected for assessment of arsenic background levels.

The distribution of arsenic on the basis of data collected during RI Addendum activities and the CMP, is shown in Figure 3.11. The distribution of arsenic is similar to that presented in the Final RI. Arsenic occurs in a plume along the First Creek Paleochannel. The maximum concentration of arsenic in this area is 4.00 $\mu\text{g/l}$ in well 37347 located on the north side of the First Creek Paleochannel northwest of Burlington Ditch. Sporadic occurrences of As are noted in the Northern Paleochannel and offpost of the northwestern RMA boundary. Additionally, arsenic was detected in the sample collected from well 37364 located along the South Platte River. In general, the range of concentration and distribution for arsenic is similar to that reported in the Final RI.

Mercury

The Final RI reported mercury in only one offpost groundwater sample. The sample, which was collected from well 37342 located in the First Creek Paleochannel, had a mercury concentration of 0.36 $\mu\text{g/l}$. Data generated during RI Addendum activities showed detectable levels of mercury in four samples collected from wells located 2000 to 7000 feet offpost of the northwestern RMA boundary. Mercury concentrations in these wells ranged from 0.210 to 1.64 $\mu\text{g/l}$. Based on the limited number of samples in which mercury was detected, the data do not suggest a mercury plume offpost and are considered sporadic. Data collected under the fall of 1989 CMP show considerably higher frequency of detection for mercury than reported in the Final RI. The FY 1990 CMP (RLSA, 1991a) reported that significant field or laboratory contamination existed for those mercury results. Thus, data for mercury are considered questionable and not representative of groundwater conditions.

Chloride

Chloride was detected in all samples reported in the Final RI. The range of chloride concentrations was from 30,000 to more than 1,000,000 $\mu\text{g/l}$. Because chloride is a naturally occurring anion in groundwater, the assessment of chloride contamination in the UFS includes a comparison with a range of concentration that is representative of background levels. The range for background chloride levels, based on data from selected upgradient wells presented in the Final RI, is 34,000 to 102,000 $\mu\text{g/l}$.

The highest concentrations of chloride reported in the Final RI occurred in samples collected from wells located in the First Creek Paleochannel near its confluence with O'Brian Canal. Concentrations of chloride in this area commonly exceeded 500,000 $\mu\text{g/l}$ and reached as high as 3,380,000 $\mu\text{g/l}$ in well 37396. Elevated chloride concentrations were also observed in samples collected from wells located at the northern end of the Northern Paleochannel. Although generally lower than levels in the First Creek Paleochannel, concentrations in samples from one well located in the Northern Paleochannel, well 37368, exceeded 500,000 $\mu\text{g/l}$.

Chloride concentrations offpost of the northwestern RMA boundary were also elevated above background levels. The highest concentrations occurred in the immediate vicinity of the NWBCS and were generally in the range of 300,000 to 400,000 $\mu\text{g/l}$. The maximum chloride concentration in that area was 714,000 $\mu\text{g/l}$ in well 37332, located near the northern end of the NWBCS along the RMA boundary.

The distribution of chloride, on the basis of data collected during RI Addendum activities and the CMP, is shown in Figure 3.12. The distribution of chloride is similar to that presented in the Final RI. Chloride occurs in plumes offpost of the northern and northwestern RMA boundaries. The maximum concentrations of chloride occur in the First Creek Paleochannel.

Chloride concentrations in the First Creek and Northern Paleochannels generally exceed 250,000 $\mu\text{g/l}$. The maximum concentration of chloride in this area was 1,800,000 $\mu\text{g/l}$ in well 37418 located in the First Creek Paleochannel. Although this concentration is considerably lower than the maximum concentration of 3,380,000 $\mu\text{g/l}$ in this area reported in the Final RI, this value is consistent with more recent chloride data. In the Northern Paleochannel, the highest concentrations are approximately slightly greater than 500,000 $\mu\text{g/l}$, similar to levels reported in the Final RI.

Offpost of the northwestern RMA boundary, chloride concentrations in excess of 250,000 $\mu\text{g/l}$ occur immediately downgradient of the RMA boundary. Chloride concentrations in this area are slightly lower than those reported in the Final RI. Concentrations reported in the Final RI along the RMA boundary in this area exceeded 300,000 $\mu\text{g/l}$ and exceeded 600,000 $\mu\text{g/l}$ in at least one well. Currently, concentrations in this area are approximately 250,000 $\mu\text{g/l}$.

A chloride plume, defined by the 100,000 $\mu\text{g/l}$ isoconcentration contour, extending northwest off the northwestern RMA boundary is apparent in Figure 3.12. New wells installed under the RI Addendum have provided additional definition for this plume. Although the chloride plume was not depicted in the Final RI, concentrations in wells throughout this area have actually decreased from those reported in the Final RI. The appearance of this plume is an artifact of the contour interval and is not the result of additional contamination migrating offpost.

In general, concentrations of chloride have generally decreased since the Final RI. The pattern of chloride contamination in offpost groundwater is similar to that reported in the Final RI, but concentrations have decreased in all plume areas, particularly in the First Creek Paleo-channel and offpost of the northwestern RMA boundary. Maximum concentrations in the First Creek Paleochannel are 1,800,000 $\mu\text{g/l}$ compared to a maximum of 3,380,000 $\mu\text{g/l}$ reported in the Final RI. Offpost of the northwestern RMA boundary, concentrations have decreased approximately 10 to 20 percent from those reported in the Final RI.

Fluoride

The Final RI reported detectable concentrations of fluoride in 68 percent (41 of 60 samples) of the samples analyzed. The range of fluoride concentrations was from 1000 to 4500 $\mu\text{g/l}$. Because fluoride is a naturally occurring anion in groundwater, the assessment of fluoride contamination in the UFS includes a comparison with a range of concentration that is representative of background levels. The range for background fluoride levels, based on data from selected upgradient wells presented in the Final RI, is 570 to <1220 $\mu\text{g/l}$.

The highest concentrations of fluoride reported in the Final RI occurred in samples collected from wells located downgradient of the extreme western end of the NBCS and in the First Creek Paleochannel between the northern RMA boundary and the confluence with O'Brian Canal. Concentrations of fluoride in these areas commonly exceeded 2000 $\mu\text{g/l}$. Fluoride concentrations were reported downgradient of the NBCS at 4650 $\mu\text{g/l}$ at well 37339 and in the First Creek Paleochannel near its confluence with O'Brian Canal at 4420 $\mu\text{g/l}$ at well 37396. Elevated fluoride concentrations were also observed in samples collected from wells located in the Northern Paleochannel, primarily in the western portion of Section 13. Although generally lower than concentrations in the First Creek Paleochannel, concentrations in samples from at least one well located in the Northern Paleochannel, well 37397, also exceeded 2000 $\mu\text{g/l}$.

Fluoride concentrations offpost of the northwestern RMA boundary were also elevated above background levels. The highest concentrations occurred in the immediate vicinity of the NWBCS, and were generally in the range of 1300 to 2000 $\mu\text{g/l}$. The maximum fluoride

concentration in that area was 2610 $\mu\text{g/l}$ in well 37382 located near the northern end of the NWBCS along the RMA boundary.

The distribution of fluoride, on the basis of data collected during RI Addendum activities and the CMP, is shown in Figure 3.13. The distribution of fluoride is similar to that presented in the Final RI. Fluoride occurs in plumes offpost of the northern and northwestern RMA boundaries. The maximum concentrations of fluoride occur in the First Creek Paleochannel and downgradient of the western end of the NBCS.

Fluoride concentrations commonly exceed 3000 $\mu\text{g/l}$ in the First Creek Paleochannel and 2200 $\mu\text{g/l}$ in the Northern Paleochannel. The maximum concentration of fluoride in these areas was 6300 $\mu\text{g/l}$ in well 37418 located in the First Creek Paleochannel. A second sample collected from well 37418 had a fluoride concentration of 3310 $\mu\text{g/l}$, suggesting a high degree of variability in the fluoride data, as was noted in the Final RI. In the Northern Paleochannel, the highest concentrations are slightly greater than 2500 $\mu\text{g/l}$, which is similar to levels reported in the Final RI. In general, fluoride concentrations in samples collected offpost of the northern RMA boundary are similar to those reported in the Final RI.

Offpost of the northwestern RMA boundary, fluoride concentrations in excess of 2000 $\mu\text{g/l}$ occur immediately downgradient of the RMA boundary. Fluoride concentrations in this area are similar to those reported in the Final RI. In the Final RI, concentrations along the RMA boundary in this area ranged from approximately 1300 to 2000 $\mu\text{g/l}$ and exceeded 2600 $\mu\text{g/l}$ in at least one well. Currently, concentrations in this area are approximately 2000 $\mu\text{g/l}$, although the maximum concentration was detected in well 37438 at 4070 $\mu\text{g/l}$.

A fluoride plume, defined by the 2000 $\mu\text{g/l}$ isoconcentration contour, extends northwest off of the northwestern RMA boundary and north of the northern RMA boundary and is apparent in Figure 3.13. New wells installed under the RI Addendum have provided additional definition for this plume. This plume was depicted in the Final RI and was slightly smaller than that depicted in this report. Fluoride concentrations in some wells in this area have increased slightly from those

reported in the Final RI. The slightly higher concentrations have increased the size of the plume in the area off of the northwestern boundary.

In general, concentrations of fluoride have remained approximately the same or increased slightly since the Final RI. The pattern of fluoride contamination in offpost groundwater is similar to that reported in the Final RI.

3.2.2 Nature and Extent of Arapahoe Formation Contamination

This section describes the distribution of organic and inorganic constituents in Arapahoe Formation groundwater. The data and interpretations presented in this section are for groundwater samples collected from seven offpost domestic and monitoring wells completed in the Arapahoe Formation. A number of the existing Arapahoe Formation wells were installed a number of years ago and may not have the same structural integrity as those wells installed more recently, particularly those installed during RI Addendum activities. This factor may have some effect on the comparability of data from the wells. Data from several sampling events, as described in Section 3.2, were used to develop the interpretations and assessment of possible contamination in the Arapahoe Formation.

Because specific information about the construction of many of the domestic wells in the Arapahoe Formation is not available, several limitations on the usefulness of data from those wells must be recognized. As discussed below, the extent of organic and inorganic contaminants in the Arapahoe Formation appears to be quite limited and probably the result of flow from contaminated groundwater in the UFS. Data from the newly installed Arapahoe Formation monitoring wells should be considered of significantly higher quality than data from the existing domestic wells. In contrast, the sporadic occurrence of organic or inorganic contaminants in samples collected from the domestic wells should not be interpreted as evidence of widespread contamination of the Arapahoe Formation.

The Arapahoe Formation wells were sampled during RI Addendum and CMP activities, as shown in Table 2.1, and were analyzed for the compounds listed in Table 2.4. Analytical results for samples collected during RI Addendum activities are included in Appendix B. Results for

samples collected and analyzed during the CMP are contained in the RMA database. The analytical results for Arapahoe Formation samples collected from domestic and monitoring wells are discussed in the following subsections.

3.2.2.1 Arapahoe Formation Organics

This section presents and discusses the results of organic analyses for groundwater samples collected from domestic and monitoring wells completed in the Arapahoe Formation. Eleven samples were collected from eight Arapahoe Formation wells and were analyzed for the target analytes listed in Table 2.4.

Two organic compounds, chloroform and DIMP, were infrequently detected in samples collected from Arapahoe Formation wells (Figure 2.2). Well 09200TW090 had detectable levels of DIMP in samples collected in January and August 1989. Chloroform was not detected in samples from this well. Well 11841TW096 was sampled three times: in September 1989, January 1990, and August 1990. The sample collected in September 1989 did not contain detectable concentrations of organic compounds. Samples collected in January and August 1990 contained DIMP and chloroform, respectively. DIMP was detected at a concentration of 0.521 $\mu\text{g/l}$, and chloroform was detected at concentrations of 24.9 and 1.17 $\mu\text{g/l}$, respectively. Additionally, chloroform results for the sample collected in January 1990 are questionable on the basis of evaluation of field QA/QC information. The sample from well 13701TW104 contained DIMP at a concentration of 3.87 $\mu\text{g/l}$. Because only one sample was collected from well 13701TW104, the occurrence of DIMP cannot be verified. Additionally, as discussed in Section 3.2.2.2, this well appears to have structural problems and the organic analytical data do not reflect samples representative of the Arapahoe Formation.

The detections of DIMP and chloroform observed in these Arapahoe Formation wells do not appear to be representative of overall aquifer conditions. The majority of samples collected from Arapahoe Formation wells did not contain organic compounds. In addition, DIMP and chloroform were not detected consistently in samples collected from well 11841TW096. It is possible that the observed concentrations of DIMP and chloroform may be artifacts of field or laboratory

procedures or may reflect the effects of well construction problems. On the basis of these data, organic contamination in the Arapahoe Formation appears to be sporadic and localized, possibly as a result of well construction problems. The groundwater quality data for the Arapahoe Formation wells installed and sampled under the RI Addendum program strongly support this conclusion.

3.2.2.2 Arapahoe Formation Inorganics

This section presents and discusses the inorganic chemistry results of groundwater quality sampling of domestic and monitoring wells completed in the Arapahoe Formation. Nine samples were collected from seven Arapahoe Formation wells and were analyzed for inorganic target analytes including metals and anions, as shown in Table 2.4. Inorganic target analytes detected in Arapahoe Formation well samples included arsenic, calcium, chloride, chromium, copper, fluoride, magnesium, mercury, nitrate-nitrite, potassium, sodium, sulfate, and zinc. In general, the analytical results for the inorganic constituents are within the expected concentration ranges. The analytical results for inorganic constituents are described below.

Arsenic was detected only in samples collected from wells 37445 and 37431 at concentrations of 4.89 and 3.22 $\mu\text{g/l}$, respectively. Calcium, chloride, fluoride, nitrate-nitrite, sodium, and sulfate were detected in all samples for which they were analyzed with the exception of fluoride and sulfate. Fluoride had two results rejected on the basis of QA/QC requirements, and sulfate had one rejected result. The concentration ranges for the inorganic constituents detected in the Arapahoe Formation samples follow:

- Calcium 1480 to 34,000 $\mu\text{g/l}$
- Chloride 2580 to 38,000 $\mu\text{g/l}$
- Fluoride 2850 to 3450 $\mu\text{g/l}$
- Nitrate-nitrite 44.2 to 2,000,000 $\mu\text{g/l}$
- Sodium 93,000 to 160,000 $\mu\text{g/l}$
- Sulfate 2490 to 180,000 $\mu\text{g/l}$

Chromium, copper, mercury, and potassium were each detected once at concentrations of 19.8 µg/l in well 37431, 31.8 µg/l in well 37445, 1.35 µg/l in well 11841TW096, and 916 µg/l in well 13701TW104, respectively. Zinc was detected twice at concentrations of 616 µg/l in well 37445 and 667 µg/l in well 13701TW104.

Cadmium, cyanide, iron, lead, manganese, and total organic carbon (TOC) were not detected above the CRL in any Arapahoe Formation well samples.

The inorganic water chemistry of groundwater samples collected from the Arapahoe Formation was evaluated to identify wells that displayed apparently inconsistent water chemistry signatures. Specific electrical conductivity (conductivity) measured at the time of sample collection was reviewed and compared to typical Arapahoe Formation ranges reported by Tri-County Health Department (Tri-County) (Tri-County, 1989). The conductivity values measured in the field were consistent with the Tri-County ranges, except for well 13701TW104. The conductivity value reported for this well was approximately 850 µmhos/cm at 25°C, which is about 50 percent higher than typical values for the Arapahoe Formation, although the Tri-County report (Tri-County, 1989) presents a broad range of values. These data, generally indicate that all of the Arapahoe Formation wells sampled, except well 13701TW104, appear to reflect inorganic water quality representative of the Arapahoe Formation.

Based on the results presented in this report, the Arapahoe Formation inorganic chemistry does not appear to be affected by RMA contaminants. Results for the six wells discussed above are generally within the concentration ranges expected. There were a few exceptions to this general conclusion. Analytical results for wells 10021TWPEO and 13701TW104 were anomalous with respect to results reported for the other Arapahoe Formation wells. Well 10021TWPEO contained nitrate-nitrite at a concentration of 2,000,000 µg/l. This value is 2000 times higher than the next highest nitrate-nitrite value and appears to be an erroneous result. A plausible explanation for this value is that the sample may have been incorrectly preserved in the field using nitric acid instead of sulfuric acid.

Well 13701TW104 contained most of the highest concentrations for detected inorganic constituents. In the case of magnesium, the concentration for this well was approximately 140 times higher than the next highest concentration. Well 13701TW104 contained the highest concentrations of calcium, chloride, fluoride, magnesium, sodium, sulfate, and zinc, and contained the only detectable levels of potassium. On the basis of these data and the reported field conductivity of 850 μ mhos/cm at 25°C, this well appears to reflect an influence of UFS groundwater quality.

3.2.3 Summary of Gas Chromatography/Mass Spectroscopy Results

GC/MS analytical methods were used to attain groundwater sample results for two purposes. The first purpose was to provide investigative results for certain target analytes (e.g., caprolactam, bis(2-ethylhexyl)phthalate, vinyl chloride) for which a certified GC method was not available. In this case, all analytes certified under the GC/MS method were reported by the laboratory. The second purpose was to provide confirmation of GC results and to assess the presence of nontarget analytes. GC/MS results are included in Appendix B.

GC results and GC/MS results were in general agreement. In one case, GC/MS confirmation results for chloroform (sample HA1069) did not confirm a GC detection (sample 37430). Because the GC detection was only slightly higher than the CRL for the GC/MS method, this does not represent a serious discrepancy. In four cases, GC/MS confirmation results reported detections where none were reported in the investigative data. Three of these cases involved carbon tetrachloride in samples HA1168, HA1169, and HA1171 at concentrations near the GC/MS CRL of 1.0 μ g/l. The fourth case involved bis(2-ethylhexyl)phthalate at 176 μ g/l, which probably represents laboratory contamination.

Chloroform and chlorobenzene GC method results were very high for several samples analyzed for the Offpost OU RI Addendum and IRA A. These results were inconsistent with historical data and suggest problems associated with cross-contamination during sampling. This problem was particularly severe during two sampling events that took place from January 25 to

March 2, 1990. Both the GC and GC/MS volatiles results were higher than historical results, and the volatiles data for the two episodes are not considered reliable.

3.2.4 Summary of Quality Assurance/Quality Control Results

QA/QC samples were collected and analyzed in accordance with the QAP. The frequency of and procedures for collecting various QA/QC samples are summarized in Table 3.2. The total numbers of various QA/QC samples collected during RI Addendum activities follow:

- 5 rinse blanks
- 4 field blanks
- 4 trip blanks
- 15 duplicates
- 7 GC/MS confirmation samples

For duplicate samples, duplicate sample agreements (DSAs) were computed for all analytes with concentrations greater than the CRL in either the investigative or duplicate sample. The DSAs are shown in Table 3.3, along with the investigative and duplicate results. Since the DSA is the ratio of the difference between the two results divided by the average of the two results, a DSA value of 0.00 indicates perfect agreement, and a value very near or equal to 2.00 indicates very poor agreement.

DSA values exceeding 1.00 were calculated for compounds in one of the 15 duplicate samples. The DSA of 1.99 for nitrate-nitrite in sample HA1166 indicates a problem with this sample. The extreme difference between 4300 $\mu\text{g/l}$ in HA1166 and 1,300,000 $\mu\text{g/l}$ in sample 37435 suggests that sample 37435 may have been inadvertently preserved with nitric acid rather than sulfuric acid. On the basis of this information, the nitrate-nitrite result for sample 37435 has been disregarded. Sample HA1079 contains seven metals results with DSAs exceeding 1.00, which suggests a possible problem with the inductively coupled plasma (ICP) metals analysis for this sampling event.

QC samples consisting of field, rinse, and trip blanks exhibited anomalous results in 4 of 13 samples. Two samples, HA1047 (field blank) and HA1177 (trip blank), had reported chloroform results slightly exceeding the CRL. Sample HA1176, a field blank, had reported chlorobenzene results slightly exceeding the CRL. The results for these three samples support the possibility that some chloroform and chlorobenzene reported results may reflect laboratory or field contamination. Samples HA1176 and HA1177 were collected during the two January to March 1990 sampling events mentioned in the GC/MS discussion.

Rinse blank sample HA1175 had reported concentrations greatly exceeding the CRL for zinc and for seven volatile organic compounds. The presence of so many elevated concentrations in this sample suggests that problems may have been encountered during field decontamination of sampling equipment. As previously discussed in Section 3.2.1.1.6, several samples collected during the period between January 25 and March 2, 1990, showed anomalously high levels of VOCs. The presence of similar contaminants in sample HA1175 further suggest that problems associated with field decontamination are the source of the anomalous contaminants in the investigative samples, as discussed in Section 3.2.1.1.6. The results for other blanks do not show any evidence of additional field decontamination problems.

In summary, the groundwater duplicate data show that metals results may lack precision for at least one sampling event (June 21 to 22, 1990). The groundwater QC data suggest that results for chloroform, chlorobenzene, and other volatiles results for the January to March 1990 sampling events reflect field contamination problems for those sampling events. The volatiles data for these two sampling events are, therefore, considered unreliable and have not been considered in the production of contaminant distribution maps.

3.2.5 Comparison of Offpost RI Results and RI Addendum Results

Groundwater data collected since the Offpost OU RI report serve to confirm and add to the data presented in the Final RI report (ESE, 1988a). Data that were collected after the Offpost OU RI have provided additional chemical and geologic data for the UFS and Arapahoe Formation.

Based on these data, new flow pathways have been identified, and plume boundaries have been reassessed and reinterpreted.

Refinements have been made in the understanding of the UFS groundwater flow system offpost. New minor paleochannels have been identified in three areas not previously described. The first of these minor paleochannels is south of and parallel to the First Creek Paleochannel, leading from the NBCS through the southwest corner of Section 14. Analytes reported in this paleochannel include chloroform, chloride, fluoride, DIMP, dieldrin, and endrin. The second of these minor paleochannels, which may be impacted by seasonal fluctuations in water levels in the UFS, is north of the First Creek Paleochannel through a narrow area of saturated alluvium and leads through the area surrounding well 37342 in Section 14. Compounds identified in this second paleochannel include arsenic, TCLEE, DIMP, and dieldrin. The third minor paleochannel is an eastern arm or tributary to the Northern Paleochannel in Section 12. This paleochannel was identified based on an evaluation of geologic and groundwater quality data from three new RI Addendum monitoring wells. Compounds identified in these wells include chloroform, DBCP, and DIMP.

On the basis of data collected after the Final RI, contaminant plume boundaries have been revised. The distribution of DIMP, identified in the Final RI report as two distinct plumes, is now interpreted as one plume of low concentration extending from the Northwestern Paleochannel to the Northern Paleochannel with higher concentrations corresponding to the First Creek and Northern Paleochannels. This reinterpretation of the extent of DIMP contamination offpost is a function of a considerably lower CRL used in this RI Addendum report. The distribution of dieldrin offpost of the RMA northwest boundary has been modified based on analytical results for newly installed monitoring wells.

A comparison of previous and current data indicates that for several compounds such as DIMP, DCPD, chlorobenzene, and chloroform, the NBCS has apparently been successful in decreasing concentrations at and near the RMA north boundary. The trailing edges of these plumes have moved as much as approximately 1500 feet downgradient from their previous

positions as reported in the Final RI. Also, downgradient from the RMA north boundary, new data indicate two isolated detections of DCPD in the Northern Paleochannel, whereas none were reported in the Final RI.

For the area between the RMA north boundary and O'Brian Canal, new data seem to support the idea stated in the Final RI that leakage from the canals has a diluting effect on groundwater. Concentrations of nearly all contaminant plumes mapped in this area decrease significantly at approximately O'Brian Canal or Burlington Ditch. Downgradient from the RMA northwest boundary, this dilution effect is not as obvious, which suggests that canal leakage is less appreciable in this area.

3.3 CONCLUSIONS

Potentiometric data collected since the Offpost OU RI are very similar to previous data, with the exception of higher water levels immediately downgradient from the NBCS. This is interpreted as an effect of the recently installed recharge trenches at the NBCS. Unconfined groundwater flows from RMA toward the north and northwest along areas of saturated alluvium known as the Northern, First Creek, and Northwest Paleochannels, as well as two unnamed minor paleochannels south and north of the First Creek Paleochannel. Confined groundwater in the Arapahoe Formation also flows northwest, although it is not directly hydraulically connected to the UFS.

Unconfined groundwater contamination and migration generally occur within the paleochannels mentioned above because of the relatively high hydraulic conductivities of the materials in those areas. Available data indicate that much of the contamination observed offpost was introduced before the NBCS and NWBCS were installed; however, recent data suggest that before recent upgrades of the NBCS and NWBCS, these two systems were not completely effective in halting offpost migration of contaminants in the UFS. Recent data indicate that contaminant levels downgradient from the NBCS are lower, suggesting that the boundary system is performing as it should. Data from the NWBCS suggest improved performance of this system.

The highest contaminant levels downgradient from the NBCS occur upgradient of O'Brian Canal. Certain volatile compounds such as chlorobenzene, chloroform, trichloroethene, and DBCP were detected at low concentrations downgradient from the canals, but well-defined plumes do not exist in this area. Semivolatile organic compounds such as dieldrin and other organochlorine pesticides are present almost exclusively upgradient from the canals.

Contamination downgradient from the NWBCS consists mainly of chlorobenzene, chloroform, DIMP, and dieldrin. The highest concentrations of chloroform occur downgradient of the RMA boundary, which suggests that the NWBCS is being relatively ineffective in reducing levels of chloroform, but appears to be an effective barrier to offpost migration of other volatiles. Semivolatiles such as dieldrin and possibly DIMP appear to have been bypassing the system on the south side. NWBCS upgrades and operational changes have been implemented to alleviate this problem. The canals seem to have no dilution effect on contamination levels in this area. Recent modifications to the NBCS and NWBCS are expected to have a significant impact on reducing downgradient contaminant levels.

The most widespread RMA-related groundwater contaminant in the Offpost OU is DIMP, which is present at low concentrations in a band from the west end of the NWBCS to the east end of the NBCS, and from the RMA boundaries to the South Platte River. The other major contaminants present in the Offpost OU are chloroform, chlorobenzene, TRCLE, TCLEE, DBCP, dieldrin, endrin, DCPD, arsenic, chloride, and fluoride.

4.0 SURFACE-WATER MONITORING RESULTS AND ASSESSMENT

This section presents a discussion of surface-water quality data developed under the RI Addendum program for the Offpost OU. The principal purpose of this section is to present the current understanding of the surface-water hydrologic system and the nature and extent of contamination in the surface-water medium in the Offpost OU. Section 4.1 presents a discussion of the nature and extent of surface-water contamination.

The first portion of Section 4.1 presents a brief overview of interpretations contained in the Final RI. Following this overview, new analytical data, which have been developed through analysis of additional surface-water samples collected during Offpost OU RI Addendum activities, are presented and discussed. Sections 4.2 and 4.3 present an assessment of the analytical results for GC/MS and QA/QC samples. Section 4.4 presents a more detailed comparison of RI Addendum results with those from the Final RI and more recent CMP reports. Section 4.5 presents conclusions about the extent of surface-water contamination in the Offpost OU. Data used in this assessment are contained in Appendix C.

4.1 NATURE AND EXTENT OF SURFACE-WATER CONTAMINATION

This section describes the concentrations and distributions of target analytes detected in surface-water samples collected in the Offpost OU. Eighteen surface-water samples were collected from 15 locations along First Creek, Burlington Ditch, O'Brian Canal, and Barr Lake as shown in Figure 2.3. Surface-water samples were collected in two sampling episodes. The first episode was conducted during November 1988 and consisted of six samples collected between 96th Avenue and the First Creek Impoundment. The second episode occurred between May and June 1990 and consisted of nine samples collected from First Creek, Burlington Ditch, O'Brian Canal, and Barr Lake. The surface-water sampling locations were collocated with sediment sampling locations (Section 5.0). Data discussed in this section have been accepted by PMRMA for inclusion in the RMA database.

The sources of surface-water contamination in the various surface-water bodies in the Offpost OU were presented in the Final RI. However, additional details regarding operation of the surface water, particularly the surface-water system, is presented below. A pipe connects O'Brian Canal and Burlington Ditch and is used infrequently to transfer water from O'Brian Canal to Burlington Ditch. Although adequate records regarding the infrequent use of the pipe are not available, the pipe was reportedly used only once during the past three years. During surface-water sampling conducted under the RI Addendum, this pipe was not in use.

Interaction between the groundwater and surface-water systems may also be a mechanism for contaminants entering O'Brian Canal or Burlington Ditch. This mechanism was investigated and reported in the Final RI. Based on survey information that showed that the bottom of the canal and ditch were above the groundwater surface in the UFS, it appears unlikely that groundwater could be entering the canal or ditch. However, in some areas, the bottom of the Burlington Ditch appears to be much lower than the levels reported in the Final RI. Based on a review of aerial photographs, the area along Burlington Ditch in the northwestern corner of Section 14 appears to contain water even when no flows are occurring in the ditch. This appears to be a result of a lower bottom elevation than in adjacent areas of the ditch. This could be an additional mechanism for the observed concentrations of typical groundwater contaminants in surface-water samples.

4.1.1 Organic Compounds

The Final RI reported that the majority of organic contamination observed in offpost surface water was directly attributable to groundwater discharge to surface water, particularly in the vicinity of the confluence of First Creek and O'Brian Canal. The surface-water samples collected from First Creek in this vicinity (sampling station 14BDD) generally contained the greatest number of contaminants and at the highest concentrations. DIMP was the most commonly detected contaminant and was found in all samples collected from First Creek at station 14BDD.

The highest concentration of DIMP was 550 $\mu\text{g/l}$, which was detected in a sample collected

from station 14BDD. At other sampling stations, concentrations of DIMP that were reported in the Final RI ranged from below CRLs to a maximum of 22 $\mu\text{g/l}$. The number of samples collected from each sampling station reported in the Final RI ranged from three to nine. The average number of samples from each station was approximately seven.

The following contaminants were detected in samples that were presented in the Final RI:

- DIMP
- Aldrin
- Dieldrin
- CPMSO2
- 1,4-Dithiane
- 12DCLE
- DCPD
- Chloroform
- Benzene
- TCLEE
- 12DCE
- Endrin

However, these contaminants were generally found only sporadically. With the exception of DIMP, 1,4-dithiane, DCPD, and TCLEE, these compounds were not detected in more than one sample collected from each station. TCLEE was detected in three of eight samples collected from a sampling station located along the South Platte River approximately 2 miles upstream of the southern boundary of the Offpost OU.

Data presented in the Final RI demonstrate that the occurrence of contaminants in offpost surface water is limited. DIMP was the only compound frequently detected in offpost surface-water samples. The distribution of DIMP and a few other contaminants is clearly associated with groundwater discharging to surface water along First Creek in the vicinity of the confluence with O'Brian Canal. The relationship between contaminant distribution and groundwater/surface-

water interactions is discussed in detail in the Surface-Water CMP reports for FY 1988 (RLSA, 1990b) and FY 1989 (RLSA, 1990a).

The following organic compounds were detected in offpost surface-water samples collected during RI Addendum activities:

- DIMP
- DMMP
- Dieldrin
- CPMSO₂
- CPMSO
- Chloroform
- 1,4-Dithiane
- Atrazine
- Chlordane
- DCPD
- DDT
- DDE

The surface-water sampling results are provided in Appendix C. The distribution of organic compounds detected above CRLs in samples collected in November 1988 and from May to June 1990 are shown on Figures 4.1 and 4.2, respectively. A comparison of these data with those from the Final RI shows that the suite of organic compounds detected in surface water offpost are similar to those observed in the samples collected during the Final RI. The samples collected from the reach of First Creek between the northern RMA boundary and the confluence with O'Brian Canal showed the greatest number of contaminants. Concentrations of most contaminants were generally highest in this area.

DIMP was the organic compound most frequently detected in offpost surface water. DIMP was also the most widely distributed compound and was detected in 12 surface-water samples collected from First Creek, O'Brian Canal, and Burlington Ditch at concentrations ranging from

0.532 to 59.0 $\mu\text{g/l}$. DIMP concentrations averaged approximately 5 $\mu\text{g/l}$ in samples collected from First Creek during November 1988, except sample HA0980SW, which contained DIMP at 13.1 $\mu\text{g/l}$. The highest concentration of DIMP, 59.0 $\mu\text{g/l}$, was observed in sample HA1154SW collected in the May to June 1990 sampling event from First Creek near the confluence with O'Brian Canal.

DIMP was not detected in samples collected from Burlington Ditch or O'Brian Canal at locations sampled upstream from the First Creek confluence. The maximum concentration of DIMP detected in surface water is considerably lower than the maximum DIMP concentration reported in the Final RI. Although concentrations in surface water are considerably lower than groundwater concentrations, the observed decreases in surface-water samples generally reflect the decreasing concentrations of DIMP in groundwater in the First Creek Paleochannel. The CMP report for FY 1990 (RLSA, 1991a) also clearly demonstrates these decreases in DIMP concentrations over the past 10 years.

The occurrence of DMMP was limited to surface-water samples collected in November 1988 from First Creek. Concentrations of DMMP in these samples ranged from 0.209 to 4.92 $\mu\text{g/l}$, but were less than 0.26 $\mu\text{g/l}$ for all samples, except sample HA0980SW, which contained DMMP at a concentration of 4.92 $\mu\text{g/l}$. DMMP was not detected in any of the samples collected from May to June 1990. DMMP was not reported in groundwater or surface-water samples data presented in the Final RI.

The CRL for DMMP reported in the Final RI was 16.3 $\mu\text{g/l}$, which is considerably higher than the levels detected in the surface-water samples collected during RI Addendum activities. In general, DMMP was not consistently detected in surface-water samples, and no pattern of DMMP in the surface-water hydrologic system is observed. DMMP has not been consistently detected in UFS groundwater. Over the past six years, DMMP has been detected in only a few UFS groundwater samples. The distribution of DMMP in surface water does not appear to be related to discharges of alluvial groundwater. On the basis of these data, the detectable levels of DMMP in

the surface-water samples are considered sporadic and not an indication of DMMP contamination in the Offpost OU.

Other organic compounds were also detected in surface-water samples, but they were detected in only one or two samples and were generally observed in samples in which DIMP was also detected. The greatest number and highest concentrations of organic compounds were detected in samples collected from First Creek between the northern RMA boundary and O'Brian Canal. RMA-related organic compounds were not detected in samples collected from O'Brian Canal upstream of the confluence of First Creek. Additionally, organic compounds were also not detected in sample HA1160SW, which was collected from the Burlington Ditch. Caprolactum, which is a suspected laboratory contaminant, was detected in two samples from O'Brian Canal at concentrations of 7.70 and 10.0 µg/l, respectively.

In general, the concentrations of organic compounds detected in offpost surface-water samples are highest in First Creek near O'Brian Canal. Sample HA1154SW, which was collected near the confluence of First Creek with O'Brian Canal, contained the highest observed concentrations of most of the organic compounds. This sample was collected from the reach of First Creek where surface-water and groundwater interaction is believed to occur. The nature and extent of organic compounds in surface water in the Offpost OU is generally consistent with the occurrence of those analytes detected in groundwater, particularly in the First Creek area.

As noted in the Final RI and the Surface-Water CMP report for FYs 1988 and 1989, groundwater discharging to surface water in this area is the principal contaminant source in the surface-water hydrologic system offpost. Analytical results for a few contaminants, including CPMSO, CPMSO₂, and DMMP, are not consistent with previous surface-water data or with previous or current groundwater data. These results are considered anomalous.

The occurrence of RMA-related organic contaminants in First Creek, Burlington Ditch, and O'Brian Canal suggests that RMA is the source of these contaminants in offpost surface water. Additionally, the absence of these compounds in samples collected from Burlington Ditch and

O'Brian Canal upstream of First Creek also suggests an upstream source of contaminants to the ditch and canal does not exist.

4.1.2 Inorganic Constituents

The Final RI reported results for inorganic analyses conducted on surface-water samples collected from the Offpost OU. The inorganic target analytes for the Final RI are slightly different than those for which analyses were performed during RI Addendum activities. The principal difference is the addition of cyanide and nitrate-nitrite to the target analyte list for the RI Addendum. The addition of these two analytes has not considerably changed any previous interpretations regarding the nature and extent of inorganic contamination in the surface-water hydrologic system offpost.

The following inorganic constituents were detected in surface-water samples collected during RI Addendum activities between November 1988 and from May to June 1990:

- Arsenic
- Calcium
- Chloride
- Cyanide
- Fluoride
- Magnesium
- Mercury
- Nitrite-nitrate
- Potassium
- Sodium
- Sulfate
- Zinc

Inorganic constituents detected during RI Addendum activities were similar to those reported in the Final RI. A few constituents, including arsenic, calcium, chloride, fluoride,

magnesium, mercury, sodium, and sulfate, occurred at concentrations exceeding typical concentrations reported in the Final RI report. Most of these higher concentrations occurred in samples collected from First Creek along the reach between the northern RMA boundary and the First Creek confluence with O'Brian Canal. This pattern is generally consistent with that reported in the Final RI and Surface-Water CMP report for FYs 1988 and 1989, which commonly reported the maximum concentrations of major inorganic constituents along First Creek at the northern RMA boundary or near the confluence with O'Brian Canal.

Arsenic was detected in six of the seven samples collected from First Creek at concentrations ranging from 2.78 to 280 $\mu\text{g/l}$. Arsenic was not detected in sample HA0973SW. Arsenic concentrations reported for samples HA0971SW and HA0980SW were 280 and 20.9 $\mu\text{g/l}$, respectively, which are generally higher than historically observed for this area. The maximum concentrations of arsenic are commonly found in surface-water samples collected from First Creek immediately downstream of the Onpost Sewage Treatment Plant. Arsenic values for that location reported in the Surface-Water CMP report for FY 1989 were approximately 30 $\mu\text{g/l}$. The arsenic concentration of 280 $\mu\text{g/l}$ for sample HA0971SW is considerably higher than historically reported for this area. This value is considered anomalous and not considered representative of surface-water conditions in the Offpost OU. The concentration of arsenic in other samples from First Creek did not considerably exceed the CRL. Other metals concentrations were also elevated in this sample and may reflect problems associated with field filtering of the sample.

Arsenic was detected in only 2 of 11 samples collected from Burlington Ditch, O'Brian Canal, and Barr Lake. The concentrations of arsenic in samples HA1197SW and HA1196SW, which were collected from O'Brian Canal upstream and downstream of the confluence with First Creek, were the same, at 2.82 $\mu\text{g/l}$.

Mercury was detected above the CRL in only one of the First Creek samples at the confluence of First Creek with O'Brian Canal. This sample, HA1154SW, contained mercury at a concentration of 0.393 $\mu\text{g/l}$, approximately four times higher than the CRL of 0.100 $\mu\text{g/l}$. Mercury was detected above the CRL in one sample, HA1160SW, collected in Burlington Ditch

upstream of First Creek. Mercury was consistently detected above the CRL in samples collected from Burlington Ditch upstream of First Creek to Barr Lake, at concentrations ranging from 0.230 to 0.557 $\mu\text{g/l}$. The highest concentrations of mercury were detected in the duplicate sample from Barr Lake and a sample from Burlington Ditch near the crossing with Second Creek at concentrations of 0.538 and 0.557 $\mu\text{g/l}$, respectively.

Cyanide was detected only in sample HA0971SW at a concentration of 12.3 $\mu\text{g/l}$. This was the only occurrence of cyanide and is considered anomalous and not representative of surface-water conditions in the Offpost OU. As noted above, the analytical results for this sample may represent problems associated with field filtering of the sample. Nitrate-nitrite was detected in 17 surface-water samples at concentrations ranging from 108 to 3300 $\mu\text{g/l}$. As these data show, nitrate-nitrite concentrations are relatively low and are consistent among sampling locations.

The results for other target analytes were generally consistent with those reported in the Final RI. However, a few inorganic constituents that were infrequently detected in samples reported in the Final RI, including cadmium, chromium, copper, and lead, were not detected in samples collected during RI Addendum activities. This difference could be attributable, in part to slight increases in the CRLs for these inorganic constituents. Additionally, as noted below, the distribution of these constituents is sporadic, and no evidence of discharges from RMA is observable. The highest concentrations of cadmium, chromium, and copper reported in the Final RI were detected in samples collected from the South Platte River northwest of the city of Brighton and outside of the Offpost OU. This distribution, which was reported in the Final RI, suggests that the occurrence of these constituents in offpost surface water is not related to releases from RMA.

4.2 SUMMARY OF GAS CHROMATOGRAPHY/MASS SPECTROSCOPY RESULTS

GC/MS analyses were performed on two surface-water samples to confirm results obtained by GC analyses. Samples HA1190SW and HA1191SW are GC/MS samples for surface-water samples HA1185SW and HA1196SW, respectively. Results for the GC/MS analyses are provided in Appendix C.

Sample HA1185SW and associated GC/MS sample HA1190SW did not have detections of organic compounds above CRLs.

Atrazine was detected above the CRL at a concentration of 4.13 $\mu\text{g/l}$ in sample HA1196SW. Results for associated GC/MS sample HA1191SW did not confirm the atrazine detection in sample HA1196SW. The CRL for atrazine analyzed by the GC/MS method is 5.90 $\mu\text{g/l}$, which is higher than the atrazine detection of 4.13 $\mu\text{g/l}$ in sample HA1196SW.

4.3 SUMMARY OF QUALITY ASSURANCE/QUALITY CONTROL RESULTS

QA/QC samples collected for the surface-water sampling program consisted of two duplicate samples. The results for the duplicate samples, with associated investigative samples noted, are listed in Appendix C. The analytical results for duplicate pairs were reviewed with respect to the compounds detected. Table 4.1 presents the calculated DSA percentage between concentrations of detected compounds. As shown in the table, DSA results are reasonable, with most of the values less than 10 percent. The highest DSA value, approximately 52 percent, is for mercury. However, considering that the concentration of mercury is less than 1 $\mu\text{g/l}$, these results are considered acceptable.

4.4 COMPARISON OF OFFPOST REMEDIAL INVESTIGATION AND REMEDIAL INVESTIGATION ADDENDUM RESULTS

A comparison of organic compounds reported for surface-water samples collected during the Final RI and RI Addendum activities indicates that, in general, the types of organic compounds detected in RI Addendum surface-water samples are similar to those reported in the Final RI. The most frequently detected compound reported in the Final RI was DIMP, with other organic compounds detected infrequently. The most frequently detected compound during the RI Addendum activities was also DIMP, with only one or two other organic compounds detected in the samples.

Several compounds, which were detected in surface-water samples collected during RI Addendum activities, including atrazine, chlordane, DDT, DDE, DMMP, and CPMSO, were not detected in surface-water samples collected during the Final RI. Aldrin, tetrachloroethene, and

1,2-dichloroethane were not detected during the RI Addendum activities but were reported in the Final RI. Organic compounds were not detected in the samples collected during RI Addendum activities from Barr Lake. Six samples were collected from Barr Lake during Final RI activities; DIMP was detected only once, however, at a concentration of 11.7 $\mu\text{g/l}$. The infrequent occurrence of DIMP in samples from Barr Lake suggests this single occurrence is not representative of site conditions.

For target analytes reported in the Final RI and RI Addendum, the concentrations of organic compounds detected in samples collected during RI Addendum activities are generally lower than concentrations reported in the Final RI. Analytical results for seven samples collected from First Creek near the confluence with O'Brian Canal (station 14BDD) reported in the Final RI showed DIMP concentrations ranging from 69.8 to 550 $\mu\text{g/l}$. Sample HA1154SW collected during RI Addendum activities near station 14BDD, contained DIMP at a concentration of 59.0 $\mu\text{g/l}$. This concentration was the highest level of DIMP detected in samples collected during RI Addendum surface-water sampling and was 10 times higher than the next highest DIMP concentration (5.90 $\mu\text{g/l}$ in sample HA0973SW). The observed decreases in DIMP concentrations depicted by these data are supported by the data in the Surface-Water CMP report for FYs 1988 and 1989, which show DIMP at 135 $\mu\text{g/l}$ and 88 $\mu\text{g/l}$, respectively.

DCPD shows a similar trend in concentration between those concentrations presented in the Final RI and concentrations reported in this report. In the Final RI, DCPD was detected in two of seven Offpost OU RI samples collected at station 14BDD, which is located on First Creek near the confluence with O'Brian Canal. Concentrations of DCPD in those samples were 24.1 and 31.5 $\mu\text{g/l}$. Sample HA1154SW, which was collected during RI Addendum activities, contained DCPD at a concentration of 7.43 $\mu\text{g/l}$. DCPD was not detected in any other offpost surface-water samples collected during the RI Addendum activities. The levels of DCPD detected in RI Addendum samples are generally consistent with those levels reported in the Surface-Water CMP for FYs 1988 and 1989.

CPMSO and CPMSO₂ were detected in samples collected from First Creek along the reach between 96th Avenue and Peoria Street. CPMSO was detected in sample HA0979SW at a concentration of 120 µg/l. CPMSO₂ was detected in two surface-water samples collected from First Creek. Samples HA0977SW and HA0979SW contained CPMSO₂ at 19.4 and 170 µg/l, respectively. These levels are considerably higher than historical levels for surface water in the Offpost OU. CPMSO was not detected in any surface-water samples reported in the Final RI. CPMSO₂ was detected in a single sample reported in the Final RI. The CPMSO₂ concentration for that sample, which was collected from station 14BDD, was 5.20 µg/l.

CPMSO and CPMSO₂ were reported above the CRL for only a few surface-water samples reported in the Surface-Water CMP for FY 1989 (RLSA, 1991b). On the basis of their sporadic occurrence in samples collected during RI Addendum activities, and considering the infrequent occurrence of these compounds reported in the Final RI and the Surface-Water CMP reports for FYs 1988 and 1989, CPMSO and CPMSO₂ are considered isolated detections of organic compounds in offpost surface water.

The isolated occurrence of CPMSO and CPMSO₂ in surface water may be related to interactions between groundwater and surface water along First Creek. Although the highest concentrations of CPMSO are generally limited to the Northern Paleochannel, CPMSO was detected in wells along First Creek west of Peoria Street. CPMSO₂ was generally found along First Creek near the confluence with O'Brian Canal. The distribution of CPMSO and CPMSO₂ in UFS groundwater was discussed in Section 3.2.1.1. According to the Surface-Water CMP for FYs 1988 and 1989, organosulfur compounds were not detected in surface-water samples collected along onpost or offpost reaches of First Creek. Considering the interaction of groundwater and surface water north of RMA, the occurrence of these organosulfur compounds is likely the result of groundwater discharge to First Creek in the Offpost OU.

A comparison of inorganic constituents detected in surface-water samples reported in the Final RI and those collected during RI Addendum activities indicates that, in general, slight increases in concentrations of calcium, chloride, fluoride, sodium, magnesium, and sulfate are

apparent in samples collected during the RI Addendum activities. These small increases may be partially related to analytical variability. The highest concentrations of inorganic constituents detected in offpost surface-water samples occur between the northern RMA boundary and the confluence with O'Brian Canal. Sample HA0971SW had the highest concentrations of inorganic constituents detected in the First Creek samples and may reflect problems associated with field filtering of the sample as previously noted.

Arsenic and mercury were only sporadically observed in surface-water samples reported in the Final RI. During the RI Addendum activities, arsenic at concentrations ranging from 2.78 to 280 $\mu\text{g/l}$ was consistently detected in samples collected from First Creek, although only one value was reported above 20.9 $\mu\text{g/l}$. Arsenic was detected in 2 of 11 samples collected from Burlington Ditch and O'Brian Canal. During RI Addendum activities, mercury was consistently detected at concentrations ranging from 0.230 to 0.557 $\mu\text{g/l}$ in samples collected from Burlington Ditch, O'Brian Canal, and Barr Lake. Mercury was detected at a concentration of 0.363 $\mu\text{g/l}$ in sample HA1154SW collected from First Creek.

One possible explanation for the apparent increase in the occurrences of arsenic and mercury in surface-water samples collected offpost during the RI Addendum is that the CRLs are currently lower than the CRLs reported in the Final RI. The CRL for arsenic decreased from approximately 3.00 $\mu\text{g/l}$ during the Offpost OU RI analytical activities to 2.35 $\mu\text{g/l}$ during the Offpost OU RI Addendum analytical activities. The CRL for mercury decreased from 0.240 $\mu\text{g/l}$ during Final RI to 0.100 $\mu\text{g/l}$ reported in the RI Addendum.

4.5 CONCLUSIONS

RI Addendum results for surface water indicate the presence of DIMP, OCPs, arsenic, and mercury, and slightly increased concentrations of some inorganic constituents. The greatest number and highest concentrations of DIMP and OCPs occur in the reach of First Creek between the northern RMA boundary and the confluence with O'Brian Canal. The highest concentrations of DIMP and OCP compounds were observed in sample HA1154SW, near the confluence of First Creek with O'Brian Canal.

Groundwater and surface-water interaction is known to occur in the reach of First Creek between the northern RMA boundary and the confluence of First Creek with O'Brian Canal. This interaction has been discussed and documented in a number of reports, including the Final RI and the Surface-Water CMP report for FYs 1988 and 1989. Comparison of the organic compounds and concentrations detected in surface-water samples with those detected in groundwater samples collected in the vicinity of this reach of First Creek supports the conclusion that contaminated groundwater discharging into First Creek may be the source of organic and inorganic contamination of surface water.

The organic contamination observed in O'Brian Canal may be attributed to contaminated surface water from First Creek, which resulted from an influx of contaminated groundwater to the surface water in First Creek. The decrease in the number and concentrations of organic compounds in Burlington Ditch and O'Brian Canal indicate that dilution of the contaminants occurs when water enters Burlington Ditch and O'Brian Canal.

The patterns of surface-water contamination observed from samples collected during RI Addendum activities are consistent with those reported during the Final RI and support the conclusion that surface-water organic compound contamination is the result of contaminated groundwater discharging to First Creek. This mechanism also appears to be responsible for elevated concentrations of some inorganic constituents, including chloride and fluoride. The occurrence of DIMP in Burlington Ditch samples may be the result of minor interactions between surface water and groundwater in this area.

The distribution of arsenic and mercury in the RI Addendum surface-water samples indicates potential sources other than groundwater discharging to First Creek. Arsenic was observed in all samples collected from First Creek, and from two samples, HA1197SW and HA1196SW, collected from O'Brian Canal, upstream and downstream of First Creek, respectively. Because the concentrations of arsenic detected in groundwater samples in the vicinity of First Creek are lower than the concentrations detected in surface-water samples, groundwater does not appear to be a probable source for arsenic detected in surface water. Analytical results presented

in the Surface-Water CMP for FYs 1988 and 1989, showed arsenic at concentrations that appear to support a potential source of arsenic transported from RMA onpost.

Samples collected during the Spring and Fall of 1990 suggest that the source of arsenic in offpost surface water may be discharges from the Onpost Sewage Treatment Plant. The high arsenic concentrations noted in samples HA0979SW (280 $\mu\text{g/l}$) and HA0980SW (20.9 $\mu\text{g/l}$) appear to be anomalous and not representative of typical conditions offpost.

The distribution of mercury in offpost surface water suggests a source upstream of First Creek, possibly in Burlington Ditch. Mercury was consistently detected in several samples collected from Burlington Ditch and in one sample upstream of the confluence with First Creek.

In general, the data collected during the RI Addendum activities support the conclusions presented in the Final RI regarding the occurrence of contaminants and possible mechanisms to explain surface-water contamination in the Offpost OU. The presence of some organic compounds reported in the Final RI were confirmed by samples collected during RI Addendum activities. Concentrations of organic compounds were generally lower in samples collected during the RI Addendum. The inorganic constituents were generally detected at slightly higher concentrations during the RI Addendum than were reported in the Final RI. The overall conclusion made during the Final RI that groundwater discharge appears to be contributing to the organic and some inorganic contaminants to surface water in the Offpost OU is substantiated by data collected during RI Addendum activities.

5.0 STREAM-BOTTOM SEDIMENT MONITORING RESULTS AND ASSESSMENT

This section presents a discussion of the analytical results for stream-bottom sediment samples (sediment) collected in the Offpost OU. The principal purpose of this section is to present the current understanding of the nature and extent of contamination in sediments along principal surface-water bodies in the Offpost OU that may have been affected by contaminant migration from onpost.

Section 5.1 presents (1) the new analytical data for samples collected under the RI Addendum program and (2) a brief overview of interpretations contained in the Final RI. Refinements made to those previous interpretations are presented and discussed. Sections 5.2 and 5.3 present an assessment of the analytical results for GC/MS and QA/QC samples. Section 5.4 presents a more detailed comparison of RI Addendum results with those from the Final RI. Section 5.5 presents conclusions about the extent of sediment contamination in the Offpost OU.

5.1 NATURE AND EXTENT OF STREAM-BOTTOM SEDIMENT CONTAMINATION

This section describes the concentrations and distributions of target analytes detected in sediment samples collected from the major surface-water bodies in the Offpost OU. Samples were collected from First Creek between the northern RMA boundary and O'Brian Canal, Burlington Ditch, the First Creek Impoundment, and Barr Lake. A total of 19 sediment samples were collected from 16 locations in November 1988 and from May to June 1990. The sediment sampling locations were collocated with the surface-water sampling locations. These sampling locations are shown in Figure 2.4. Data discussed in this section have been accepted by PMRMA for inclusion in the RMA database. Data used in this assessment are contained in Appendix D.

The Final RI reported analytical results for two sampling episodes conducted in the Offpost OU. Those previous sampling episodes were conducted in April 1986 and April 1988. Samples were collected from 11 locations during the April 1986 sampling episode. During the April 1988 sampling episode, sediment samples were collected from an additional 9 locations.

5.1.1 Organic Compounds

The Final RI reported that organic compounds were not detected in sediment samples collected in April 1986, although metals were detected in several of the samples. The CRLs for the organic analytes were quite high relative to current CRLs and are considered the principal reason that organic compounds were not detected in the samples. The highest concentrations of metals were detected in samples collected from Barr Lake. Metals detected in the samples collected from Barr Lake include cadmium, chromium, copper, lead, zinc, and mercury. The most frequently detected metals were chromium, copper, lead, and zinc. Cadmium, arsenic, and mercury were detected in only 1 to 3 of the 11 samples collected in April 1986.

Organic and inorganic analytes were detected in a number of samples collected in April 1988. The organic compounds detected in the samples included DDE, DDT, and dieldrin. These analytes were detected in only a few samples, as discussed below. DDE and DDT were detected in only one sample, which was collected from O'Brian Canal approximately 1 mile upstream of the confluence with First Creek. Dieldrin was detected in two samples collected from O'Brian Canal and one sample from First Creek. Concentrations of these organic analytes ranged from 3.0 to 8.0 $\mu\text{g/kg}$. The CRLs for these samples were generally in the range of 1 to 3 $\mu\text{g/kilograms (kg)}$, although a few compounds had much higher CRLs, with the CRL for CPMSO₂ as high as 2,870 $\mu\text{g/kg}$.

The organic compounds detected in offpost sediment samples collected during RI Addendum activities include aldrin, chlordane, dieldrin, endrin, DDE, DDT, DBCP, and CL6CP. The stream-bottom sediment sampling results are provided in Appendix D. The distribution of organic compounds detected in sediment samples collected in November 1988 and from May to June 1990 are shown in Figures 5.1 and 5.2, respectively.

The distribution of organic compounds in sediment, on the basis of data collected during RI Addendum activities, is discussed below. As noted above, several organic compounds were reported in the Final RI. Although a few additional compounds, including DBCP and CL6CP were detected in sediment samples collected during RI Addendum activities, the types of

compounds were generally those that tend to sorb to sediments. This finding is consistent with the interpretations contained in the Final RI. DBCP was detected in two samples collected from along the First Creek Paleochannel. The occurrence of DBCP in these samples is considered to be related to a groundwater DBCP plume in this vicinity. CL6CP was detected at 52.8 $\mu\text{g}/\text{kg}$ in sample HA1192SE, which is a duplicate of sample HA1182SE. CL6CP was not detected in the investigative sample. This sample was located along Burlington Ditch in the vicinity of the confluence with First Creek. Because it was detected in only one sample at a concentration considerably higher than the CRL of 1.4 $\mu\text{g}/\text{kg}$ and was not detected in the investigative sample or the GC/MS confirmation sample, the occurrence of CL6CP is considered anomalous and not representative of sediment conditions offpost.

Shallow sediment samples, which were collected from the upper 2 inches of sediment, were collected from five locations. These samples were analyzed only for VOCs. The sediment sampling locations where these samples were collected are identified in Appendix D.

Dieldrin was detected in nine stream-bottom sediment samples collected during RI Addendum activities. The highest concentration of dieldrin was 370 $\mu\text{g}/\text{kg}$ in sample HA0972SE, collected from a groundwater seep in First Creek. Dieldrin was detected in three other samples collected in First Creek at concentrations of 25 to 28 $\mu\text{g}/\text{kg}$. Dieldrin was not reported in samples HA0976SE and HA1153SE and may reflect the low sorptive capacity of the sandy sediments at those two locations.

Dieldrin was detected in sample HA1181SE, collected from Burlington Ditch upstream of the First Creek confluence with O'Brian Canal, at a concentration of 6.90 $\mu\text{g}/\text{kg}$. Sample HA1184SE, collected from Burlington Ditch approximately 2.5 miles downstream of the First Creek confluence with O'Brian Canal, contained dieldrin at a concentration of 5.2 $\mu\text{g}/\text{kg}$. Sample HA1159SE, collected from O'Brian Canal, approximately 1 mile downstream of the confluence with First Creek, contained dieldrin at a concentration of 6.20 $\mu\text{g}/\text{kg}$. The sample collected from Barr Lake contained dieldrin at a concentration of 10.2 $\mu\text{g}/\text{kg}$.

These results for dieldrin show a significant decrease in dieldrin concentration with increasing distance from the RMA northern boundary. The highest concentrations of dieldrin occur within approximately 100 feet of the northern RMA boundary, immediately north of the North Bog, which is located onpost in the northwestern corner of Section 24 approximately in the center of the NBCS, as shown in Figure 5.1. Dieldrin concentrations between this location and the confluence with O'Brian Canal are typically approximately 25 $\mu\text{g}/\text{kg}$, although the result for sample HA1153SE, which is located nearest the confluence with O'Brian Canal, was below a CRL of 1.8 $\mu\text{g}/\text{kg}$.

Concentrations in sediment samples collected along O'Brian Canal and Burlington Ditch were similar upgradient and downgradient of First Creek and ranged from below the CRL to approximately 10 $\mu\text{g}/\text{kg}$. These levels strongly suggest that other sources of dieldrin exist in the Offpost OU but that the highest levels of dieldrin occur in First Creek and are associated with transport from RMA.

Endrin was detected in two sediment samples. Sample HA0975SE, which was collected from First Creek upstream of Peoria Street, had a reported endrin concentration of 7 $\mu\text{g}/\text{kg}$. Sample HA1181SE, which was collected from Burlington Ditch upstream of the First Creek confluence with O'Brian Canal, had a reported endrin concentration of 9.2 $\mu\text{g}/\text{kg}$. Both of these results are near the endrin CRLs of 4.7 to 6 $\mu\text{g}/\text{kg}$. Endrin was not detected in samples collected from O'Brian Canal. These data suggest that endrin is not widespread in the offpost sediment. No pattern to the distribution of endrin in offpost sediment can be inferred.

Aldrin was detected in three samples collected from First Creek. Samples HA0975SE, HA0974SE, and HA0981SE had concentrations of aldrin ranging from 4.0 to 14.0 $\mu\text{g}/\text{kg}$. Aldrin was also detected in only one sample collected from Burlington Ditch and O'Brian Canal. Sample HA1184SE, which was collected from Burlington Ditch approximately 2.5 miles downstream of First Creek, reported an aldrin concentration of 10.2 $\mu\text{g}/\text{kg}$. These values suggest aldrin only sporadically occurs in the Offpost OU and that aldrin is not widespread in offpost sediment.

DDE was detected in two samples collected from Burlington Ditch and in one sample collected from Barr Lake. The samples collected from Burlington Ditch, HA1181SE and HA1184SE, contained DDE at concentrations of 9.00 and 6.80 $\mu\text{g}/\text{kg}$, respectively. DDE was detected at a concentration of 6.70 $\mu\text{g}/\text{kg}$ in sample HA1187SE collected from Barr Lake. DDE was not detected in samples collected from First Creek or O'Brian Canal. This distribution suggests that the source for this compound is not RMA.

DDT was detected in six offpost sediment samples. These samples are located in First Creek, O'Brian Canal, Burlington Ditch, and Barr Lake. Only one sample from First Creek, HA0974SE, which was collected from upstream of the First Creek Impoundment had detectable levels of DDT. This sample had a DDT concentration of 22.0 $\mu\text{g}/\text{kg}$. Detectable levels of DDT in O'Brian Canal and Burlington Ditch occurred in samples collected upstream and downstream of First Creek. Concentrations of DDT upstream of First Creek ranged from 6.70 to 14.8 $\mu\text{g}/\text{kg}$. Downstream of First Creek, concentrations ranged from 5.00 to 21.5 $\mu\text{g}/\text{kg}$. Sample HA1187SE, which was collected from Barr Lake, had a DDT concentration of 11.8 $\mu\text{g}/\text{kg}$. These data strongly suggest that the distribution of DDT reflects sources other than RMA. The occurrence of DDT in Burlington Ditch and O'Brian Canal upstream of First Creek and the range of concentration in these samples relative to the levels reported for First Creek also indicate additional sources of DDT.

Chlordane was fairly consistently detected in samples collected from O'Brian Canal and Burlington Ditch but was not detected in sediment samples collected from First Creek. The concentrations of chlordane in samples collected from O'Brian Canal ranged from 37.4 to 77.5 $\mu\text{g}/\text{kg}$. Chlordane was detected in Barr Lake sample HA1187SE at a concentration of 64.5 $\mu\text{g}/\text{kg}$. The highest concentration of chlordane was detected in sample HA1181SE, which is located in Burlington Ditch upstream of First Creek. The data indicate that chlordane is not related to releases from RMA.

DBCP was only detected in two samples collected from First Creek. The highest concentration of DBCP was 240 $\mu\text{g}/\text{kg}$ for sample HA0981SE collected from the First Creek Impoundment.

Sample HA1153SE had a DBCP concentration of 8.80 $\mu\text{g}/\text{kg}$. These data suggest that the DBCP detected in sediment samples from First Creek may be associated with contaminated groundwater discharge from RMA occurring in that area. DBCP was only detected in two sediment samples offpost, suggesting that the distribution of DBCP in the Offpost OU is limited.

5.1.2 Inorganic Constituents

Sediment samples were analyzed for a selected number of metals, as shown in Table 2.4 and Appendix D. The distributions of arsenic and mercury are depicted on Figures 5.1 and 5.2. The distributions of the other metals are not presented in figures but are described below. The distributions of the metals and the range of concentrations are compared to typical values, as shown in Table 5.1.

Mercury was not detected in sediment samples collected from First Creek but was detected in all samples collected from Burlington Ditch, O'Brian Canal, and Barr Lake, as shown in Figures 5.1 and 5.2. The concentrations of mercury ranged from 0.0661 to 1.01 $\mu\text{g}/\text{gram}$ (g). The highest concentration of mercury was detected in sample HA1152SE located on O'Brian Canal 3.5 miles downstream of First Creek. The typical concentration of mercury detected in sediment samples was approximately 0.200 to 0.250 $\mu\text{g}/\text{g}$. The lowest concentration of mercury was 0.0661 $\mu\text{g}/\text{g}$ for sample HA1159SE, which is located on O'Brian Canal 1.5 miles downstream of First Creek. The data clearly indicate that the distribution of mercury is not attributable to releases from RMA.

Arsenic was detected in four sediment samples collected from First Creek and two samples collected from O'Brian Canal, as shown in Figures 5.1 and 5.2. Concentrations of arsenic in First Creek samples ranged from 2.48 to 7.17 $\mu\text{g}/\text{g}$. The highest concentration was for sample HA0972SE, which is located immediately north of the North Bog. The samples collected from O'Brian Canal had arsenic concentrations of 3.26 and 6.59 $\mu\text{g}/\text{g}$. In general, the concentrations of arsenic were fairly consistent for all samples and were only slightly above the CRL of 2.5 $\mu\text{g}/\text{g}$.

Table 5.1 presents a summary of the concentrations of metals commonly reported for uncontaminated fresh-water sediments. This table was previously presented in the Final RI. As

Table 5.1 demonstrates, the levels of mercury and arsenic are consistent with the ranges of concentrations for uncontaminated sediments. Arsenic values clearly fall within the anticipated range. Mercury also falls within the anticipated range of values, with the exception of the reported concentration of 1.01 $\mu\text{g}/\text{kg}$ for sample HA1152SE. All other mercury concentrations fall within the range for uncontaminated fresh-water sediments of 0.1 to 0.5 $\mu\text{g}/\text{g}$.

The concentrations of the other metals were generally higher than the values reported for arsenic and mercury, with the exception of cadmium. Cadmium was only detected in four sediment samples at concentrations ranging from 0.926 to 4.35 $\mu\text{g}/\text{g}$. The CRL for cadmium ranged from 0.740 to 1.20 $\mu\text{g}/\text{g}$. These levels of cadmium exceed the anticipated range, as presented in Table 5.1.

The concentrations of the other metals (chromium, copper, lead, and zinc) detected in samples collected from First Creek fall within the range for uncontaminated sediments. The highest concentrations of these other metals occur in samples collected from O'Brian Canal, Burlington Ditch, and Barr Lake. Chromium concentrations for all samples fall within the range for sediments in Table 5.1. Approximately six to seven of the samples show concentrations for copper, lead, and zinc that exceed the range for uncontaminated sediments in Table 5.1. This distribution of exceedances is systematic and occurs for all three metals in the same six or seven samples. The highest concentration of chromium occurs in sample HA1181SE, which was collected from Burlington Ditch upstream of First Creek. The highest concentrations of copper, lead, and zinc occur in sample HA1152SE, which is located on Burlington Ditch approximately 3.5 miles downstream of First Creek.

The pattern of occurrence of the metals indicates that RMA is probably not the source of inorganic constituents in sediment offpost. Numerous metals detected in samples are highest in the samples that were collected from locations upstream of First Creek or from Burlington Ditch, which receives only minor, if any, flow from First Creek. Examination of the typical ranges of the metals concentrations, as shown in Table 5.1, shows that concentrations in excess of this range do not occur in First Creek sediment samples. The distributions of many of the elevated metals

concentrations suggest that other sources for these metals exist in the Offpost OU. Additionally, information presented in the Final RI shows that concentrations of several metals in sediment samples collected from the South Platte River outside of the Offpost OU also exceeded the anticipated ranges shown in Table 5.1. These data further support offpost sources of metals in addition to RMA.

5.2 SUMMARY OF GAS CHROMATOGRAPHY/MASS SPECTROSCOPY RESULTS

GC/MS analyses were performed (1) to obtain investigative data for analytes for which a certified GC method was not available, and (2) to confirm results attained by GC analyses. GC/MS data and results for confirmation samples, which were collected at two locations, are provided in Appendix D.

The confirmation samples were of limited use because only one organic compound was detected in the corresponding GC investigative sample. DBCP was detected at a concentration of 0.0099 $\mu\text{g/g}$ in sample HA1153SE. The CRL for DBCP by GC/MS method is 0.300 $\mu\text{g/g}$. Because this CRL is higher than the GC sample result, the detected value for DBCP could not be confirmed.

5.3 SUMMARY OF QUALITY ASSURANCE/QUALITY CONTROL RESULTS

QA/QC samples collected for the sediment monitoring program consisted of two duplicate samples. These samples were HA1192SE, a duplicate of HA1193SE; and HA1193SE, a duplicate of HA1187SE.

The agreement between duplicates was generally acceptable, but a few disagreements existed. The DSA for CL6CP in samples HA1192SE and HA1182SE was high at a value of 190 percent as shown in Table 5.2. The compound was detected at a concentration of 52.8 $\mu\text{g/kg}$ in the duplicate, but it was less than the CRL of 1.4 $\mu\text{g/kg}$ in the investigative sample (HA1182SE). Similarly, low levels of dieldrin and TRCLE were reported in the duplicate but not in the investigative sample.

Low levels of chlordane and DDT in sample HA1187SE were unconfirmed in duplicate sample HA1192SE. Additionally, cadmium, DBCP, and endrin were detected in the duplicate but not in the investigative sample. The highest DSA for these samples was 117 percent for DBCP.

5.4 COMPARISON OF REMEDIAL INVESTIGATION RESULTS AND REMEDIAL INVESTIGATION ADDENDUM RESULTS

RI Addendum data confirm the data and interpretations presented in the Final RI. Data presented in the RI Addendum indicate endrin, aldrin, chlordane, DBCP, and arsenic were detected at concentrations above the CRL in several samples. These compounds were not detected in stream-bottom sediment samples collected during the Final RI. The compounds DDE and DDT were detected in samples collected during the RI Addendum at higher concentrations and in more locations than in samples collected during the Final RI. Several of these discrepancies may be explained by the use of lower CRLs for RI Addendum analytical activities than were used in the Final RI. Other discrepancies may be explained by increased sampling density during the RI Addendum, especially in the area immediately north of 96th Avenue.

5.5 CONCLUSIONS

The RI Addendum data, combined with Final RI data, indicate that First Creek may be a source of downstream stream-bottom sediment contamination for dieldrin, aldrin, DDT, DBCP, and arsenic. This finding is supported by the presence of relatively higher concentrations of the constituents in First Creek near RMA and decreased concentrations or nondetections farther from RMA.

Alternate or additional sources of contamination for the constituents dieldrin, DDT, chlordane, and mercury are suggested by their occurrence upstream of First Creek. The presence of these constituents in the canals upgradient from the First Creek confluence, and by their generally infrequent occurrence or absence or relatively low concentrations in First Creek area samples indicates that RMA is not the only source for these contaminants in stream-bottom sediments in the Offpost OU. The distribution of DDE, and its absence in samples from First Creek, suggests that RMA is not the source of DDE in Offpost OU sediment. The extremely

limited occurrence of endrin in sediment samples suggests that the distribution of endrin is quite limited and may not be associated with releases from RMA.

Possible mechanisms for contaminant transport via First Creek include (1) contaminated groundwater seepage into First Creek, (2) introduction of constituents to First Creek before it exits RMA, and (3) windblown transport of contaminated dust particles from RMA to the course of the creek.

6.0 SURFICIAL AND SUBSURFACE SOIL MONITORING RESULTS AND ASSESSMENT

This section presents a discussion of the chemical quality of surficial and subsurface soil samples collected in the Offpost OU. The concentrations and distributions of organic compounds and inorganic constituents detected in these samples are presented and described. The results of the analyses of QA/QC samples and GC/MS confirmation samples are also presented. A comparison of data is presented and evaluated for RI Addendum samples and those collected by CDH in the 96th Avenue residential area and other CDH samples collocated with HLA samples.

6.1 NATURE AND EXTENT OF SURFICIAL AND SUBSURFACE SOIL CONTAMINATION

This section describes the concentrations and distributions of target analytes detected in surficial and subsurface soil samples collected in the Offpost OU to the west, north, and east of RMA and to the east. The surficial and subsurface soil data consist of results for 80 samples, including eight duplicate and four background samples, collected between February 1989 and July 1990. An additional 19 samples, including two duplicate samples, were collected in May 1991 to confirm some isolated occurrences of anomalously high concentrations for a few target analytes. With the exception of the data for the 12 CDH samples collected in the vicinity of the 96th Avenue residential area, all data discussed in this section have been accepted by PMRMA for inclusion in the RMA database. Data used in this assessment are contained in Appendixes E, G, and H.

6.1.1 Surficial Soil

Surficial soil samples, which consist of the upper 2 inches of soil, were collected and analyzed for organochlorine pesticides, arsenic, and mercury. The sample locations are shown in Figures 2.5, 2.6, and 2.7. The following sections describe the distributions of the OCPs and metals detected in the surficial soil samples.

6.1.1.1 Organic Compounds

The organochlorine pesticides DDT, DDE, aldrin, chlordane, dieldrin, endrin, HCCPD, and isodrin were detected in surficial soil samples collected in the Offpost OU. Appendix E lists the surficial soil sampling results for samples collected by HLA. Analytical results for samples collected and analyzed by CDH are presented in Appendix G. Data generated in the surficial soil sample collection effort in May 1991 by WCFS are contained in Appendix H.

The distribution of the organic compounds and metals in surficial soil is shown in Figures 6.1, 6.2, and 6.3. As the figures show, the most widespread and frequently detected OCP compound was dieldrin. Aldrin, endrin, DDT, and DDE were also frequently detected and generally occurred in samples in which dieldrin was also detected. Dieldrin was detected in approximately 90 percent of the samples at concentrations ranging from 2.20 to 250 $\mu\text{g}/\text{kg}$. DDT was detected in approximately 50 percent of the samples at concentrations ranging from 2.80 to 790 $\mu\text{g}/\text{kg}$. Aldrin, endrin, and DDE were each detected in 20 to 30 percent of the samples.

The concentrations of endrin and DDE ranged broadly. Aldrin concentrations ranged from 3.2 to 7.2 $\mu\text{g}/\text{kg}$, with a median of approximately 5 $\mu\text{g}/\text{kg}$. Endrin concentrations ranged from 5.1 to 390 $\mu\text{g}/\text{kg}$. However, the median value for endrin was less than 10 $\mu\text{g}/\text{kg}$. The highest concentration of endrin occurred in a soil sample collected from a residence about 0.5 mile north of RMA. This high result for endrin is probably associated with past pesticide application by the former resident and not with migration from RMA.

DDE concentrations were slightly higher than concentrations of endrin. The concentration range for DDE was 4 to 260 $\mu\text{g}/\text{kg}$. The median concentration of DDE was about 25 $\mu\text{g}/\text{kg}$. The highest concentrations of DDE were detected in samples collected from Section 10, approximately 1.5 miles north of RMA. The three highest concentrations of DDE detected in the Offpost OU, which range from 130 to 260 $\mu\text{g}/\text{kg}$, occur in this area. These data suggest a local source of DDE that is not related to RMA.

As discussed below, the remaining OCPs, chlordane, HCCPD, and isodrin, were sporadically detected in 10 percent or fewer of the samples. Chlordane was detected in only five samples at

concentrations ranging from 42.0 to 520 $\mu\text{g}/\text{kg}$. Chlordane was detected only in the area immediately north of RMA, in the 96th Avenue residential area. This compound is contained in commercially available pesticides and is known to have been applied by landowners at several of the 96th Avenue properties. The highest concentration is associated with application of this compound by a former resident.

HCCPD was detected in only two samples located north of the RMA boundary in Sections 11 and 13. Concentrations of HCCPD in those two samples were 2.7 and 20.3 $\mu\text{g}/\text{kg}$. Isodrin was reported in five samples collected from north of RMA. The concentrations of isodrin ranged from 2.2 to 3.50 $\mu\text{g}/\text{kg}$.

The distributions of OCPs in the Offpost OU appear to generally correlate with the trend observed in wind patterns at RMA, although a number of these compounds clearly have other sources, as discussed below. The prevalent wind direction at RMA is from south to north, with the high event wind direction from west to east. The trend in distribution of the OCPs generally follows this pattern. The greatest number of compounds and highest concentrations are observed in samples collected from immediately north of RMA, with fewer occurrences to the east and west of RMA.

Although a number of exceptions exist, concentrations generally decrease with distance from RMA. For example, the concentrations of dieldrin, DDT, and DDE at location HA1231WB, approximately 1.5 miles north of RMA, appear to be anomalously high. The exceptions are likely the result of one or more of the following factors: (1) several of the compounds detected in the surficial soil are or have been available commercially and may have been applied agriculturally or residentially, and (2) some areas where samples were collected have been irrigated with canal and/or groundwater.

The assumption that the OCP contaminants were transported from RMA by wind and deposited offpost does not adequately explain some of the results. Two sampling locations, HA1226WB and HA1231WB, have anomalously high results with respect to other soil samples. It was assumed that if a windblown mechanism was responsible for transporting contaminants

offsite, that samples collected nearest RMA would be most representative of RMA contamination. Analysis of the relative contaminant concentrations for aldrin, chlordane, dieldrin, and DDT in samples collected near 96th Avenue and Peoria Street indicate that the concentration of dieldrin was considerably greater than the other compounds. The concentration of dieldrin is commonly 10 to 40 times greater than the other three compounds. Samples selected and averaged for the purpose of assessing the pattern were HA0990WB, HA0993WB, HA0994WB, and HA0995WB.

For sample HA1226WB, the concentration for chlordane is considerably higher than expected and has less than expected proportions of dieldrin. In addition, the magnitude of concentrations in this sample does not fit the spatial pattern for dieldrin and DDT observed for the soil samples as shown in Figures 6.1, 6.2, and 6.3. The anomalous concentrations of OCPs in this sample are likely the result of OCP application for pest control purposes by a former resident.

Anomalous results were also noted for sample HA1231WB located about 1.5 miles northwest of RMA in Section 10. In this sample, the concentration of DDT was six times greater than dieldrin; aldrin and chlordane were not detected in the sample. This pattern of occurrence indicates that the source of OCPs is potentially different than those for 96th Avenue. In addition, the magnitude of the OCP concentrations does not fit the spatial pattern shown in Figures 6.1, 6.2, and 6.3. The results for this sample suggests a source other than RMA.

In general, the distribution of the OCPs in surficial soil in the immediate vicinity of the northern RMA boundary appears to reflect a wind-transported migration mechanism. The highest concentrations of most of these compounds occur immediately north of RMA and generally decrease with distance from RMA. Concentrations of these compounds decrease fairly rapidly with distance and appear to approach levels that are typical of background values within about 1 mile of the RMA boundary. However, irrigation using contaminated groundwater is an additional plausible mechanism that could explain the observed distribution of the OCPs in surficial soils, particularly in areas northwest of the canals. It is clear from assessment of land use in the Offpost OU and evaluation of aerial photographs that cropland irrigation has historically been conducted in the area northwest of O'Brian Canal and Burlington Ditch. Use of contaminated water for

irrigation purposes could have had some contribution to the occurrence of a number of the OCPs in surficial soils in the Offpost OU.

Several occurrences of anomalously high concentrations of some of these compounds, including chlordane, DDE, dieldrin, and endrin were observed. These higher concentrations are clearly associated with application of these compounds by former or current residents. This indication is important because it demonstrates that sources for the OCPS other than RMA are present in the Offpost OU. This interpretation is consistent with the results of the literature survey described in Section 6.1.3, which indicates that detectable levels of these compounds are expected to be present, on the basis of past agricultural or domestic application of these commercially available compounds.

6.1.1.2 Inorganic Constituents

Arsenic and mercury were detected in surficial soil samples collected in the Offpost OU. Appendix E contains the soil sampling results, and Figures 6.1 and 6.3 show the distribution of arsenic and mercury in offpost soil. Arsenic was detected in approximately 25 percent of the samples. Concentrations ranged from 2.61 to 4.62 $\mu\text{g/g}$. Arsenic was detected most frequently in the samples collected and analyzed by CDH. Arsenic in the CDH samples ranged from 4 to 12 $\mu\text{g/kg}$. The highest concentrations were detected in samples from 100 to 200 feet north of the RMA northern boundary. Arsenic concentrations reported for samples collocated with the CDH samples or located nearby were considerably lower than those reported by CDH or were below the CRL of 2.5 $\mu\text{g/g}$.

In general, concentrations of arsenic in the HLA samples were consistent for all locations. Additionally, concentrations in these samples were considerably lower than concentrations reported by CDH. The distribution of arsenic, as depicted in Figure 6.3, appears to show higher concentrations northeast of Burlington Ditch and lower concentrations of arsenic nearest to the RMA boundary. The concentrations of arsenic reported for the HLA samples fall within the range of 2.8 to 10.9 $\mu\text{g/g}$ reported for natural surficial soils (Schacklette and Boerngen, 1984), as

discussed below. These data suggest that arsenic levels found in offpost soils are not affected by migration from RMA.

Mercury was detected in approximately 10 percent of the samples. Concentrations ranged from 0.0719 to 0.325 $\mu\text{g/g}$. Mercury was only detected in samples collected near Burlington Ditch and O'Brian Canal and in one sample collected in the 96th Avenue residential area north of the RMA boundary. Mercury was not detected east or northeast of RMA or in many areas north of RMA.

The distribution of arsenic and mercury in surficial soil collected near the Burlington Ditch suggests that they may be contributed to the soil from irrigation water coming from Burlington Ditch. The concentrations of arsenic in surficial soil do not exceed the normal range, 2.80 to 10.9 $\mu\text{g/g}$, for arsenic (Schacklette and Boerngen, 1984). Mercury does not exceed the normal background range of 0.0200 to 0.110 $\mu\text{g/g}$ in soil samples except in samples collected north of the canals. The majority of the flow in Burlington Ditch, which is used for irrigation, consists of treated sewage wastewater that may contain higher concentrations of metals, including arsenic and mercury, than natural background.

6.1.2 Subsurface Soil

Six subsurface soil samples were collected in the 96th Avenue residential area and analyzed for OCPs, arsenic, and mercury. The locations and analytical results for these samples are shown in Figure 2.5. The analytical results for these samples are shown in Figure 6.4. The following sections describe the distributions for these analytes in subsurface soil.

6.1.2.1 Organic Compounds

OCPs were reported in only one subsurface soil sample. Dieldrin was detected at a concentration of 7.00 $\mu\text{g/kg}$ in a sample collected between 0 and 1 foot at HA0985SO.

6.1.2.2 Inorganic Constituents

Arsenic was detected in one subsurface soil sample at a concentration of 3.59 $\mu\text{g/g}$. The sample was collected between 0 and 1 foot at HA0988SO.

Mercury was not detected above the CRL in any subsurface soil samples.

6.1.3 Background Surficial Soil Samples

Four samples were collected from an area approximately 2 miles northeast of Brighton, Colorado. This area is generally similar in land use to the area north of RMA. The surficial soil samples collected near Brighton are believed to be representative of background chemical quality of surficial soil in the Offpost OU. The locations of the samples and the distribution of OCPs, arsenic, and mercury detected above CRLs in the background samples are shown in Figure 6.5. To support the use of the concentrations observed in the Brighton samples as background data, further analysis of the available data and literature was performed.

6.1.3.1 Site-specific Data

A statistical evaluation was performed to better assess background concentrations of OCPs in the Offpost OU. Background concentrations are defined as concentrations detected in soils that have not been impacted by RMA contaminants. In the initial step of the evaluation of background OCP concentrations, the four background sample results were compared with 12 sample results located northeast of RMA, and 1 sample located west of RMA. The samples used in this assessment are identified in Figure 2.6. Samples collected near RMA's northeast boundary generally have lower concentrations and lower frequencies of detection than other samples near the northwest and northern RMA boundaries.

The results for the group of 12 samples collected northeast of RMA were not found to be statistically different from the four background samples. Statistical procedures used were (1) method of proportions when the percentage of nondetections was greater than 50 percent and (2) the Wilcoxon rank sum test when the percentage of nondetections was less than 50 percent (EPA, 1989). A significance level of 0.1 was used in these analyses. This procedure was very conservative since it selected samples that emphasized nondetections of the target OCPs.

The next step for evaluating background concentrations of OCPs in surficial soil involved computing the arithmetic mean and 95th percentile concentration for the contaminants detected in

the above-referenced surficial soil samples. Reported nondetections with quantitation levels greater than the maximum reported concentration were removed, and other nondetections were adjusted to one-half the quantitation limit (EPA, 1989). The results are contained in Table 6.1. Surficial soil exceeding the 95th percentile concentration are considered contaminated above background. The dieldrin arithmetic mean concentration is 3 $\mu\text{g}/\text{kg}$ and the 95th percentile is 8 $\mu\text{g}/\text{kg}$.

6.1.3.2 Literature Data

The cyclodiene compounds aldrin, endrin, dieldrin, and isodrin have been used as insecticides from the 1940s to the mid-1970s. Aldrin was used in the early 1950s to protect cotton against boll weevils and in the 1970s for soil applications in grain crops and termite control. In Colorado, dieldrin was used to control insects in field vegetable, grain, and fruit crops (Mullins and others, 1971) and against termites and locust. Endrin was also used to control a wide range of pests. These insecticides were banned for general uses in 1975 by the EPA.

Aldrin and dieldrin may still be used for certain restricted uses such as subsurface insertion for termite control and dipping of nonfood roots. DDT and chlordane are very persistent in the environment. DDT and its degradation product DDE can be detected in samples collected today, even though it was banned for use by EPA in 1972. When in use, DDT was a broad-spectrum insecticide. Chlordane, banned from use in 1988, is a contact insecticide used to control a variety of pests including ants, grasshoppers, and termites. It is used for applications in soil, agriculture, household use, and treatment around buildings.

A literature search was conducted to assess the magnitude of residue levels (background) of the previously mentioned insecticides in soil. The results of several studies of soil residue levels are summarized in Table 6.2. Both cropland (wheat and vegetables) and residential soil were sampled. For aldrin, the arithmetic mean residue levels in cropland varied from 10 to 41 $\mu\text{g}/\text{kg}$, with a range in concentrations from <10 to >13,000 $\mu\text{g}/\text{kg}$. The arithmetic mean for dieldrin in cropland soil varied from 40 to 100 $\mu\text{g}/\text{kg}$ with a range of <10 to <1000 $\mu\text{g}/\text{kg}$. The endrin

arithmetic mean varied from <10 to approximately 500 $\mu\text{g/kg}$, with a range of not detected (detection limit not given) to 3500 $\mu\text{g/kg}$.

Only one study addressed isodrin levels in cropland soil. The arithmetic mean for isodrin was <10 $\mu\text{g/kg}$ with a range of <10 to 20 $\mu\text{g/kg}$. For residential areas, the dieldrin means varied from <10 to 10 $\mu\text{g/kg}$, with a range of not detected to 2200 $\mu\text{g/kg}$. In most cases for cropland and residential soil samples, between 25 and 50 percent of the samples tested contained measurable amounts of dieldrin, while 9 to 70 percent contained aldrin.

A search of the available literature was conducted to evaluate residues of DDT, DDE, and chlordane in soil. The results are summarized in Table 6.2. For DDT in cropland, the arithmetic mean concentration varied from 20 to 5600 $\mu\text{g/kg}$. The arithmetic mean for DDE varied from 20 to 360 $\mu\text{g/kg}$, with a range of <5 to 5500 $\mu\text{g/kg}$. For chlordane, the arithmetic mean ranged from 20 to 60 $\mu\text{g/kg}$, with a range of <5 $\mu\text{g/kg}$ to 7900 $\mu\text{g/kg}$. For noncropland use (golf courses, open fields, residential areas), DDT means varied from 60 to 940 $\mu\text{g/kg}$, with a range of not detected to 80,000 $\mu\text{g/kg}$. DDE results were not available for noncropland uses. The chlordane means varied from 90 to 5400 $\mu\text{g/kg}$, with a range of not detected to 52,000 $\mu\text{g/kg}$.

Mullins and others (1971) observed residual levels of pesticides in the soil of Weld County, Colorado. The arithmetic means for aldrin and dieldrin in soil were 410 and 70 $\mu\text{g/kg}$, respectively. The four surficial soil background samples collected from an area located 2 miles northwest of Brighton, Colorado, were collected in noncropland areas. The arithmetic mean aldrin concentration detected in the samples was 3 $\mu\text{g/kg}$ with a range of <2 to 6 $\mu\text{g/kg}$. The arithmetic mean concentration of dieldrin detected in the samples was 34 $\mu\text{g/kg}$ with a range of <2 to 99 $\mu\text{g/kg}$. Endrin and isodrin were not detected in any of the background samples.

All of the available literature data were published before 1980. The cyclodienes are generally recognized as the most persistent OCPs in the environment (Nash and Woolson, 1967). The removal of insecticides from soil is a first order rate reaction (Nash and Woolson, 1967). The half-lives for aldrin and dieldrin are 5 years and 7 years, respectively. Current residue levels in

cropland areas were calculated for aldrin and dieldrin using the following standard decay equation:

$$C = C_o e^{-kt}$$

where

C = soil concentration (mg/kg) at time t

C_o = initial soil concentration

k = decay constant (yr⁻¹)

t = decay time (yr)

The calculated levels for aldrin were based on initial concentrations of 10 and 410 µg/kg, which represent the range of arithmetic means from various studies.

The period considered was 16 years (1975 to 1991). The calculated values for aldrin were 1 and 45 µg/kg, respectively. Thus, in 16 years, the concentration of aldrin dropped by one order of magnitude. Aldrin calculated concentrations from the literature compare very favorably with offpost data. The calculations for dieldrin were based on an arithmetic mean range of 40 to 100 µg/kg. The resulting residual dieldrin concentrations were 8 and 21 µg/kg. Calculated dieldrin concentrations also compare favorably (within a factor of 3) with offpost data. Aldrin is oxidized to dieldrin at a rate of 24 percent per year (Hamaker, 1964), which may actually increase dieldrin residues.

From site-specific data in the offpost and from literature data updated by degradation calculations, background concentrations of OCPs in surficial soil appear to be best defined by the 95th percentile shown in Table 6.1. The 95th percentile interval was selected because of conservative selection of the background data set and from the literature data.

6.2 SUMMARY OF GAS CHROMATOGRAPHY/MASS SPECTROSCOPY RESULTS

GC/MS analyses were performed on two surficial soil samples, one investigative sample and one background sample, to confirm results obtained by GC analyses. The results for the two GC/MS samples are listed in Appendix E.

Only a single organic compound was detected in the samples analyzed by the GC method. Dieldrin was detected at a concentration of 5.50 µg/kg in sample HA1233WB. The CRL for the analysis of dieldrin by the GC method is 1.80 µg/kg, while the CRL for the GC/MS method is 300 µg/kg. The dieldrin concentration in sample HA1233WB was not confirmed by GC/MS analysis because of the low concentration with respect to the GC/MS CRL. Analytes were not detected in either of the GC/MS confirmation samples.

6.3 SUMMARY OF QUALITY ASSURANCE/QUALITY CONTROL RESULTS

QA/QC samples collected for the surficial and subsurface soil program consisted of eight duplicate samples. The results for duplicate samples, with associated investigative samples noted, are listed in Table 6.3. Duplicate pairs were reviewed with respect to the compounds detected and the calculated DSA between concentrations of detected compounds. Five of the eight duplicate pairs had the same reported compounds. Two of the eight duplicate pairs had compounds reported in one sample only. One of the eight duplicate pairs had no compounds detected in either sample. This pair of duplicate samples, HA1217WB and HA1241WB, is not listed in Table 6.3.

Generally good agreement was observed between duplicate pairs. The few high DSA values reflect analytical results near the respective CRL. Because the reported concentration for some analytes is close to the CRL, reproducibility is expected to be lower. In general, the DSA values are considered acceptable.

6.4 COMPARISON OF REMEDIAL INVESTIGATION ADDENDUM RESULTS AND COLORADO DEPARTMENT OF HEALTH RESULTS

Table 6.4 shows a comparison of HLA and CDH analyses. Results for CDH analyses are of unknown quality because QA/QC data were not provided with the sample results, and the data could not be verified or validated. However, the CDH data are included for qualitative comparison with HLA validated data.

In general, results between the HLA and CDH collocated samples are comparable for some analytes but not for others. The HLA samples generally had detections for more target analytes

than reported by CDH. Concentrations of organic compounds detected in the HLA samples are generally higher than the values reported by CDH.

For arsenic and mercury, the CDH results show a higher frequency of detection and slightly higher concentrations. For the samples presented in Table 6.4, arsenic was detected in all CDH samples but in only one HLA sample. The concentration of arsenic detected in the HLA sample was approximately three times lower than the concentration detected in the collocated CDH sample.

6.5 CONCLUSIONS

RI Addendum data for surficial soil indicate the presence of OCPs, arsenic, and mercury above CRLs in offpost surficial soil. The highest number and concentrations of contaminants occur in the area directly north of RMA, primarily in the 96th Avenue residential area. The distribution of the organic contaminants appears to correlate to the dominant wind directions at RMA but do not completely follow the trend of decreasing concentration with distance from RMA. In addition, several of the compounds detected are or have been commercially available and may have been applied by residents and/or in agricultural practices in the surrounding rural area. These patterns indicate that a mechanism of windblown contaminants, combined with agricultural or residential application, or through use of contaminated groundwater for irrigation, may be responsible for the observed distribution of OCPs.

Review of the concentrations of arsenic and mercury detected in surficial soil samples indicates that these metals did not exceed typical background concentrations, except for mercury detections in a few samples collected north of the canals. The extremely limited distribution of mercury, which was detected in a few samples generally located adjacent to Burlington Ditch, suggests that RMA is not a source of mercury in surficial soil in the Offpost OU.

RI Addendum data for six subsurface soil samples collected from the 96th Avenue residential area indicate the presence of dieldrin in only one sample. The presence of arsenic was also detected in only one sample at a concentration slightly above the CRL. Mercury was not detected

above the CRL in any subsurface soil sample. These data appear to indicate that the organic and inorganic contamination of the subsurface soil is not extensive.

7.0 BIOTA MONITORING RESULTS AND ASSESSMENT

The biota monitoring program of the RI Addendum consisted of an ecological characterization of the Offpost OU and an assessment of the nature and extent of contamination in the biota in the Offpost OU. These two components, along with a comparison of contaminant levels in biota and their associated water and soil samples, are presented in this section.

7.1 ECOLOGICAL CHARACTERIZATION STUDY RESULTS

This section will provide detailed results of ecological characterization studies of the Offpost OU. These studies provided an overview of the ecological condition of the area, including whatever observations could be made of RMA contaminant effects.

7.1.1 Aquatic Characterization

The First Creek Impoundment (impoundment) and the adjacent sections of First Creek were evaluated in three subsections of similar characteristics:

- First Creek from the RMA northern boundary to the impoundment
- The impoundment
- First Creek from the impoundment to Highway 2

7.1.1.1 RMA to the Impoundment

The section of First Creek running northwest from 96th Avenue to Peoria Street was largely dry. A few small areas along the drainage contained small amounts of standing water and marshy wetlands. On the basis of visual inspection of this area, the quantity of water generally increased from east to west until a small stream of water flowing at a rate of less than 1 cubic foot/12 hours was observed from Peoria Street to the impoundment. Maximum depth of First Creek in this section was about 3 inches.

Two relatively large wetland areas characterized by dense stands of cattails (*Typha angustifolia*) and bulrush (*Scirpus* sp.) occurred along this section of First Creek. Channel banks along First Creek were choked with terrestrial grasses. However, aquatic vegetation was sparse

because of the ephemeral nature of the creek. Within the channel, green and brown algae were prevalent, comprising greater than 80 percent of the bottom cover vegetation. Duckweed (*Lemna* sp.) and submergent vascular plants were limited, each accounting for less than 5 percent of the bottom cover. The remaining 10 percent of bottom cover was comprised of litter and bare substrate. This section of creek was relatively undisturbed, with a minimal amount of grazing. Cattle grazing was restricted to the inlet of the impoundment where grazing pressure was intense and essentially all aquatic vegetation had been eliminated.

7.1.1.2 First Creek Impoundment

The impoundment occurs along a reach of First Creek that apparently has been diverted and impounded by an earthen dam approximately 13 feet high. The impoundment has a maximum acreage of approximately 5 acres, but at the time of the field investigation had receded to a narrow, excavated channel approximately 25 feet by 400 feet. The maximum depth of the impoundment was 2 feet, and the substrate consisted of approximately 3 feet of thick, viscous, organic silt. Aquatic vegetation was minimal and consisted of approximately 2 percent coverage of green algae and 1 percent duckweed. Aquatic vertebrates and invertebrates were sampled using seine nets, gill nets, and hand screens. The species found in the impoundment are listed in Table 7.1.

The area surrounding the offpost impoundment and the desiccated pond bottom were subject to continual cattle grazing. This grazing has resulted in severe disturbance of the aquatic habitat and an accumulation of organic matter in pond sediments from livestock excrement.

7.1.1.3 First Creek Impoundment to Highway 2

The section of First Creek below the impoundment has been channelized into a straight channel characterized by 10- to 13-foot high steep banks for three-fourths of the channel length before emerging onto flat open terrain. On the basis of visual inspection of this area, the stream flow rate through this section is estimated at greater than 1 cubic foot/12 hours. A maximum water depth of 1 foot was obtained within the steep-sided channel, decreasing to a maximum

depth of 3 inches in the flats. Aquatic vegetation along this section of First Creek consisted of the following:

Duckweed	30 percent of surface area
Green algae	60 percent of bottom cover
Brown algae	20 percent of bottom cover
Submergents	12 percent of bottom cover
Bare substrate	8 percent of bottom cover

This section of First Creek showed evidence of past and present disturbance. Channelization has limited the aquatic habitat to a narrow corridor along the creek. The surrounding area consisted of pasture subject to continuous horse (*Equus* sp.) grazing that has disturbed and destroyed much of the accessible portions of aquatic habitat along First Creek.

7.1.2 Terrestrial Characterization

The area of the Offpost OU near the northwest corner of RMA reflects intensive human land use, including dryland farming, cattle grazing, small landfills, and residences, as shown in Figure 2.8. Small vacant lots, fallow fields, wetlands along First Creek, and prairie dog colonies comprise the balance of habitat types in the immediate Offpost OU. On the basis of the habitats present on the Offpost OU and the habitats used by vertebrate species in Colorado (CDOW, 1981, 1982a, 1982b), a list of potentially occurring species was developed for the Offpost OU and is presented in Appendix F. Rare and accidental species were eliminated from the potential species list because of the negligible likelihood that they would occur in the Offpost OU. Wildlife species using these habitats in the Offpost OU were also common at RMA. However, wildlife species diversity in the Offpost OU is limited by the lack of variety in habitats and degree of human impact.

The predominant species in the weedy forbs habitat type (WF) include *Kochia (iranica)*, prickly lettuce (*Lactuca serriola*), thistle (*Cirsium arvensis* and *Carduus nutans*), russian thistle (*Salsola iberica*), field bindweed (*Convolvulus arvensis*), various sunflowers (*Helianthus* sp.), and

tumble mustard (*Sisymbrium altissimum*). The grasses and weedy forbs habitat type (GWF) is similar to the WF habitat type but with an increased abundance of cheatgrass (*Bromus tectorum*), western wheatgrass (*Agropyron smithii*), and bluegrass (*Poa* sp.), in addition to the WF species mentioned above. These habitat types were also described in the Biota RI (with GWF described as cheatgrass/weedy forb in the Biota RI). WF and GWF habitat types support cattle and horse grazing in the Offpost OU, particularly along the channelized portion of First Creek below the impoundment.

Wetlands along First Creek extend along both sides of the creek from the northern RMA boundary to the impoundment. These wetlands (TG-W) contain taller grasses such as quackgrass (*Agropyron repens*), intermediate wheatgrass (*Agropyron intermedium*), and cheatgrass. Many forbs found in the WF and GWF habitat types were also found in or adjacent to the wetland vegetation. Interspersed in this drainage are areas dominated by sedges (*Carex* sp. and *Scirpus* sp.) and cattail marshes (CTM; *Typha angustifolia*). Below the impoundment, the wetland vegetation is limited to the banks of First Creek, which has been channelized and grazed back to a GWF habitat type. No immersed wetlands occur along First Creek below the offpost impoundment until the creek empties into the O'Brian Canal. Wetlands habitat, along with WF and GWF habitats, supported the most wildlife species observed in the Offpost OU.

Prairie dog colonies (PD) offpost resemble their RMA counterparts, with perhaps a bit less vegetative cover consisting of field bindweed and occasional bunchgrasses (such as crested wheatgrass, *Agropyron cristatum*). A horse and cattle range was nearly devegetated, with only a few forbs and grasses interspersed in those areas. Fallow fields (PFF and FF) were lightly vegetated with remnant crops and grasses. The unplowed corners of the fallow fields were covered with WF type vegetation, including the common russian thistle plants. Shelter belt cottonwood trees and ornamental plants were found surrounding the residences and buildings in the Offpost OU.

7.2 NATURE AND EXTENT OF BIOTA CONTAMINATION

A number of biological samples were taken from the Offpost OU to assess the possible contamination of wildlife from RMA sources. Target analytes in biological samples, their levels in comparison to onpost analyte concentrations, and possible contamination of endangered species are presented in this section. An evaluation of analyte concentrations in biota compared to surface water and surface-water concentrations is also presented in this section. Data used in this assessment are contained in Appendix F.

7.2.1 Target Analytes in Biological Samples

Target analytes for biota samples were presented in Tables 2.4 and 2.5. Data from chemical analyses of biological samples are contained in Appendix F. This section presents a brief summary of the target analytes detected in biota samples. The locations of biota samples are presented in Figure 2.9. The analytical results for the offpost biota samples are presented in Figures 7.1 through 7.3.

Figure 7.1 shows the distribution of target analytes for agricultural biota samples. The distribution of target analytes for aquatic biota is presented in Figure 7.2. Figure 7.3 shows the distribution of target analytes in terrestrial biota. The figures also identify the type of biota species for which analytical results are presented.

Dieldrin was the contaminant found most often among offpost biota. Bovine fat, chicken tissues, fish, earthworms, deer mice, prairie dogs, and pheasant samples all had detectable concentrations of dieldrin. Arsenic concentrations were detected in (1) algal mats and crayfish from the impoundment, (2) earthworms, and (3) one prairie dog sample. Mercury was detected in fathead minnows and carp from the impoundment, and in 3 of 5 earthworm samples. DDE was detected in sample HA1042BP, which consisted of the fat and skin portion of a chicken. Aldrin, endrin, and DDT were not detected in any biological sample taken offpost. DBCP was not detected in milk samples.

7.2.2 Comparison of Onpost and Offpost Contaminant Data

Onpost biota data from the Biota RI were compared to the offpost data for aquatic plants, fish, pheasant, grasshoppers, earthworms, and prairie dogs. Deer mice, crayfish, cattle, and chickens were not sampled onpost. These comparisons were undertaken to permit general conclusions about the contaminant levels in biota in the Offpost OU. In general, target analytes were less frequently detected and at lower concentrations in biota samples collected from the Offpost OU than in the Onpost OU. The following paragraphs discuss the extent of contamination in biota samples. The target analytes discussed include arsenic, mercury, dieldrin, aldrin, endrin, DDT, and DDE.

Arsenic was detected in a planktonic sample from the onpost lakes at a concentration of 0.432 $\mu\text{g/g}$. An algal sample collected from the impoundment contained 1.02 $\mu\text{g/g}$ of arsenic. Neither Onpost nor Offpost OU fish samples contained any arsenic. Concentrations of arsenic in earthworms averaged 3.17 $\mu\text{g/g}$ in Section 36 onpost, 1.03 $\mu\text{g/g}$ in onpost control samples, and 1.4 $\mu\text{g/g}$ in the offpost samples. Grasshoppers contained up to 6.6 $\mu\text{g/g}$ in Section 36 onpost, while arsenic was not detected in offpost samples. Only 7 of 42 onpost pheasant samples contained arsenic (up to 4.07 $\mu\text{g/g}$), while none of the 3 pheasants collected offpost had detectable levels of arsenic. One of the offpost prairie dogs contained arsenic at 0.771 $\mu\text{g/g}$, while 3 of 14 onpost RMA samples contained up to 4.22 $\mu\text{g/g}$. Control samples for the Biota RI (from northern Colorado) did not contain detectable levels of arsenic in terrestrial or aquatic samples of similar species.

Mercury was not detected in onpost or offpost algal/planktonic samples. Fish from the impoundment contained up to 0.155 $\mu\text{g/g}$ of mercury in a carp sample, while onpost, mercury was present in most samples from the southern lakes with a maximum concentration detected in a bass from Lower Derby Lake of 0.550 $\mu\text{g/g}$.

Mercury was detected in 3 of 5 of the samples collected from the impoundment. The average concentration of mercury in these samples was 1.2 $\mu\text{g/g}$. Onpost samples of earthworms collected from the South Plants area contained up to 2.35 $\mu\text{g/g}$. Mercury was not detected in

offpost grasshoppers, while grasshoppers from onpost Section 36 averaged 0.058 $\mu\text{g/g}$. Mercury was not detected in any onpost or offpost pheasant samples. Mercury was not detected in offpost prairie dog samples or in any of the whole body samples collected onpost. Prairie dog kidney samples collected from onpost Section 36 were found to contain mercury at an average concentration of 0.178 $\mu\text{g/g}$. Control samples for onpost studies (from northern Colorado) showed no mercury contamination in terrestrial samples, while all five bluegill control samples taken averaged up to 0.188 $\mu\text{g/g}$.

Dieldrin was not detected in onpost planktonic samples or in algal samples collected from the impoundment. Dieldrin was detected in channel catfish (0.251 $\mu\text{g/g}$) collected and carp (up to 0.235 $\mu\text{g/g}$) from the impoundment. Bluegill and bass samples collected from the onpost Lower Lakes contained dieldrin at concentrations of up to 0.161 to 0.860 $\mu\text{g/g}$, respectively. Onpost samples of earthworms contained from 1.37 $\mu\text{g/g}$ in a South Plants sample to 5.3 $\mu\text{g/g}$ in a sample collected in Section 5. Offpost earthworm samples showed dieldrin concentrations ranging from 0.0211 to 0.0282 $\mu\text{g/g}$. Dieldrin was not detected in offpost grasshoppers, while grasshoppers collected from onpost Sections 26 and 36 contained average concentrations ranging from 2.53 to 0.381 $\mu\text{g/g}$, respectively.

A pheasant liver sample collected from the Offpost OU contained 0.380 $\mu\text{g/g}$ dieldrin, while onpost RMA pheasant whole carcasses contained an average of 0.767 $\mu\text{g/g}$ dieldrin. One offpost prairie dog of 4 samples contained 0.0327 $\mu\text{g/g}$ dieldrin. Onpost prairie dog samples from Section 36 averaged 1.44 $\mu\text{g/g}$, while samples collected from Sections 19 and 20 contained dieldrin at up to 0.346 $\mu\text{g/g}$. Control samples for the onpost studies (from northern Colorado) showed no detections of dieldrin in biota, although a pheasant sample collected on a golf course near Ft. Collins did contain detectable levels of dieldrin.

Aldrin was not detected in samples collected from the Offpost OU. Onpost grasshopper samples collected near former Basin F showed a mean concentration for aldrin of 1.59 $\mu\text{g/g}$. The only other detections of aldrin in the onpost RMA sampling were in 5 samples of large mouth bass from Lower Derby Lake. Because aldrin converts to dieldrin rapidly in soil and water and *in vivo*

(Hall and others, 1971; Metcalf and others, 1973), aldrin is not expected to be widespread in biota in the Offpost OU.

Endrin was not detected in samples collected from the Offpost OU. Endrin was detected in onpost grasshopper and earthworm samples at concentrations up to 1.65 $\mu\text{g/g}$. Control samples for onpost Biota RI studies did not contain detectable levels of endrin.

DDE was found in 2 of 18 onpost pheasant samples and in 1 chicken sample in the Offpost OU. DDT was not detected in onpost or offpost biota samples. Control samples for onpost RI studies did not contain detectable levels of DDE or DDT.

7.2.3 Comparison of Biota Contaminant Levels with Concentrations in Surface Soil and Water

Biota sampling locations were collocated with surface soil and water sampling locations, to the maximum extent practicable, as part of an integrated sampling approach. With the possible exception of pheasants (see below), the species sampled in the Offpost OU are generally restricted to a relatively small area. Thus, a comparison of the surface water or soil concentrations to the levels in biota was made. Concentrations of target analytes in biota compared to concentrations from nearby soil and water samples are presented in Table 7.2.

Dieldrin levels in cow and chicken tissues could be caused by accumulation from ingestion of contaminated soil. Soil samples in the vicinity of cattle grazing areas contained 0.110 $\mu\text{g/g}$. Dieldrin concentrations in soil in areas where chickens fed ranged from 0.010 to 0.020 $\mu\text{g/g}$. Dieldrin concentrations in catfish and carp samples ranged from 0.026 to 0.251 $\mu\text{g/g}$ compared to sediment concentrations of 0.025 $\mu\text{g/g}$ and water concentrations of 0.147 $\mu\text{g/l}$ in the impoundment. Earthworms contained dieldrin levels just above the CRL, while shallow soil concentrations ranged from 0.008 to 0.093 $\mu\text{g/g}$. Concentrations of dieldrin in prairie dogs and deer mice ranged from 0.0267 to 0.571 $\mu\text{g/g}$ compared to dieldrin soil concentrations of 0.0128 $\mu\text{g/g}$ to 0.020 $\mu\text{g/g}$.

Mercury and arsenic were detected in fish, earthworms, and prairie dogs offpost. However, mercury and arsenic in soil and water samples are below CRLs at many locations.

7.2.4 Threatened and Endangered Species in the Offpost OU

Threatened or endangered species samples were not collected from the Offpost OU during the RI Addendum. A single bald eagle egg was collected in 1988 from an abandoned nest at Barr Lake (ESE, 1989b). The embryo was approximately five days from hatching at the time of abandonment and exhibited normal development. Residues detected in the egg contents were 0.099 $\mu\text{g/g}$ mercury, 0.808 $\mu\text{g/g}$ dieldrin, and 6.93 $\mu\text{g/g}$ DDE. Arsenic, aldrin, endrin, and DDT were not detected. Although RMA as a source of these contaminants cannot be completely ruled out, preliminary evaluation of sediment and water data from onpost and offpost surveys and existing knowledge on the feeding habits and foraging range of the Barr Lake eagles did not indicate that the observed contaminant levels were a result of migration from RMA sources.

Other possible threatened or endangered species in the Offpost OU are peregrine falcons (*Falco peregrinus*) or black-footed ferrets (*Mustela nigripes*). The CDOW has classified peregrine falcons in the RMA vicinity as migrants, and black-footed ferret searches on prairie dog colonies onpost have concluded that ferrets probably do not occur in the area (ESE, 1989b).

7.3 QUALITY ASSURANCE AND QUALITY CONTROL FOR CHEMICAL ANALYSES

Analytical procedures were consistent with the PMRMA CQAP (PMRMA, 1989). Samples were analyzed using PMRMA-certified methods, as shown in Table 2.5. These methods use standard matrix spikes as the means of demonstrating that all analytical methods are in control during sample analysis. Control charts are generated using the standard matrix spike data, and recoveries of individual lots are compared to established control limits on the control charts to determine if the analysis is in control. These control charts are reviewed by the analyst, the Laboratory Quality Assurance Coordinator, and by the Quality Assurance Branch of the Laboratory Support Division of PMRMA. All 15 animal tissue samples were analyzed in the following three lots: QRQ (Method M-6), GVS (Method B-6-A), and QOP (Method C-6-A). The one algae sample was analyzed as a plant tissue, and its analysis results appear in the following three lots: QPA (Method QH-01), GVT (Method B-6-P), and QOQ (Method C-6-P).

Two laboratory duplicates were analyzed by the laboratory, as shown in Appendix F. The sample selected for the duplicate analysis was the pheasant flesh that was collected on January 2, 1990, and was assigned HLA site I.D. HA1255BF. The analysis of this sample and its duplicate gave analysis results that were below the CRL for all analytes. While the results for the duplicate analysis confirm the absence of analytes in the sample, no estimates of sampling and analytical accuracy and precision can be calculated from these results.

7.4 SUMMARY AND CONCLUSIONS OF CHARACTERIZATION AND CONTAMINANT STUDIES

Characterization studies examined the status of offpost ecosystems. The Offpost OU terrestrial systems are dominated by human agricultural land use, with extensive plowed and planted lands, a range for cattle and horses, and small trash dumps. Aquatic systems are limited to the First Creek drainage, with the least disturbed section of the creek occurring just north of RMA. Because of the high degree of land-use disturbance, species diversity is low in the Offpost OU compared to RMA. The land-use practices have resulted in limited assessment of the impacts of RMA-derived contaminants on the overall ecosystem Offpost OU. Some of the birds listed in Table F4, Species of Possible Occurrence in the Offpost Study Area, are protected under the Migratory Bird Treaty Act.

Contaminants in the Offpost OU biota are similar to those found at RMA, although the concentrations detected in Offpost OU biota are considerably lower than levels detected in Onpost OU samples. Contaminants most commonly detected in biota samples offpost include arsenic, mercury, and dieldrin. Although onpost RMA sources may impact some animal species found in the Offpost OU, contamination detected in offpost biota samples collected during RI Addendum activities appears to come from in-situ environmental sources rather than from migration of onpost RMA wildlife.

8.0 REMEDIAL INVESTIGATION ADDENDUM SUMMARY AND CONCLUSIONS

This RI Addendum report was prepared to present analytical results and more recent interpretations of the nature and extent of contamination in the various media in the Offpost OU since the Final RI was issued in December 1988. Additional groundwater monitoring wells have been installed in the UFS and Arapahoe Formation. Samples from these wells and existing wells sampled under the CMP have been incorporated into the interpretation of the extent of groundwater contamination in offpost UFS and Arapahoe Formation groundwater.

Additional offpost surface-water, sediment, and biota samples were also collected from the Offpost OU and were analyzed for appropriate target analytes. Surficial soil samples, which were not collected during the Final RI program, were collected during the RI Addendum program. Several episodes of surficial soil sampling were conducted to eliminate data gaps for revising the Draft Final EA/FS, which is currently under preparation. On the basis of the data and interpretations presented in this RI Addendum report, particularly comparisons to findings contained in the Final RI, where possible, sufficient data are available for revising the Offpost OU EA/FS report for the Offpost OU.

The following sections present the major conclusions for each of the offpost media sampled under this RI Addendum program. Each discussion initially presents a brief overview of the data collection activities conducted for that medium. The nature and extent of contamination for that medium is then briefly presented and discussed. The extent of contamination is then compared to interpretations contained in the Final RI.

8.1 GROUNDWATER

Section 3.0 presented the results of the groundwater monitoring program for the RI Addendum. The extent of groundwater contamination associated with RMA-derived contaminants was characterized through the installation of additional monitoring wells completed in the UFS and Arapahoe Formation. Installation of these wells also added to the understanding of the geology and hydrogeology of the Offpost OU. Water levels were measured, and water-quality

samples were collected from 124 wells in the Offpost OU. A total of 34 new monitoring wells were installed in the offpost OU, including 3 wells in the Arapahoe Formation. Additionally, samples were collected from 25 domestic wells located in the Offpost OU. Assessment of the extent of contamination was also based on recent water-quality data generated in fiscal years 1988 through 1990 under the CMP. These data were used in contouring the major target analyte plumes in the UFS.

The geologic and hydrogeologic data presented in this report confirm the existence of major paleochannels north of RMA. Additionally, groundwater samples from these wells confirmed that the highest concentrations of most of the major target analytes occur in the UFS along the First Creek and Northern Paleochannels. The major organic contaminants detected in the UFS include DIMP, DCPD, dieldrin, chloroform, and TCLEE. Inorganic analytes detected in the UFS north of RMA include arsenic, chloride, and fluoride.

The operation of the NBCS has had a significant impact on reducing the concentrations of the organic and inorganic contaminants in the UFS. Additionally, recent physical and operational changes to the NBCS are apparently enhancing the reduction of contaminants in the area immediately downgradient of the NBCS.

Offpost of the RMA northwestern boundary, the principal organic contaminants detected in the UFS are chloroform and dieldrin, although DIMP was also detected in groundwater samples from this area. Inorganic analytes detected in this area include chloride and fluoride. Groundwater concentrations are considerably lower in this area than observed in the First Creek and Northern Paleochannels. The NWBCS has not been completely effective at reducing the concentrations of chloroform detected in groundwater offpost in this area. Modifications to the operation of the NWBCS are being implemented, and decreases in chloroform, and other contaminants offpost are expected to occur.

8.2 SURFACE WATER

Section 4.0 presents the results of the surface-water monitoring program for the RI Addendum. Surface-water samples were collected from a number of locations along First Creek,

O'Brian Canal, Burlington Ditch, and Barr Lake. Samples were collected during two sampling episodes conducted in November 1988 and from May to June 1990. Surface-water samples were analyzed for organic and inorganic analytes.

The analytical results for the surface-water samples confirm the nature and extent of contamination reported in the Final RI. The principal organic compounds identified in the samples include DIMP and dieldrin. Inorganic compounds detected include arsenic and mercury. In general, the highest concentrations of the organic and inorganic analytes were detected in First Creek. DIMP concentrations in First Creek were highest in the area 100 to 200 feet upstream of O'Brian Canal where groundwater discharge to First Creek is occurring. Concentrations of DIMP in this area are considerably lower than levels reported in the Final RI.

The highest concentrations of arsenic were detected in the samples collected from First Creek near the northern RMA boundary. The levels are likely associated with discharges from the Onpost Sewage Treatment Plant. Mercury and arsenic were detected in surface-water samples collected from O'Brian Canal upstream of the confluence with First Creek, suggesting additional sources of the constituents. Organic compounds were not detected in the surface-water sample collected from Barr Lake. The occurrence of mercury in the Barr Lake sample is probably associated with past sludge disposal activities in Barr Lake, as described in the Final RI. These disposal activities were not associated with any RMA operations.

8.3 STREAM-BOTTOM SEDIMENT

Section 5.0 presents the results of the stream-bottom sediment monitoring program. Sediment samples were collected from several locations along First Creek, O'Brian Canal, Burlington Ditch, and Barr Lake. The sediment sampling locations were collocated with the surface-water sampling locations. Samples were collected in November 1988 and from May to June 1990. The sediment samples were analyzed for the same organic and inorganic contaminants as the surface-water samples.

The analytical results for the sediment samples confirm the results presented in the Final RI. The most commonly detected contaminants were dieldrin, arsenic, and mercury. The highest

concentration of dieldrin was in a sample collected from First Creek immediately north of the northern RMA boundary. Concentrations of dieldrin in other locations were generally much lower than concentrations observed in First Creek samples. Numerous organic and inorganic contaminants were detected in sediment samples collected from O'Brian Canal and Burlington Ditch upstream of the confluence with First Creek. Contaminants detected in these samples include DDT, DDE, chlordane, dieldrin, endrin, and mercury. This distribution indicates that other sources of these analytes probably exist offpost.

8.4 SURFICIAL AND SUBSURFACE SOILS

Section 6.0 presents the results of the surficial and subsurface soil monitoring program. Surficial soil samples were collected from a broad area in the Offpost OU. A number of samples were collected outside of the Offpost OU, including nine samples from east of RMA and four samples from an area northeast of Brighton, Colorado. Surficial soils were collected by HLA in February 1989 and from June to July 1990. Additional surficial soil samples were collected by WCFS in May 1991. These samples were analyzed for OCPs, arsenic, and mercury, except for the samples collected in May 1991, which were analyzed for OCPs only. Subsurface samples were collected from a few areas in February 1989. These samples were analyzed for OCPs, arsenic, and mercury. Because surficial soil samples were not collected under the previous RI activities, these data cannot be compared to findings presented in the Final RI.

The most commonly occurring organic compound in soils was dieldrin. Dieldrin was detected in approximately 90 percent of the samples. Other organic compounds detected include DDT, DDE, aldrin, and endrin, which were detected in 25 to 50 percent of the samples. A few isolated occurrences of some analytes were observed, including chlordane, isodrin, and HCCPD. The distribution of these analytes is considered sporadic and not representative of RMA-derived contamination. Chlordane was detected in a sample approximately 0.5 mile north of RMA and was reportedly used by a former resident.

The highest levels of most of the OCPs are generally found in the immediate vicinity of the RMA northern boundary. The concentrations generally decrease with distance from RMA.

However, because these compounds were commercially available historically, there is a likely contribution to the observed concentration from such commercial or residential application. This is evidenced by the anomalously high concentrations dieldrin, DDT, and DDE approximately 1.5 miles northwest of RMA. Background levels for the OCPs were assessed by collection of surficial soil samples near Brighton, Colorado and northeast of RMA. Target analytes detected in these background samples include dieldrin, aldrin, DDT, and endrin.

Arsenic and mercury were detected in offpost surficial soil. Arsenic was detected in approximately 25 percent of the samples. The highest concentrations were detected in samples collected from northwest of Burlington Ditch. Mercury was detected less frequently than arsenic. However, the areas of highest concentration were also northwest of Burlington Ditch. These data suggest sources of these contaminants other than RMA.

Subsurface soil showed only two occurrences of organic or inorganic contaminants. Arsenic and dieldrin were each detected in only one sample.

8.5 BIOTA

Section 7.0 presents the results of the biota monitoring program. Biota samples were collected from the area immediately north of RMA. This area represents the locations of highest surface-water and surficial soil contamination, which would likely have the most significant impact on biota. Biota samples representing several trophic levels were collected in several sampling episodes. Agricultural, aquatic, and terrestrial biota samples were collected and analyzed for organic compounds, arsenic, and mercury. The biota monitoring program also included an assessment of the habitats that occur in the Offpost OU and the types of species that may exist in the area.

The Final RI reported limited biota results. The RI Addendum biota monitoring program provided significant additional data to assess the impacts, if any, on the biotic community in the Offpost OU. The most commonly occurring compounds include dieldrin, arsenic, and mercury. The concentrations of these target analytes were considerably lower than levels observed onpost.

Additionally, the types of analytes reported in these samples were consistent with those compounds reported onpost.

An assessment of endangered species that could occur in the Offpost OU showed that no endangered or threatened species occur in the Offpost OU, except for a pair of bald eagles at Barr Lake. Contaminants (mercury, dieldrin, and DDE) detected in a Bald Eagle egg collected in 1988 from an abandoned nest at Barr Lake could not be attributed to releases from RMA sources.

9.0 GLOSSARY

°C	degrees Celsius
µg/l	micrograms per liter
12DCLE	1,2-dichloroethene
Army	U.S. Department of the Army
As	arsenic
BCHPD	bicycloheptadiene
bgs	below ground surface
CCL4	carbon tetrachloride
Cd	cadmium
CDH	Colorado Department of Health
CDOW	Colorado Division of Wildlife
CFS	confined flow system
CL6CP	hexachlorocyclopentadiene
cm	centimeters
CMP	Comprehensive Monitoring Plan
COC	contaminants of concern
CPMS	4-chlorophenylmethyl sulfide
CPMSO	4-chlorophenylmethyl sulfoxide
CPMSO2	4-chlorophenylmethyl sulfone
CQAP	Chemical Quality Assurance Plan
Cr	chromium
CRL	certified reporting limit
CSC	Chemical Sales Company
Cu	copper
DBCP	dibromochloropropane
DCPD	dicyclopentadiene

DDE	2,2-bis(para-chlorophenyl)-1,1-dichloroethene
DDT	2,2-bis(para-chlorophenyl)-1,1-trichloroethane
DDVP	vapona
DIMP	diisopropylmethyl phosphonate
DITH	1,4-dithiane
DMMP	dimethylmethyl phosphonate
DMP	Data Management Plan
DSA	duplicate sample agreement
EA	endangerment assessment
EPA	U.S. Environmental Protection Agency
ESE	Environmental Science and Engineering, Inc.
FOP	Field Operations Procedure Plan
FS	feasibility study
ft	foot, feet
FY	fiscal year
g	gram
GC	gas chromatography
Hg	mercury
HLA	Harding Lawson Associates
HSA	hollow-stem auger
HSP	Health and Safety Plan
IBCS	Irondale Boundary Containment System
ICAP	inductively coupled argon plasma
ICP	inductively coupled plasma
ID	inside diameter
IRA A	Groundwater Intercept and Treatment System North of RMA
kg	kilogram

m	meter
MKE	Morrison-Knudsen Engineers, Inc.
MS	mass spectroscopy
NBCS	North Boundary Containment System
NPP	nitrogen phosphorus pesticide
NWBCS	Northwest Boundary Containment System
OAS	Organizations and State (EPA, Shell, Army, and the State)
OCP	organochlorine pesticide
OU	operable unit
Pb	lead
PID	photoionization detector
PMRMA	Program Manager for Rocky Mountain Arsenal
QA	quality assurance
QAP	Quality Assurance Plan
QC	quality control
RI	remedial investigation
RLSA	R.L. Stollar Associates
RMA	Rocky Mountain Arsenal
Shell	Shell Chemical Company
SVOC	semivolatile organic compound
TCLEE	tetrachloroethene
TDS	total dissolved solids
TOC	total organic carbon
TRCLE	trichloroethene
Tri-County	Tri-County Health Department
UFS	unconfined flow system
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency

USFWS	U.S. Fish and Wildlife Service
VOC	volatile organic compound
WCFS	Woodward-Clyde Federal Services
Work Plan	Draft Final Work Plan

10.0 LIST OF REFERENCES

- Burt, W. H., P. Grossenheider, 1976. A field guide to the mammals. Houghton Mifflin Co., Boston, Mass.
- Carey, A. E., and others, 1980. Residue Concentrations of Propanil, TCAB and Other Pesticides in Rice-Growing Soils in the United States, 1972. *Pest. Monit. J.* 14: 23-25.
- Carey, A. E., and others, 1979. Pesticide Residue Levels in Soils and Crops from 37 States, 1972 - National Soils Monitoring Program (IV). *Pest. Monit. J.* 12: 209-229.
- Carey, A. E., and others, 1978. Pesticide Residue Levels in Soils and Crops, 1971 - National Soils Monitoring Program (III). *Pest. Monit. J.* 12: 117-136.
- Colorado Department of Health (CDH), 1990. State Proposed Surficial Soil Sampling Program, North and Northwest of the RMA. April.
- Colorado Division of Wildlife. 1981. Colorado Reptile and Amphibian Distribution Latilong Study. G. Hammerson and D. Langlois Eds. CDOW Nongame Section.
- Colorado Division of Wildlife. 1982a. Colorado Mammal Distribution Latilong Study. S.J. Bissel and M.B. Dillon Eds. CDOW Nongame Section.
- Colorado Division of Wildlife. 1982b. Colorado Bird Distribution Latilong Study. C.A. Chase III, S.J. Bissel, H.E. Kingery, and W.D. Graul Eds. CDOW Nongame Section.
- Ebasco, 1989. Rocky Mountain Arsenal Water Remedial Investigation Report. Final Report. July.
- Environmental Science and Engineering and Harding Lawson Associates (HLA). 1988a. Rocky Mountain Arsenal Offpost Operable Unit Remedial Investigation and Chemical Specific Applicable or Relevant and Appropriate Requirements. Final Report Version 3.1. Volume 1. Office of the Program Manager for RMA, U.S. Army. December. RIC Number 89173R01.
- Environmental Science and Engineering, Inc., 1988b. Air Remedial Investigation. Final Report. Office of the Program Manager for RMA, U.S. Army. June.
- Environmental Science and Engineering, Inc., and others, 1989a. Offpost Operable Unit Endangerment Assessment/Feasibility Study with Applicable or Relevant and Appropriate Requirements. Draft Final Report. Version 2.1. March. RIC Number 89144R01.
- Environmental Science and Engineering, Inc., 1989b. Biota Remedial Investigation Final Report. Office of the Program Manager for RMA, U.S. Army. Version 3.2. May. RIC Number 89144R01.
- Fahey, J. E., Butcher, J. W., Murphy, R. T., 1965. Chlorinated Hydrocarbon Insecticide Residues in Soil of Urban Areas, Battle Creek, MI. *J. Econ. Entomol.* 58: 1026-1027.
- Gish, C. D., 1970. Organochlorine Insecticide Residues in Soils and Soil Invertebrates from Agricultural Lands. *Pest. Monit. J.* 3: 241-251.
- Hall, E. R., 1981. The Mammals of North America. Second Edition. Wiley and Sons, NY, p. 1181.

Hall, J. E., Y. A. Greichus, K. E. Severson. 1971. Effects of Aldrin on Young Pen-reared Pheasants. *Journal of Wildlife Management* 35:429-434.

Hamaker, J. W., 1964, Mathematical prediction of cumulative pesticide levels in soil: in R.F. Gould (ed.), *Organic Pesticides in the Environment*, Advan. Chem. Servcs., 60, Amer. Chem. Soc., Washington, D.C.

Harding Lawson Associates, 1989a. Draft Final Work Plan Offpost Operable Unit Remedial Investigation/Endangerment Assessment /Feasibility Study. Office of the Program Manager for RMA, U.S. Army, December. RIC Number 90078R01.

Harding Lawson Associates, 1989b. Offpost Interim Response Action and Remedial Investigation/Feasibility Study, Draft Final, Field Operations Procedures Plan, August. RIC Number 8926R02.

Harding Lawson Associates, 1989c. Offpost Operable Unit, Draft Final Quality Assurance Plan, August. RIC Number 89268R01.

Harding Lawson Associates, 1989d. Offpost Interim Response Action and Remedial Investigation/Feasibility Study, Draft Final Health and Safety Plan, August. RIC Number 89268R03.

Harding Lawson Associates, 1989e. Offpost Interim Response Action and Remedial Investigation/Feasibility Study, Draft Final Data Management Plan, August.

Harding Lawson Associates, 1990. Surficial Soil Sampling Plan, April. Transmitted under Army cover letter June 11, 1990.

Harrington, H. D., 1964. *Manual of the Plants of Colorado*. Swallow Press, Chicago, Illinois.

Lang, J. T., Rodriguez, L. L., Livingston, J. N. Organochlorine Pesticide Residues in Soils from Six U.S. Air Bases 1975-1976. *Pest. Monit. J.* 12: 230-233.

Metcalf, R. L., I. P. Kapoor, P. Y. Lu, C. K. Schuth, and P. Sherman. 1973. Model Ecosystem Studies of the Environmental Fate of Six Organochlorine Pesticides. *Environmental Health Perspectives*. June 1973. pp. 35-44.

Mullins, D. E., Johnsen, R. E., Starr, R. I., 1971. Persistence of Organochlorine Insecticide Residues in Agricultural Soils of Colorado. *Pest. Monit. J.* 5: 268-275.

Nash, R. G., E. A. Woolson, 1967. Persistence of chlorinated hydrocarbon insecticides in soils, *Science*, 157:924-927.

Needham, J. G., P. R. Needham, 1977. *A guide to the study of fresh-water biology*. Holden Day, Inc., San Francisco, California.

Program Manager for Rocky Mountain Arsenal, 1989. Chemical Quality Assurance Plan, Version 1.0, U.S. Army Material Command. July. RIC Number 89244R01.

R.L. Stollar and Associates, 1989. Comprehensive Monitoring Program Annual Groundwater Report for 1988. June.

R.L. Stollar and Associates, 1990a. Comprehensive Monitoring Program Annual Groundwater Report for 1989. Version 2.0. June.

- R.L. Stollar and Associates, 1990b. Comprehensive Monitoring Program Final Surface-Water Data Assessment Report for 1988. May.
- R.L. Stollar and Associates, 1990c. Comprehensive Monitoring Program Air Quality and Data Assessment Report for 1989. June.
- R.L. Stollar and Associates, 1991a. Comprehensive Monitoring Program Annual Groundwater Report for 1990. Version 1.1. August.
- R.L. Stollar and Associates, 1991b. Comprehensive Monitoring Program Final Surface-Water Data Assessment Report for 1989. November.
- Saha, J. G., Sumner, A. K., 1971. Organochlorine Insecticide Residues in Soil from Vegetable Farms in Saskatchewan. *Pest. Monit. J.* 5:28-31.
- Shacklette, H. T., J. G. Boerngen, 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States, U.S. Geological Surv. Professional Paper 1270. 105 pp.
- Shell Oil Company, 1992. Letter dated January 20, 1992 from Mr. Edward J. McGrath of Holme, Roberts, and Owen to Mr. Kevin Blose of the Office of the Program Manager, Rocky Mountain Arsenal.
- Trautman, W. L., Chesters, G., Poinke, H. B., 1968. Organochlorine Insecticide Composition of Randomly Selected Soils from Nine States. *Pest. Monit. J.* 2: 93-96.
- Tri-County Health Department, 1989. Draft Final Rocky Mountain Arsenal Offpost Private Well Inventory and Information Survey, August. RIC Number 89248R01.
- U.S. Environmental Protection Agency, 1989. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, EPA/530 SW-89-026.
- Weber, W. A., 1976. Rocky Mountain Flora. Colorado Associated University Press, Boulder, Colorado.

Table 1.1: Data Needs in Each Offpost Operable Unit Medium Addressed in RI Addendum

Medium	Description of Need
Groundwater	- Additional data on contaminant distribution in the area immediately downgradient of the RMA northern boundary. - Additional data on contaminant distribution in the area downgradient of the RMA northwest boundary. - Additional data on contaminant distribution in the area downgradient of the canals.
Surface water	- Data on surface-water quality along First Creek and O'Brian Canal.
Surficial soil	- Data on contaminant distributions in surficial soil in the vicinity of First Creek and the northwest boundary, including assessment of background concentrations of selected compounds.
Sediment	- Data on distribution of contamination in sediments along First Creek and O'Brian Canal. - Data on distribution of contamination in sediments along Burlington Ditch.
Biota	- Data on possible contamination of native and domestic biota in area immediately north of RMA northern boundary.

RMA = Rocky Mountain Arsenal

Table 2.1: Aquifer Designations and Sampling Dates for Wells in Offpost Operable Unit
(Page 1 of 4)

<u>Well Number</u>	<u>Aquifer Designation Category</u>	<u>Source for Aquifer Designation Information</u>	<u>Sampling Date(s)</u>
37307	1	ESE	11/09/89
37308	1	ESE	11/07/89
37309	1	ESE	11/07/89
37312	1	ESE	11/07/89
37313	1	ESE	11/27/89
37320	2	ESE	10/25/89
37323	4	ESE	11/09/89
37327	1	ESE	11/08/89
37330	1	ESE	10/30/89
37331	1	ESE	10/30/89
37332	1	ESE	11/13/89
37333	2	ESE	11/10/89
37334	3	ESE	10/27/89
37335	1	ESE	10/27/89
37336	3	ESE	10/27/89
37337	2	ESE	10/25/89
37338	1	ESE	11/09/89
37339	1	ESE	11/09/89
37341	1	ESE	10/26/89
37342	1	ESE	10/31/89
37343	2	ESE	10/25/89
37344	1	ESE	10/31/89
37345	1	ESE	11/01/89
37346	1	ESE	11/16/89
37347	1	ESE	11/13/89
37348	1	ESE	10/30/89
37349	1	ESE	11/17/89
37350	2	ESE	10/30/89
37351	1	ESE	11/01/89
37352	1	ESE	11/06/89
37353	1	ESE	11/06/89
37354	1	ESE	11/01/89
37355	1	ESE	10/25/89
37356	1	ESE	10/27/89
37357	1	ESE	11/01/89
37358	1	ESE	10/30/89
37359	1	ESE	11/03/89
37360	1	ESE	11/03/89
37361	1	ESE	11/03/89
37362	1	ESE	11/14/89
37363	1	ESE	11/03/89
37364	2	ESE	11/08/89
37367	1	ESE	11/02/89
37368	1	ESE	11/07/89
37369	1	ESE	10/25/89
37370	1	ESE	11/07/89
37371 ⁽¹⁾	4	ESE	11/08/89

Table 2.1: (Page 2 of 4)

<u>Well Number</u>	<u>Aquifer Designation Category</u>	<u>Source for Aquifer Designation Information</u>	<u>Sampling Date(s)</u>
37373	1	ESE	10/31/89
37374	1	ESE	10/31/89
37377	1	ESE	10/25/89
37378	1	ESE	11/17/89
37381	2	ESE	11/02/89
37382	3	ESE	11/18/89
37383	1	ESE	11/02/89
37385	1	ESE	11/06/89
37386	1	ESE	11/17/89
37389	3	ESE	11/08/89
37391	1	ESE	10/25/89
37392	1	ESE	10/25/89
37395	1	ESE	11/15/89
37396	1	ESE	11/08/89
37397	2	ESE	11/08/89
37402	1	HLA	09/27/89, 02/22/90
37403	1	HLA	09/25/89, 02/21/90
37404	1	HLA	09/26/89, 02/22/90
37405	1	HLA	09/26/89, 02/21/90
37406	1	HLA	09/26/89, 02/21/90
37407	1	HLA	09/26/89, 02/21/90
37408	1	HLA	12/01/89
37409	1	HLA	11/29/89
37410	1	HLA	12/04/89
37418	1	HLA	12/18/89, 06/22/90
37419	1	HLA	12/15/89
37420	1	HLA	12/13/89, 06/21/90
37428	1	HLA	12/27/89
37429	1	HLA	12/29/89, 02/26/90
37430	1	HLA	12/28/89, 02/26/90
37433	1	Appendix A	01/03/90, 02/26/90
37434	1	Appendix A	01/03/90, 02/27/90
37435	1	Appendix A	12/29/89, 02/27/90
37436	1	Appendix A	01/02/90, 02/28/90
37437	1	Appendix A	01/02/90, 02/28/90
37438	1	Appendix A	01/25/90, 02/28/90
37439	1	Appendix A	01/25/90, 03/01/90
37440	1	Appendix A	01/25/90, 03/01/90
37441	1	Appendix A	01/29/90, 03/01/90, 06/12/90
37442	1	Appendix A	03/02/90, 06/12/90
37443	1	Appendix A	03/01/90, 06/13/90
37444	1	Appendix A	03/02/90, 06/13/90
37445	ARA	Appendix A	08/28/90
37446	ARA	Appendix A	-
SAC18	1	Appendix A	10/31/89

Table 2.1: (Page 3 of 4)

<u>Well Number</u>	<u>Aquifer Designation Category</u>	<u>Source for Aquifer Designation Information</u>	<u>Sampling Date(s)</u>
Domestic Wells			
8834A TW 096	1	Per Comm	08/22/90, 08/24/90
8834B TW 096	1	Per Comm	08/22/90
8834C TW 096	ARA	Per Comm	08/22/90
09200 TW 090	1	Per Comm	01/17/89, 09/08/89
09610 TW PEO	ARA	Tri-Co	04/20/89 ⁽²⁾
10021 TW PEO	ARA	Tri-Co	02/27/89
10100 TW 108	1	Tri-Co	05/30/90
10150 TW HY2	1	Tri-Co	05/30/90
37431	ARA	Appendix A	09/13/89, 11/21/89
10720 TW BRI	1	Tri-Co	04/21/89 ⁽²⁾ , 09/08/89, 12/28/89
10791 TW BRI	1	Tri-Co	05/09/90
11010 TW HAV	1	Tri-Co	01/26/90 (Abandoned 10/90)
11071 TW 112	1	Tri-Co	01/31/89, 08/21/90
11295 TW 108	1	Tri-Co	01/31/89, 08/22/90, 08/24/90
11460 TW PEO	1	Tri-Co	08/21/90
11515 TW 096	ARA	Tri-Co	04/20/89 ⁽²⁾
11755 TW BRI	1	Tri-Co	05/30/90
11810 TW BRI	1	Tri-Co	05/10/90
11830 TW 112	1	Tri-Co	01/31/89, 09/08/89
11841 TW 096	ARA	Tri-Co	04/20/89 ⁽²⁾ , 09/07/89, 01/26/90, 08/21/90
11921 TW 096	ARA	Tri-Co	04/20/89 ⁽²⁾ , 09/07/89
12001 TW BRI	1	Tri-Co	05/10/90
13350 TW 104	1	Tri-Co	01/17/89
13701 TW 104	ARA	Tri-Co	01/17/89

Sources:

ESE = Environmental Science and Engineering, Inc., and others, 1988a. Offpost Operable Unit Remedial Investigation and Chemical Specific Applicable or Relevant and Appropriate Requirements, Final Report (Version 3.1) - 3 Volumes, December.

HLA = Harding Lawson Associates, 1990. Results of Pilot-Scale Hydraulic and Treatment Testing North of Rocky Mountain Arsenal Interim Response Action A, Draft Final Report, 2 Volumes, June.

Appendix A = Appendix A of this report.

Tri-Co = Tri-County Health Department, 1989. Draft Final Rocky Mountain Arsenal Offpost Private Well Inventory and Information Survey, August.

Per Comm = Personal communication with well owner.

Table 2.1: (Page 4 of 4)

- (1) **Piezometer; sampled for water quality analyses**
(2) **All data for analyses of these samples were rejected by PMRMA**
- 1 = **Alluvial well with screen <3 feet into claystone bedrock**
2 = **Alluvial well with screen 3 to 6 feet into claystone bedrock**
3 = **Screened mostly in Denver Formation but because of relative transmissivity of the alluvial and Denver materials, screen considered to be representative of alluvial water levels and water chemistry**
4 = **Screened entirely in Denver Formation but because of relative transmissivity of the alluvial and Denver materials, screen considered to be representative of alluvial water levels and water chemistry**

ARA = Screened entirely in Arapahoe Formation

- not sample

Table 2.2: Technical Justification for Monitoring Wells Installed
Under Remedial Investigation Addendum Program
(Page 1 of 3)

<u>HLA Designation</u>	<u>IRDMS Designation</u>	<u>Approximate Location</u>	<u>Technical Justification</u>
RI-1	NA	Not Installed	Well 37441 was installed by South Adams County at the proposed location of this well
RI-2	NA	Not Installed	Access could not be negotiated in a timely fashion. Current groundwater-quality data indicate that this well is not necessary.
RI-4	37442	Intersection of I-76 and State Highway 85, east central area of Section 16	Useful in assessing and characterizing extent of dieldrin and chloroform plumes northwest of RMA.
RI-5	37443	OSCO Property Study Area IB, west central area of Section 15	Useful in assessing continuity of chloroform and dieldrin contamination downgradient of the NWBCS.
RI-8	37430	Highway 85 south of 104th Avenue, Study Area II, northeast corner of Section 16	Useful for increased well control to assess isolated detections of dieldrin, chlorobenzene, chloroform, tetra-chloroethylene, and DIMP as well as the distal extent of plumes emanating from Study Area Ib.
RI-9	37433	Along Burlington Ditch west of Havana Street between south of 104th Avenue and southeast of I-76, Study Area II, east central area of Section 15	Useful for downgradient assessment of contaminant migration beyond O'Brian Canal and Burlington Ditch. Increases well control needed to assess isolated detections of DIMP and chlorobenzene.
RI-10	37429	Intersection of Havana Street and 104th Avenue, Study Area II, southeast corner of Section 10	Useful for increased definition of DIMP and dieldrin detections as well as for assessing dilution effects downgradient of O'Brian Canal and Burlington Ditch
RI-11	37434	On 112th Avenue northwest of I-76, Study Area II, central area of Section 11	Useful in refining the configuration of the DIMP plume in Section 11. Useful as upgradient control for plumes in Study Area II.

Table 2.2: (Page 2 of 3)

<u>HLA Designation</u>	<u>IRDMS Designation</u>	<u>Approximate Location</u>	<u>Technical Justification</u>
RI-12	37435	On 120th Avenue west of Peoria Street, Study Area II, southeast corner of Section 2	Useful in assessing contaminant migration along the Northern Paleochannel downgradient of O'Brian Canal. Increases well control north of the Northern Paleo-channel and northwest of the canals.
RI-13	37436	Northwest of the intersection of 88th Avenue and Yosemite Street, southeast corner of Section 21	Useful in refining the extent of dieldrin and chloroform plumes, also used to assess the extent of dieldrin at the south end of the NWBCS. Geologic data from this boring useful to further define a suspected paleochannel in this area.
RI-14	37437	500 feet northeast of RI-13	Useful in refining the extent of dieldrin and chloroform at the south end of the NWBCS. Geologic data from this boring are necessary to further define a suspected paleo-channel in this area.
RI-15	NA	Southeast of 96th Avenue along State Highway 2, middle of Section 22	No well installed. No alluvial groundwater encountered. Boring is useful in assessing extent of saturated alluvium in this area.
RI-16	37438	Southeast of O'Brian Canal in Section 22, located on northwest boundary of feed lot	Useful in evaluating the northern lateral extent of dieldrin and chloroform detected in well 37382.
RI-17	37439	Along Burlington Ditch in the northwest corner of Section 22	Useful in assessing the downgradient extent of dieldrin and chloroform detected in well 37382, also used to assess dilution from the canals and evaluate the continuity of the plumes extending from wells 37382 and 37336.
RI-18	NA	Not Installed	Access could not be negotiated in a timely fashion. Current groundwater-quality data indicate that this well is not necessary.
RI-19	NA	Not Installed	This well was not installed because of early objections by the OAS and was removed from the RI/EA/FS Work Plan.

Table 2.2: (Page 3 of 3)

<u>HLA Designation</u>	<u>IRDMS Designation</u>	<u>Approximate Location</u>	<u>Technical Justification</u>
RI-20	37440	On the south side of 96th Avenue, 100 yards east of the intersection of 96th Avenue and Union Pacific Railroad, northeast corner of Section 21	Useful in assessing the lateral extent and continuity of contamination between 37336 and 37337.
RI-21	37444	Along Union Pacific Railroad right-of-way, northeast of RI-20, southeast corner of Section 16	Useful in assessing downgradient extent of contaminants detected at well 37336 in an area suspected to be the terminus of the dieldrin and chloroform plumes.
AP-1	37431	East of Highway 2, southwest quarter of Section 12	Useful in assessing water quality in the Arapahoe Formation in an area of the Northern Pathway where alluvium is contaminated by chloroform, DIMP, and other compounds.
AP-2	37445	East of Havana Street in the northwest quarter of Section 11	Useful in assessing water quality in the Arapahoe Formation in an area where DIMP has been detected in the unconfined flow system downgradient from the Northern Pathway.
AP-3	37446	East of Brighton Road in the southeast quarter of Section 9	Useful in assessing water quality in the Arapahoe Formation in an area where DIMP has been detected in the unconfined flow system downgradient of the First Creek Pathway.

DIMP = diisopropylmethylphosphonate

HLA = Harding Lawson Associates

IRDMS = Installation Restoration Data Management System

NA = Not applicable; applies to wells that were planned but not installed

NWBCS = Northwest Boundary Containment System

OAS = Organizations and State

RI/EA/FS = remedial investigation/endorsement assessment/feasibility study

Table 2.3: Completion Data for New Monitoring Wells

Boring Number	Well Number	Location Coordinates		Ground Level Elevation (ft)	Elevation Top of Casing (ft)	Screen Interval (ft/bgl)	Top of Sand (ft/bgl)	Top of Bentonite (ft/bgl)	Depth to Bedrock (ft/bgl)
		UTM (meters)	UTM (meters)						
		North	East						
RI-4	37442	4414147.35	509455.04	5073.5	5074.85	16.0 - 33.0	11.0	6.0	33.0
RI-5	37443	4413862.59	510158.80	5081.5	5083.06	12.5 - 32.5	10.0	6.3	31.5
RI-8	37430	4414644.10	509958.07	5068.8	5070.21	14.0 - 29.0	9.0	4.0	29.0
RI-9	37433	4414167.81	511227.76	5100.0	5101.55	31.0 - 45.0	26.0	21.0	45.0
RI-10	37429	4414847.55	511539.02	5090.6	5092.06	29.0 - 44.0	25.5	20.0	44.0
RI-11	37434	4415616.14	512139.15	5090.31 ⁽¹⁾	5089.85	33.0 - 48.0	28.0	22.7	48.0
RI-12	37435	4416437.64	513001.19	5091.2	5091.10	31.0 - 42.0	26.0	21.0	42.0
RI-13	37436	4411806.93	509671.52	5116.89 ⁽¹⁾	5116.04	28.0 - 55.0	25.0	20.0	55.0
RI-14	37437	4411897.02	509757.11	5120.12 ⁽¹⁾	5119.56	32.0 - 52.0	28.0	23.0	52.5
RI-15 ⁽²⁾	-	4412359.22	510816.57	5134.95	-	-	-	-	30.0
RI-16	37438	4412801.57	510606.01	5115.0	5116.30	25.0 - 37.0	20.3	14.7	37.5
RI-17	37439	4412742.69	510068.26	5107.4	5108.98	26.0 - 46.0	21.0	16.4	47.3
RI-20	37440	4413199.55	509505.48	5093.63 ⁽¹⁾	5092.95	18.0 - 38.0	13.5	8.5	37.0
RI-21	37444	4413550.68	509710.47	5085.15	5086.41	14.6 - 34.6	10.0	5.2	35.5
AP-1	37431	4415230.40	513456.66	5121.9	5124.26	280.0 - 320.0 210 - 230	170.0	160.0	52.0
AP-2	37445	-	-	-	-	380.0 - 420.0	200.0	180.6	47.0
AP-3	37446	-	-	-	-	356.0 - 396.0	270.0	258.0	33.0

(1) Flush mounted, elevation taken to top of casing

(2) RI-15 was not completed as a monitoring well. The boring was dry, and data from this boring were used as control for bedrock surface elevation.

- = Data not available

ft = feet

ft/bgl = feet below ground level

UTM = Universal Transverse Mercator

20000,350.10 - RI A

0426030192

Table 2.4: Target Analyte List
(Page 1 of 3)

Analyte	Medium				Biota	Method
	Ground-water	Surface Water	Soil/Stream and Pond Sediment	Surface Sediment		
<u>Volatile Organic Compounds</u>						
1,1,1-Trichloroethane	x	x	x			GC, GC/MS
1,1,2-Trichloroethane	x	x	x			GC, GC/MS
1,1-Dichloroethane	x	x	x			GC, GC/MS
1,2-Dichloroethane	x	x	x			GC, GC/MS
1,1-Dichloroethene	x	x	x			GC, GC/MS
1,2-Dichloroethenes (cis and trans)	x	x	x			GC, GC/MS
Benzene	x	x	x			GC, GC/MS
Carbon tetrachloride	x	x	x			GC, GC/MS
Chlorobenzene	x	x	x			GC, GC/MS
Chloroform	x	x	x			GC, GC/MS
Dibromochloropropane		x	x	x		GC, GC/MS
Dimethyldisulfide		x	x	x		GC, GC/MS
Ethylbenzene	x	x	x			GC, GC/MS
m-Xylene	x	x	x			GC, GC/MS
Methylene chloride	x	x	x			GC, GC/MS
Methylisobutylketone	x	x	x			GC, GC/MS
o,p-Xylenes	x	x	x			GC, GC/MS
Tetrachloroethene	x	x	x			GC, GC/MS
Toluene	x	x	x			GC, GC/MS
Trichloroethene	x	x	x			GC, GC/MS
Vinyl chloride	x	x	x			GC, GC/MS
<u>Semivolatile Organic Compounds/Pesticides</u>						
1,4-Oxathiane	x	x	x	x		GC, GC/MS
2,2-bis(parachlorophenyl) 1,1-Dichloroethene (DDE)	x	x	x	x	x	GC, GC/MS
2,2-bis(parachlorophenyl) 1,1-Trichloroethane (DDT)	x	x	x	x	x	GC, GC/MS GC, GC/MS
2,3,6-Trichlorophenol	x	x				GC, GC/MS
2,4,6-Trichlorophenol	x	x				GC, GC/MS
2,4-Dichlorophenol	x	x				GC, GC/MS
2,4-Dimethylphenol	x	x				GC, GC/MS

Table 2.4: (Page 2 of 3)

Analyte	Medium				Biota	Method
	Ground-water	Surface Water	Soil/Stream and Pond Sediment	Surface Sediment		
Semivolatile Organic Compounds/Pesticides (con't)						
2,4-Dinitrophenol	x	x				GC, GC/MS
2-Chlorophenol	x	x				GC, GC/MS
2-Methylphenol	x	x				GC, GC/MS
2-Nitrophenol	x	x				GC, GC/MS
3-Methyl-4-chlorophenol	x	x				GC, GC/MS
4-Chlorophenylmethyl sulfide	x	x	x	x		GC, GC/MS
4-Chlorophenylmethyl sulfone	x	x	x	x		GC, GC/MS
4-Chlorphenylmethyl sulfoxide	x	x	x	x		GC, GC/MS
4-Methylphenol	x	x				GC, GC/MS
4-Nitrophenol	x	x				GC, GC/MS
Aldrin	x	x	x	x	x	GC, GC/MS
Atrazine	x	x	x	x		GC, GC/MS
Benzothiazole	x	x	x	x		GC, GC/MS
Bicyclo(2,2,1)hepta-2,5-diene	x	x	x			GC, GC/MS
bis(2-Ethylhexyl) phthalate	x	x				GC, GC/MS
Caprolactum	x	x				GC, GC/MS
Chlordane	x	x	x	x		GC, GC/MS
Dicyclopentadiene	x	x	x	x		GC, GC/MS
Dieldrin	x	x	x	x	x	GC, GC/MS
Diisopropylmethylphosphonate	x	x	x	x		GC, GC/MS
Dimethylmethylphosphonate	x	x	x			GC, GC/MS
Dithiane	x	x	x	x		GC, GC/MS
Endrin	x	x	x	x	x	GC, GC/MS
Hexachlorocyclopentadiene	x	x	x	x		GC, GC/MS
Isodrin	x	x	x	x		GC, GC/MS
Malathion	x	x	x	x		GC, GC/MS
Parathion	x	x	x	x		GC, GC/MS
Pentachlorophenol	x	x				GC, GC/MS
Phenol	x	x				GC, GC/MS
Vapona	x	x	x	x		GC, GC/MS
Supona	x	x	x	x		GC, GC/MS

Table 2.4: (Page 3 of 3)

Analyte	Medium					Method
	Ground-water	Surface Water	Soil/Stream and Pond Sediment	Surface Sediment	Biota	
<u>Inorganics/General Characteristics</u>						
Arsenic	x	x	x	x	x	ICP, GFAA, CVAA
Cadmium	x	x	x	x		ICP, GFAA, CVAA
Calcium	x	x		x		ICP, GFAA, CVAA
Chloride	x	x				ICP, GFAA, CVAA
Chromium	x	x	x	x		ICP, GFAA, CVAA
Copper	x	x	x	x		ICP, GFAA, CVAA
Cyanide	x	x	x			ICP, GFAA, CVAA
Fluoride	x	x				ICP, GFAA, CVAA
Iron	x			x		ICP, GFAA, CVAA
Lead	x	x	x	x		ICP, GFAA, CVAA
Magnesium	x	x		x		ICP, GFAA, CVAA
Manganese	x			x		ICP, GFAA, CVAA
Mercury	x	x	x	x	x	ICP, GFAA, CVAA
Nitrate/nitrite	x					ICP, GFAA, CVAA
Potassium	x	x		x		ICP, GFAA, CVAA
Sodium	x	x		x		ICP, GFAA, CVAA
Sulfate	x	x				ICP, GFAA, CVAA
Zinc	x	x	x	x		ICP, GFAA, CVAA
Total Organic Carbon	x	x	x			
Total Suspended Solids	x					

CVAA = Cold vapor atomic absorption

GC = Gas chromatography

GC/MS = Gas chromatography/mass spectrometry

GFAA = Graphite furnace atomic absorption

ICP = Inductively coupled plasma

Table 2.5: Analytical Methods and Certified Reporting Limits
(Page 1 of 11)

Lab	Media	Method(1)	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
ED	Animal Tissue	B6	Metals/Tissue/GFAA	Arsenic	0.250	µg/g
ED	Animal Tissue	B6A	Metals/Tissue/GFAA	Arsenic	0.250	µg/g
ED	Animal Tissue	C6	Metals/Tissue/CVAA	Mercury	0.0500	µg/g
ED	Animal Tissue	C6A	Metals/Tissue/CVAA	Mercury	0.0500	µg/g
ED	Animal Tissue	M6	Pesticides/Tissue/GCEC	Aldrin Dieldrin Endrin 2,2-Bis(parachlorophenyl)1,1-Dichloroethene (DDE) 2,2-Bis(parachlorophenyl)1,1-Trichloroethane (DDT)	0.0150 0.0160 0.0360 0.0650 0.132	µg/g
UB	Groundwater	AV8	Aromatics/Water/GCPID	m-Xylene Benzene Chlorobenzene Ethyl benzene Toluene o,p-Xylene	1.32 1.05 1.39 1.37 1.47 1.36	µg/l
UB	Groundwater	AX8	Metals/Water/GFAA	Arsenic	2.35	µg/l
ED	Groundwater	CN1	Cyanide/Water/UVVIS	Cyanide	8.90	µg/l
UB	Groundwater	LL8	Anions/Water/Technicon	Nitrate/Nitrite	10.0	µg/l
ED	Groundwater	MM8A	Pesticides/Water/GCEC	Aldrin Hexachlorocyclopentadiene Chlordane Dieldrin Endrin Isodrin 2,2-Bis(parachlorophenyl)1,1-Dichloroethene (DDE) 2,2-Bis(parachlorophenyl)1,1-Trichloroethane (DDT)	0.083 0.083 0.152 0.0539 0.0600 0.0500 0.0460 0.0500	µg/l

Table 2.5: (Page 2 of 11)

Lab	Media	Method(1)	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
UB	Groundwater	N8	Halocarbons/Water/GCCON	1,1,1-Trichloroethane 1,1,2-Trichloroethane 1,1-Dichloroethane 1,1-Dichloroethane 1,2-Dichloroethanes (cis & trans) 1,2-Dichloroethane Vinyl chloride Carbon tetrachloride Methylene chloride Chloroform Chlorobenzene Tetrachloroethane Trichloroethane	0.760 0.780 1.70 0.730 0.760 1.10 1.01 0.990 7.40 0.500 0.820 0.750 0.560	µg/l
ED	Groundwater	NN8	Anions/Water/Ionchrom	Chloride Fluoride Sulfate	1590 1000 5000	µg/l
ED	Groundwater	R9D	Metals/Water/ICAP	Arsenic Calcium Cadmium Chromium Copper Magnesium Sodium Lead Zinc	25.0 50.0 5.00 22.0 10.0 89.2 251 52.0 20.0	µg/l
ED	Groundwater	SS8	Aromatics/Water/GCPID	m-Xylene Benzene Ethyl benzene Toluene o,p-Xylene	1.04 1.92 0.620 2.10 1.34	µg/l
UB	Groundwater	TF20	Cyanide/Water/Technicon	Cyanide	5.00	µg/l
ES	Groundwater	TF22	Nit/Water/Technicon	Nitrate/Nitrite	10.0	µg/l

Table 2.5: (Page 3 of 11)

Lab	Media	Method ⁽¹⁾	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
ED	Groundwater	TT8	Halocarbons/Water/GCHALL	1,1,1-Trichloroethane 1,1,2-Trichloroethane 1,1-Dichloroethene 1,1-Dichloroethane 1,2-Dichloroethenes (cis & trans) 1,2-Dichloroethane Carbon tetrachloride Methylene chloride Chloroform Chlorobenzene Tetrachloroethene Trichloroethene	1.09 1.63 1.85 1.93 1.75 2.07 1.69 2.48 1.88 1.96 2.76 1.31	µg/l
AL	Groundwater	UG05	Halocarbons/Water/GCCON	Carbon tetrachloride Methylene chloride Chloroform Chlorobenzene Tetrachloroethene Trichloroethene	0.151 2.02 0.727 1.01 0.0300 0.965	µg/l
UB	Groundwater	UM21	Volatiles/Water/GCMS	1,1,1-Trichloroethane 1,1,2-Trichloroethane 1,1-Dichloroethene 1,1-Dichloroethane 1,2-Dichloroethenes (cis & trans) 1,2-Dichloroethane m-Xylene Vinyl chloride Benzene Carbon tetrachloride Methylene chloride Chloroform Chlorobenzene Ethyl benzene Toluene Methylisobutyl ketone Tetrachloroethene Trichloroethene o,p-Xylene	1.0 1.0 1.0 1.0 5.0 1.0 1.0 12 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.4 1.0 1.0 2.0	µg/l

Table 2.5: (Page 4 of 11)

Lab	Media	Method(1)	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
ED	Groundwater	VV8	Metals/Water/GFAA	Arsenic	2.50	µg/l
ED	Groundwater	WW8	Metals/Water/CVAA	Mercury	0.500	µg/l
ED	Plant Tissue	B6P	Metals/Tissue/GFAA	Arsenic	0.250	µg/g
ED	Plant Tissue	C6P	Metals/Tissue/CVAA	Mercury	0.0500	µg/g
ED	Plant Tissue	QH01	Pesticides/Biota/GCEC	Aldrin	0.0210	µg/g
				Dieldrin	0.0260	
				Endrin	0.0460	
				2,2-Bis(parachlorophenyl)1,1-Dichlorethene (DDE)	0.0430	
				2,2-Bis(parachlorophenyl)1,1-Trichlorethene (DDT)	0.155	
CL	Sediment	FF9	Organophosphor/Soil/GCFF	Diisopropyl methylphosphonate	0.050	µg/g
				Dimethylmethyl phosphonate	0.050	
UB	Sediment	KK9B	Pesticides/Soil/GCEC	Aldrin	0.00211	µg/g
				Hexachlorocyclopentadiene	0.00137	
				Chlordane	0.0230	
				Dieldrin	0.00181	
				Endrin	0.00471	
				Isodrin	0.00188	
				2,2-Bis(parachlorophenyl)1,1-Dichlorethene (DDE)	0.00466	
				2,2-Bis(parachlorophenyl)1,1-Trichlorethene (DDT)	0.00377	
UB	Sediment	L9	Organics/Soil/GCMS	Aldrin	0.30	µg/g
				Atrazine	0.30	
				Hexachlorocyclopentadiene	0.60	
				Chlordane	2.0	
				4-Chlorophenylmethyl sulfide	0.90	
				4-Chlorophenylmethyl sulfoxide	0.30	
				4-Chlorophenylmethyl sulfone	0.30	
				Dibromochloropropane	0.30	
				Dicyclopentadiene	1.0	
				Vapona	3.0	

Table 2.5: (Page 5 of 11)

Lab	Media	Method(1)	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
UB	Sediment (continued)	L9	Organics/Soil/GCMS	Diisopropyl methylphosphonate	1.0	µg/g
				Dithiane	0.40	
				Dieldrin	0.50	
				Endrin	0.50	
				Isodrin	0.30	
				Malathion	0.70	
				1,4-Oxathiane	0.30	
				2,2-Bis(parachlorophenyl)1,1-Dichloroethene (DDE)	0.60	
				2,2-Bis(parachlorophenyl)1,1-Trichloroethane (DDT)	0.50	
				Parathion	0.90	
				Supona	0.60	
UB	Sediment	LM23	Volatiles/Soil/GCMS	1,1,1-Trichloroethane	0.20	µg/g
				1,1,2-Trichloroethane	0.35	
				1,1-Dichloroethene	0.27	
				1,1-Dichloroethane	0.49	
				1,2-Dichloroethenes (cis & trans)	0.32	
				1,2-Dichloroethane	0.32	
				m-Xylene	0.25	
				Vinyl chloride	1.8	
				Benzene	0.10	
				Carbon tetrachloride	0.31	
				Methylene chloride	4.4	
				Chloroform	0.24	
				Chlorobenzene	0.10	
				Ethyl benzene	0.19	
				Toluene	0.10	
				Methylisobutyl ketone	0.63	
				Tetrachloroethene	0.16	
				Trichloroethene	0.25	
				o,p-Xylene	0.78	
UB	Sediment	N9	Volatiles/Soil/GCMS	1,1,1-Trichloroethane	0.43	µg/g
				1,1,2-Trichloroethane	0.39	
				1,1-Dichloroethane	1.7	
				1,2-Dichloroethane	0.56	
				1,2-Dichloroethenes (cis & trans)	1.7	
				m-Xylene	0.74	
				Bicyclo (2,2,1) hepta-2,5-diene	0.36	
				Benzene	0.25	
				Carbon tetrachloride	0.25	
				Methylene chloride	1.5	

Table 2.5: (Page 6 of 11)

Lab	Media	Method(1)	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
UB (continued)	Sediment	N9	Volatiles/Soil/GCMS	Chloroform	0.29	$\mu\text{g/g}$
				Chlorobenzene	1.5	
				Dibromochloropropane	2.4	
				Dicyclopentadiene	0.64	
				Dimethyl disulfide	20	
				Ethyl benzene	0.38	
				Toluene	0.25	
				Methylisobutyl ketone	0.73	
				Tetrachloroethene	0.25	
				Trichloroethene	0.64	
				o,p-Xylene	4.9	
UB	Sediment	P9	Metals/Soil/ICP	Cadmium	0.74	$\mu\text{g/g}$
				Chromium	6.5	
				Copper	4.7	
				Lead	8.4	
				Zinc	8.7	
UB	Sediment	PP9	Volatiles/Soil/GCFID	Bicyclo (2,2,1) hepta-2,5-diene	1.10	$\mu\text{g/g}$
				Dicyclopentadiene	0.450	
				Methylisobutyl ketone	0.640	
UB	Sediment	S9	Pesticides/Soil/GCEC	Dibromochloropropane	0.00600	$\mu\text{g/g}$
UB	Soil	AA9	Aromatics/Soil/GCPID	m-Xylene	0.260	$\mu\text{g/g}$
				Benzene	0.0850	
				Ethyl benzene	0.160	
				Toluene	0.190	
				o,p-Xylene	0.390	
UB	Soil	B9	Metals/Soil/GFAA	Arsenic	2.50	$\mu\text{g/g}$
UB	Soil	HH9	Organosulfurs/Soil/GCFP	Benzothiazole	2.04	$\mu\text{g/g}$
				4-Chlorophenylmethyl Sulfide	4.40	
				4-Chlorophenylmethyl Sulfoxide	4.81	
				4-Chlorophenylmethyl Sulfone	9.01	
				Dithiane	1.45	

Table 2.5: (Page 7 of 11)

Lab	Media	Method ⁽¹⁾	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
UB	Soil (continued)	HH9	Organosulfurs/Soil/GCFP	Dimethyl disulfide	3.12	µg/g
UB	Soil	JS12	Inorganic/Soil/ICP	1,4-Oxathiane	1.74	µg/g
				Arsenic	16.4	µg/g
				Calcium	26.3	
				Cadmium	1.20	
				Chromium	1.04	
				Copper	2.84	
				Iron	6.66	
				Potassium	131	
				Magnesium	10.1	
				Manganese	9.87	
				Sodium	38.7	
				Lead	7.44	
				Zinc	2.34	
UB	Soil	KK9A	Pesticides/Soil/GCEC	Aldrin	0.00190	µg/g
				Hexachlorocyclopentadiene	0.00180	
				Chlordane	0.0230	
				Dieldrin	0.00330	
				Endrin	0.00580	
				Isodrin	0.00110	
				2,2-Bis(parachlorophenyl)-1,1-Dichloroethene (DDE)	0.00240	
				2,2-Bis(parachlorophenyl)-1,1-Trichloroethene (DDT)	0.00200	
UB	Soil	NN9	Halocarbons/Soil/GCCON	1,1,1-Trichloroethane	0.0880	µg/g
				1,1,2-Trichloroethane	0.280	
				1,1-Dichloroethene	0.240	
				1,1-Dichloroethane	0.0740	
				1,2-Dichloroethenes (cis & trans)	0.260	
				1,2-Dichloroethane	0.0850	
				Carbon tetrachloride	0.120	
				Methylene chloride	3.70	
				Chloroform	0.0680	
				Chlorobenzene	0.200	
				Tetrachloroethene	0.270	
				Trichloroethene	0.140	
UB	Soil	Y9	Metals/Soil/CVAA	Mercury	0.0500	µg/g

Table 2.5: (Page 8 of 11)

Lab	Media	Method ⁽¹⁾	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
UB	Surface Water	AAA8	Organosulfurs/Water/GCFP	Benothiazole 4-Chlorophenylmethyl sulfide 4-Chlorophenylmethyl sulfoxide 4-Chlorophenylmethyl sulfone Dithiane Dimethyl disulfide 1,4-Oxathiane Diisopropyl methylphosphonate Dimethylmethyl phosphonate	5.00 5.69 11.5 7.46 1.34 0.550 2.38 0.392 0.188	µg/l µg/l
UB	Surface Water	AT8	Organophosphor/Water/GCFP	Diisopropyl methylphosphonate Dimethylmethyl phosphonate	0.392 0.188	µg/l
UB	Surface Water	CC8	Metals/Water/CVAA	Mercury	0.100	µg/l
UB	Surface Water	GG8	Metals/Water/ICP	Calcium Cadmium Chromium Copper Potassium Magnesium Sodium Lead Zinc	500 8.40 24.0 26.0 250 500 940 74.0 22.0	µg/l
UB	Surface Water	HH8A	Anions/Water/Ionchrom	Chloride Fluoride Sulfate	720 482 351	µg/l
UB	Surface Water	JJ8	Organics/Water/GCMS	Dieldrin Dimethylmethyl phosphonate Endrin Isodrin Malathion 1,4-Oxathiane 2,2-Bis(parachlorophenyl)-1,1-Dichloroethene (DDE) 2,2-Bis(parachlorophenyl)-1,1-Trichloroethane (DDT)	4.7 33 8.0 3.7 14 7.9 6.1 9.3	µg/l

Table 2.5: (Page 9 of 11)

Lab	Media	Method(1)	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
UB	Surface Water (continued)	JJ8	Organics/Water/GCMS	Parathion Supona Aldrin Atrazine Hexachlorocyclopentadiene Chlordane 4-Chlorophenylmethyl sulfide 4-Chlorophenylmethyl sulfoxide 4-Chlorophenylmethyl sulfone Dibromochloropropane Dicyclopentadiene Vapona Diisopropyl methylphosphonate Dithiane	19 9.3 7.5 6.6 21 9.4 17 29 7.2 19 7.3 17 14 21	µg/l
UB	Surface Water	KK8	Pesticides/Water/GCEC	2,2-Bis(parachlorophenyl)1,1-Dichloroethane (DDE) 2,2-Bis(parachlorophenyl)1,1-Trichloroethane (DDT) Aldrin Hexachlorocyclopentadiene Chlordane Dieldrin Endrin Isodrin	0.0540 0.0490 0.0500 0.0480 0.0950 0.0500 0.0500 0.0510	µg/l
UB	Surface Water	P8	Volatiles/Water/GCFID	Bicyclo (2,2,1) hepta-2,5-diene Dicyclopentadiene Methylisobutyl ketone	5.90 5.00 4.90	µg/l
UB	Surface Water	SS12	Metals/Water/ICP	Arsenic Calcium Cadmium Chromium Copper Iron Potassium Magnesium Manganese Sodium Lead Zinc	117 105 6.78 16.8 18.8 77.5 1240 135 9.67 279 43.4 16.0	µg/l

Table 2.5: (Page 10 of 11)

Lab	Media	Method(1)	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
UB	Surface Water	TT09	Anions/Water/Ionchrom	Chloride Fluoride Sulfate	278 153 175	µg/l
UB	Surface Water	UH11	NP-Pesticides/Water/GCEC	Atrazine Vapona Malathion Parathion Supona	4.03 0.384 0.373 0.647 0.787	µg/l
UB	Surface Water	UM25	Organics/Water/GCMS	2,3,6-Trichlorophenol 2,4,6-Trichlorophenol 2,4,6-Trichlorophenol 2,4-Dichlorophenol 2,4-Dimethylphenol 2,4-Dinitrophenol 2-Chlorophenol 2-Methylphenol 2-Nitrophenol 3-Methyl-4-Chlorophenol 4-Methylphenol 4-Nitrophenol Aldrin Atrazine Bis-(2-Ethylhexyl) Phthalate Hexachlorocyclopentadiene Chlordane 4-Chlorophenylmethyl sulfide 4-Chlorophenylmethyl sulfoxide 4-Chlorophenylmethyl sulfone Dibromochloropropane Dicyclopentadiene Vapona Diisopropyl methylphosphonate Dithiane Dieldrin Dimethylmethyl phosphonate Endrin Isodrin Malathion N-Nitroso dimethylamine	1.7 2.8 2.8 3.6 8.4 4.4 176(2) 2.8 3.6 8.2 8.5 2.8 96 13 5.9 7.7 54 37 10 15 5.3 12 5.5 8.5 21 3.3 26 130 18 7.8 21 9.7	µg/l

Table 2.5: (Page 11 of 11)

Lab	Media	Method(1)	Method Name	Analyte	Certified Reporting Limit	Unit of Measure
UB	Surface Water (continued)	UM25	Organics/Water/GCMS	1,4-Oxathiane Pentachlorophenol Phenol 2,2-Bis(parachlorophenyl)1,1-Dichloroethene (DDE) 2,2-Bis(parachlorophenyl)1,1-Trichloroethane (DDT) Parathion Supona	27 9.1 2.2 14 18 37 19	µg/l

- (1) All methods used during Remedial Investigation (RI) Addendum Analytical Program are Program Manager for Rocky Mountain Arsenal (PMRMA) -certified methods and were performed by PMRMA-certified laboratories.
- (2) The certified reporting limit of 176 µg/l was obtained directly from the installation restoration data management system methods file. Method UM25 is only certified to report two figures.

µg/l = micrograms per liter

µg/g = micrograms per gram

AL = Arthur D. Little Laboratory

CL = California Analytical Laboratories, Inc.

CVAA = cold vapor atomic absorption

ED = Environmental Science & Engineering, Inc., Denver, CO

ES = Environmental Science & Engineering, Inc., Gainesville, FL

GCCON = gas chromatography/conductivity detector

GCEC = gas chromatography/electron capture

GCFID = gas chromatography/flame ionisation detector

GCFP = gas chromatography/flame photometric detector

GCHALL = gas chromatography/Hall detector

GCMS = gas chromatography/mass spectroscopy

GCPIID = gas chromatography/photolionisation detector

GFAA = graphite furnace atomic absorption

ICAP = inductively coupled argon plasma

ICP = inductively coupled plasma

UB = DataChem Laboratories, Salt Lake City, UT

UVVIS = ultra violet visible spectrophotometry

20000.350.10 - RIA

0625030192

**Table 2.6: Biota Samples Collected in the Offpost Operable Unit
During Remedial Investigation Addendum Program**

<u>Species</u>	<u>Number/Type of Sample</u>	<u>Collection Method</u>
Aquatic Invertebrates	2 composite samples	Net and/or by hand
Aquatic Plants	1 composite sample	Hand collection
Bluegill	2 composite samples	Seine, gill net, hand net
Fathead minnow	1 composite sample	Seine, gill net, hand net
Carp	2 samples	Seine, gill net
Channel catfish	1 sample	Seine, gill net
Ring-necked Pheasant	2 males, 1 female	Steel shot - shotgun
Earthworms	10 composite samples	Spade soil, then sort
Grasshoppers	2 composite samples	Sweep net
Deer mice	7 composite samples (2 mice/sample)	Live Sherman Traps
House mice	2 composite samples (2 mice/sample)	Live Sherman Traps
Prairie dog	5 males	Live Have-a-Hart, .22 caliber rifle
Cow milk	2 samples	Provided by Ohle Farm
Cow fat	3 samples	Provided by Ohle Farm
Cow brain	1 sample	Provided by Ohle Farm
Cow muscle	1 sample	Provided by Ohle Farm
Cow liver	1 sample	Provided by Ohle Farm
Cow kidney	1 sample	Provided by Ohle Farm
Chicken egg	1 sample	Provided by Ohle Farm
Chicken fat/skin	1 sample	Provided by Ohle Farm
Chicken muscle	1 sample	Provided by Ohle Farm
Chicken liver	1 sample	Provided by Ohle Farm

Table 2.7: Summary of Certified Biota Analysis Methods

Method Code	Analysis Name	Analysis Type	Lower CRL ($\mu\text{g/g-wet}$)	Upper CRL ($\mu\text{g/g-wet}$)
B-6-A	Arsenic in Animal Tissue	GFAA	0.25	5.0
B-6-P	Arsenic in Plant Tissue	GFAA	0.25	5.0
C-6-A	Mercury in Animal Tissue	CVAA	0.05	0.4
C-6-P	Mercury in Plant Tissue	CVAA	0.5	0.4
M-6	Organochlorine Pesticides in Animal Tissue	GC	(1)	—
QH-01	Organochlorine Pesticides in Plant Tissue	GC	(2)	—

- (1) Certified Reporting Limits (in $\mu\text{g/g-wet}$) for target analytes are: Aldrin - LCRL = 0.013, UCRL = 0.300; Dieldrin - LCRL = 0.018, UCRL = 0.300 Endrin - LCRL = 0.036, UCRL = 0.600; P,P'-DDE - LCRL = 0.063, UCRL = 1.88; P,P'-DDT - LCRL = 0.132, UCRL = 3.75.
- (2) Certified Reporting Limits (in $\mu\text{g/g-wet}$) for target analytes are: Aldrin - LCRL = 0.021, UCRL = 0.300; Dieldrin - LCRL = 0.026, UCRL = 0.300 Endrin - LCRL = 0.045, UCRL = 0.400; P,P'-DDE - LCRL = 0.042, UCRL = 1.50; P,P'-DDT - LCRL = 0.155, UCRL = 1.87.

CRL = certified reporting limit

CVAA = cold vapor atomic adsorption spectrometry

GC = gas chromatography

GFAA = graphite furnace atom adsorption spectrometry

**Table 3.1: Unconfined Flow System Groundwater Elevations
Used to Construct Potentiometric Surface Map
(Page 1 of 3)**

<u>Well Number</u>	<u>Measurement Date</u>	<u>Depth to Water from Top of Casing (feet)</u>	<u>Groundwater Elevation (feet)</u>
37307	02/13/90	14.05	5135.97
37308	02/14/90	3.55	5125.52
37309	02/13/90	4.50	5120.23
37312	02/14/90	5.89	5134.93
37313	02/13/90	4.85	5105.61
37320	02/12/90	21.05	5100.98
37323	02/13/90	10.15	5117.39
37327	02/12/90	34.95	5115.81
37330	02/14/90	34.41	5092.34
37331	02/14/90	34.21	5092.58
37332	02/14/90	45.15	5091.43
37333	02/14/90	37.08	5092.16
37334	02/12/90	41.15	5091.89
37335	02/12/90	33.40	5089.31
37336	02/12/90	22.28	5073.50
37337	02/12/90	25.53	5069.03
37338	02/12/90	12.83	5123.37
37339	02/13/90	14.80	5121.80
37341	02/12/90	28.60	5073.40
37342	02/13/90	19.84	5098.86
37343	02/13/90	6.55	5105.65
37344	02/12/90	23.58	5090.62
37345	02/12/90	29.63	5073.97
37346	02/12/90	19.45	5078.25
37347	02/12/90	31.05	5063.65
37348	02/12/90	25.35	5058.55
37349	02/12/90	35.41	5047.99
37350	02/12/90	36.85	5042.45
37351	02/12/90	22.60	5055.50
37352	02/12/90	30.78	5044.22
37353	02/12/90	34.85	5036.65
37354	02/12/90	24.53	5033.07
37355	02/12/90	15.08	5039.82
37356	02/12/90	9.68	5017.12
37357	02/12/90	7.13	5016.27
37358	02/12/90	47.93	5094.07
37359	02/12/90	32.51	5083.89
37360	02/12/90	34.65	5081.65
37361	02/12/90	28.89	5063.31
37362	02/12/90	44.18	5125.42
37363	02/12/90	9.48	5036.12
37364	02/12/90	9.05	5001.35
37367	02/12/90	20.94	5099.16
37368	02/12/90	26.29	5084.11
37369	02/13/90	3.65	5121.05

Table 3.1: (Page 2 of 3)

<u>Well Number</u>	<u>Measurement Date</u>	<u>Depth to Water from Top of Casing (feet)</u>	<u>Groundwater Elevation (feet)</u>
37370	02/13/90	10.46	5109.44
37373	02/13/90	5.40	5109.20
37374	02/13/90	12.46	5108.14
37377	02/13/90	27.80	5111.40
37378	02/13/90	28.99	5111.11
37381	02/13/90	5.31	5106.69
37382	02/14/90	34.65	5088.75
37383	02/12/90	22.48	5099.92
37385	02/12/90	31.81	5084.89
37386	02/14/90	43.11	5091.09
37389	02/13/90	6.31	5123.09
37391	02/13/90	27.45	5111.05
37392	02/13/90	25.41	5111.59
37395	02/12/90	28.06	5089.84
37396	02/13/90	5.15	5105.35
37397	02/12/90	26.48	5090.92
37398 ⁽¹⁾	02/13/90	5.47	5109.06
37399 ⁽¹⁾	02/13/90	5.74	5109.26
37402	02/13/90	25.12	5084.51
37403	02/12/90	22.25	5102.25
37404	02/12/90	18.28	5089.20
37405	02/13/90	41.66	5072.96
37406	02/12/90	26.05	5084.09
37407	02/13/90	9.37	5105.66
37408	02/13/90	23.20	5093.15
37409	02/13/90	21.67	5092.24
37410	02/13/90	19.85	5095.78
37411 ⁽¹⁾	02/13/90	21.25	5092.59
37412 ⁽¹⁾	02/13/90	21.43	5092.50
37413 ⁽¹⁾	02/13/90	20.20	5095.32
37414 ⁽¹⁾	02/13/90	19.98	5095.71
37415 ⁽¹⁾	02/13/90	22.34	5093.49
37416 ⁽¹⁾	02/13/90	21.89	5093.67
37417 ⁽¹⁾	02/13/90	21.60	5092.39
37418	02/13/90	4.77	5106.58
37419	02/13/90	7.77	5107.69
37420	02/13/90	4.60	5107.62
37428	02/13/90	15.76	5088.37
37429	02/12/90	34.51	5075.55
37430	02/14/90	19.79	5050.42
37433	02/13/90	35.65	5065.90
37434	02/13/90	36.63	5053.22
37435	02/13/90	31.25	5059.85
37436	02/13/90	26.70	5089.34
37437	02/14/90	30.72	5088.84
37438	02/13/90	29.62	5086.68
37439	02/12/90	29.26	5079.72

Table 3.1: (Page 3 of 3)

<u>Well Number</u>	<u>Measurement Date</u>	<u>Depth to Water from Top of Casing (feet)</u>	<u>Groundwater Elevation (feet)</u>
37440	02/12/90	21.52	5071.43
37442	02/12/90	18.03	5056.82
37443	02/14/90	16.48	5066.58
37444	02/14/90	18.15	5068.26

(1) Piezometer; not used for groundwater quality

Table 3.2: Groundwater Field Quality Assurance/Quality Control Samples

<u>QA/QC Sample Type</u>	<u>Required Frequency</u>	<u>Preparation</u>
Volatile Trip Blank	One set of four septum vials per sampling day	Transport filled blank volatile septum vials to field, return to laboratory with samples.
Rinse Blank	One suite per day, or 5 percent of investigative samples, whichever is more	Decontaminate equipment used to collect samples. Pour deionized water into cleaned sampling equipment, then transfer to sample bottles. Perform while onsite. Not applicable if dedicated pump is used.
Field Blank	One suite per day, or 5 percent of investigative samples, whichever is more	Pour deionized water directly into sample bottles. Perform while onsite.
Duplicates	10 percent of investigative samples, or one per day, whichever is more	Collect additional sample bottles while onsite.
GC/MS Confirmation	10 percent of investigative samples	Collect additional sample bottles while onsite.

GC/MS = gas chromatography/mass spectrometry
QA/QC = quality assurance/quality control

Table 3.3: Groundwater Duplicate Sample Agreement
(Concentrations in µg/l)
(Page 1 of 5)

<u>Analyte</u>	<u>Investigative Results</u>	<u>Duplicate Results</u>	<u>DSA (percent)</u>
<u>Investigative Sample ID:</u> 37418			
<u>Duplicate Sample ID:</u> HA1045 <u>Sample Date:</u> 12/18/89			
1,2-Dichloroethane	21.5000	23.7000	9.73
Aldrin	0.1810	0.3000	49.48
Arsenic	3.6400	3.8000	4.30
Atrazine	4.8000	< 4.0300	17.44
Calcium	550000.0000	590000.0000	7.02
Chloride	1700000.0000	1600000.0000	6.06
Chlordane	0.9350	1.4000	39.83
4-Chlorophenylmethyl sulfone	8.0900	< 7.4600	8.10
Dicyclopentadiene	460.0000	530.0000	14.14
Diisopropyl methylphosphonate	5600.0000	4300.0000	26.26
Dithiane	27.3000	25.6000	6.43
Endrin	0.1000	< 0.0500	66.67
Fluoride	3310.0000	3290.0000	0.61
Iron	227.0000	276.0000	19.48
Isodrin	< 0.0510	0.1200	80.70
Potassium	9540.0000	10200.0000	6.69
Toluene	< 1.4700	3.8000	88.43
Magnesium	196000.0000	199000.0000	1.52
Manganese	187.0000	197.0000	5.21
Sodium	840000.0000	870000.0000	3.51
Nitrite, nitrate (nonspecific)	930.0000	1200.0000	25.35
1,4-Oxathiane	7.1200	8.9400	27.67
2,2-Bis(parachlorophenyl)-1,1-Dichloroethene (DDE)	0.3410	0.4000	15.92
2,2-Bis(parachlorophenyl)-1,1,1-Trichloroethane (DDT)	0.1480	0.1390	6.27
Sulfate	1500000.0000	1500000.0000	0.00
Tetrachloroethene	10.2000	11.2000	9.35
Total organic carbon	12000.0000	10000.0000	18.18
Trichloroethene	6.5200	7.0800	8.24
Zinc	90.9000	124.0000	30.81
<u>Investigative Sample ID:</u> 37404			
<u>Duplicate Sample ID:</u> HA1165 <u>Sample Date:</u> 02/22/90			
Calcium	160000.0000	170000.0000	6.06
Chloride	230000.0000	220000.0000	4.44
Iron	48.6000	37.5000	25.78

Table 3.3 (Page 2 of 5)
(Concentrations in µg/l)

Analyte	Investigative Results	Duplicate Results	DSA (percent)
<u>Investigative Sample ID:</u> 37404			
<u>Duplicate Sample ID:</u> HA1165 <u>Sample Date:</u> 02/22/90			
(continued)			
Magnesium	43000.0000	46000.0000	6.74
Sodium	210000.0000	220000.0000	4.65
Nitrite, nitrate (nonspecific)	4300.0000	4200.0000	2.35
Sulfate	540000.0000	530000.0000	1.87
Total organic carbon	5.0000	6.0000	18.18
Total suspended solids	23.0000	27.0000	16.00
Zinc	< 20.0000	24.4000	19.82
<u>Investigative Sample ID:</u> 37407			
<u>Duplicate Sample ID:</u> HA1166 <u>Sample Date:</u> 02/21/90			
Calcium	250000.0000	240000.0000	4.08
Chloride	370000.0000	360000.0000	2.74
Fluoride	1160.0000	1250.0000	7.47
Iron	604.0000	794.0000	27.18
Magnesium	58000.0000	58000.0000	0.00
Manganese	1250.0000	1360.0000	8.43
Sodium	360000.0000	340000.0000	5.71
Nitrite, nitrate (nonspecific)	1300000.0000	4300.0000	198.68
Sulfate	700000.0000	680000.0000	2.90
Total organic carbon	7.0000	7.0000	0.00
Zinc	< 20.0000	23.3000	15.24
<u>Investigative Sample ID:</u> 37435			
<u>Duplicate Sample ID:</u> HA1172 <u>Sample Date:</u> 02/27/90			
Calcium	123000.0000	118000.0000	4.15
Chloride	98000.0000	100000.0000	2.02
Diisopropyl methylphosphonate	10.8000	10.0000	7.69
Dimethylmethyl phosphonate	1.0100	< 0.1880	137.23
Fluoride	1890.0000	1740.0000	8.26
Potassium	4580.0000	4570.0000	0.22
Magnesium	37000.0000	36100.0000	2.46
Manganese	< 9.6700	12.6000	26.31
Sodium	130000.0000	130000.0000	0.00
Nitrite, nitrate (nonspecific)	1700.0000	1800.0000	5.71
Sulfate	290000.0000	300000.0000	3.39
Total organic carbon	3000.0000	3000.0000	0.00

Table 3.3 (Page 3 of 5)
(Concentrations in µg/l)

Analyte	Investigative Results	Duplicate Results	DSA (percent)
Investigative Sample ID: 37438			
Duplicate Sample ID: HA1173 Sample Date: 02/28/90			
Aldrin	0.0711	< 0.0500	34.85
Calcium	66800.0000	65600.0000	1.81
Chloride	280000.0000	280000.0000	0.00
Copper	< 18.8000	20.7000	9.62
Diisopropyl Methylphosphonate	3.4700	3.7600	8.02
Dieldrin	0.1270	0.1100	14.35
Fluoride	4070.0000	4080.0000	0.25
Potassium	2600.0000	2190.0000	17.12
Magnesium	21200.0000	21000.0000	0.95
Sodium	260000.0000	260000.0000	0.00
Nitrite, nitrate (nonspecific)	4900.0000	5000.0000	2.02
Sulfate	170000.0000	170000.0000	0.00
Total Organic Carbon	2000.0000	2000.0000	0.00
Investigative Sample ID: 37439			
Duplicate Sample ID: HA1174 Sample Date: 03/01/90			
Calcium	104000.0000	99300.0000	4.62
Chloride	200000.0000	200000.0000	0.00
Diisopropyl Methylphosphonate	2.5400	2.5600	0.78
Fluoride	2340.0000	2350.0000	0.43
Potassium	3810.0000	3880.0000	1.82
Magnesium	28200.0000	27100.0000	3.98
Manganese	28.8000	21.0000	31.33
Sodium	150000.0000	160000.0000	6.45
Nitrite, nitrate (nonspecific)	1800.0000	1800.0000	0.00
Sulfate	180000.0000	170000.0000	5.71
Total organic carbon	2000.0000	2000.0000	0.00
Investigative Sample ID: 37444			
Duplicate Sample ID: HA1198 Sample Date: 06/13/90			
Arsenic	2.6500	< 2.3500	12.00
Calcium	109000.0000	99700.0000	8.91
Chloroform	2.6500	3.2300	19.73
Chloride	140000.0000	140000.0000	0.00
Diisopropyl methylphosphonate	0.8140	5.5400	148.76
Fluoride	1330.0000	1320.0000	0.75
Mercury	1.0100	1.4900	38.40
Potassium	2610.0000	2800.0000	7.02
Magnesium	23900.0000	21900.0000	8.73
Sodium	100000.0000	100000.0000	0.00
Nitrite, nitrate (nonspecific)	4200.0000	4200.0000	0.00
Sulfate	130000.0000	130000.0000	0.00

Table 3.3 (Page 4 of 5)
(Concentrations in µg/l)

Analyte	Investigative Results	Duplicate Results	DSA (percent)
<u>Investigative Sample ID:</u> 37444 <u>Duplicate Sample ID:</u> HA1198 <u>Sample Date:</u> 06/13/90 (continued)			
Total Organic Carbon	1000.0000	1000.0000	0.00
<u>Investigative Sample ID:</u> 37418 <u>Duplicate Sample ID:</u> HA1079 <u>Sample Date:</u> 06/22/90			
1,2-Dichloroethane	21.2000	22.1000	4.16
Atrazine	46.0000	< 4.0300	167.78
Benzene	2.3900	3.9000	48.01
Calcium	560000.0000	174000.0000	105.18
Chloroform	30.0000	45.1000	40.21
Chloride	1800000.0000	1800000.0000	0.00
Chlorobenzene	13.0000	29.7000	78.22
Chromium	< 16.8000	71.5000	123.90
Copper	< 18.8000	108.0000	140.69
Dibromochloropropane	0.3260	0.3910	18.13
Dicyclopentadiene	370.0000	380.0000	2.67
Diisopropyl methylphosphonate	5800.0000	3900.0000	39.18
Dithiane	28.0000	30.0000	6.90
Fluoride	6300.0000	6300.0000	0.00
Iron	1430.0000	46400.0000	188.04
Isodrin	0.1130	0.1030	9.26
Potassium	8690.0000	12200.0000	33.60
Magnesium	194000.0000	80800.0000	82.39
Malathion	1.7600	1.6300	7.67
Manganese	243.0000	2650.0000	166.40
Sodium	1100000.0000	150000.0000	152.00
Nitrite, nitrate (nonspecific)	540.0000	410.0000	27.37
1,4-Oxathiane	6.4800	6.8600	5.70
Parathion	1.2200	1.0700	13.10
Sulfate	1800000.0000	1700000.0000	5.71
Tetrachloroethene	9.7300	8.9800	8.02
Total organic carbon	14000.0000	15000.0000	6.90
Trichloroethene	6.7500	6.1800	8.82
Zinc	36.3000	117.0000	105.28

Investigative Sample ID: 11830TW112
Duplicate Sample ID: HA1031 Sample Date: 01/31/89

Calcium	100000.000	110000.000	9.52
Chloride	87000.000	86000.000	1.16
Cyanide	12.000	10.200	16.22
Diisopropyl methylphosphonate	5.110	5.610	9.33
Dimethylmethyl phosphonate	0.241	0.253	4.86

Table 3.3 (Page 5 of 5)
(Concentrations in µg/l)

Analyte	Investigative Results	Duplicate Results	DSA (percent)
<u>Investigative Sample ID:</u> 11830TW112			
<u>Duplicate Sample ID:</u> HA1031 <u>Sample Date:</u> 01/31/89			
(continued)			
Fluoride	1840.000	1520.000	19.05
Potassium	4200.000	4530.000	7.56
Magnesium	32500.000	31100.000	4.40
Sodium	78500.000	80600.000	2.64
Nitrite, nitrate (nonspecific)	3400.000	3500.000	2.90
Sulfate	200000.000	200000.000	0.00
 <u>Investigative Sample ID:</u> 13350TW104			
<u>Duplicate Sample ID:</u> HA1030 <u>Sample Date:</u> 01/17/89			
Calcium	83500.000	84200.000	0.83
Chloride	60000.000	69000.000	13.95
Diisopropyl methylphosphonate	22.000	18.900	15.16
Fluoride	1540.000	1580.000	2.56
Potassium	1070.000	1030.000	3.81
Magnesium	8790.000	9110.000	3.58
Sodium	190000.000	200000.000	5.13
Nitrite, nitrate (nonspecific)	290.000	290.000	0.00
Sulfate	280000.000	320000.000	13.33
Zinc	23.100	24.600	6.29

Results are reported in micrograms per liter.
DSA is reported in percent.
Reported values are accurate to three significant figures.

DSA = duplicate sample agreement

20000,350.10 - RIA
0625030192

Table 3.4: Tentatively Identified Compounds in Groundwater

Site ID	Tentatively Identified Compound	Concentration	Units
10590TWHY2	ACETIC ACID,BUTYL ESTER	4.50	µg/l
37410	CYCLOPROPANE,ETHENYLMETHYLENE	4.80	µg/l
37418	4,4-DIOXIDE-1,4-OXATHIANE	5.10	µg/l
37420	4,4-DIOXIDE-1,4-OXATHIANE	7.60	µg/l
37420	ETHENYLPENTADIENE ISOMER	18.00	µg/l
37430	BICYCLOHEPTADIENE ISOMER	5.80	µg/l
37435	OCTADECANE	6.90	µg/l
37435	NONADECANE	7.80	µg/l
37435	EICOSANE	4.60	µg/l
37435	BICYCLOHEPTADIENE ISOMER	5.60	µg/l
37442	BUTENE ISOMER	12.00	µg/l
37442	METHYL T-BUTYL ETHER	1200.00	µg/l
37443	1,2,3,4-tetrachloro-5-(dichloro-methylene)-1,3-cyclopentadiene	11.00	µg/l
HA1019	BENZOPHENONE	13.00	µg/l
HA1045	BICYCLO[3.2.0]HEPTA-2,6-DIENE	5.00	µg/l
HA1045	ANHYDRIDE HEXANOIC ACID	4.20	µg/l
HA1045	4,4-DIOXIDE-1,4-OXATHIANE	5.10	µg/l
HA1045	BICYCLO[2.2.1]HEPT-2-ENE, 5-ETHYLIDIENE & MIXED SPECTRA	13.00	µg/l
HA1048	4,4-DIOXIDE-1,4-OXATHIANE	5.20	µg/l
HA1048	BICYCLO[2.2.1]HEPT-2-ENE, 5-ETHYLIDIENE & MIXED SPECTRA	15.00	µg/l
HA1048	4,4-DIOXIDE-1,4-OXATHIANE	5.70	µg/l
HA1048	BICYCLO[2.2.1]HEPT-2-ENE, 5-ETHYLIDIENE & MIXED SPECTRA	15.00	µg/l
HA1048	1,3-CYCLOPENTADIENE	5.90	µg/l
HA1048	BICYCLO[3.2.0]HEPTA-2,6-DIENE	7.80	µg/l
HA1048	1,3-CYCLOPENTADIENE	5.20	µg/l
HA1048	BICYCLO[3.2.0]HEPTA-2,6-DIENE	6.80	µg/l
HA1070	HEXANOIC ACID, ANHYDRIDE	10.00	µg/l
HA1070	5-METHYL-1,3-CYCLOPENTADIENE ISOMER	4.00	µg/l
HA1072	4,4-DIOXIDE-1,4-OXATHIANE	9.90	µg/l
HA1072	5-ETHYL-BICYCLO[2.2.1]HEPT-2-ENE	7.00	µg/l
HA1072	5-METHYL-1,3-CYCLOPENTADIENE ISOMER	4.10	µg/l
HA1078	5-ETHYL-BICYCLO[2.2.1]HEPT-2-ENE	7.10	µg/l
HA1163	2-CYCLOPENTEN-1-ONE, 2-(4-METHYL-2-FURYL)-ISOMER	9.60	µg/l
HA1163	5-METHYL-ISOMER-1,3-CYCLOPENTADIENE	5.60	µg/l
HA1169	BICYCLOHEPTADIENE ISOMER	5.40	µg/l
HA1171	BICYCLOHEPTADIENE ISOMER	7.10	µg/l
HA1172	BICYCLOHEPTADIENE ISOMER	5.20	µg/l
HA1173	BICYCLOHEPTADIENE ISOMER	9.30	µg/l
HA1175	BICYCLOHEPTADIENE ISOMER	5.10	µg/l
HA37418	ANHYDRIDE HEXANOIC ACID	5.10	µg/l
HA37418	4,4-DIOXIDE-1,4-OXATHIANE	4.40	µg/l
HA37418	BICYCLO[2.2.1]HEPT-2-ENE, 5-ETHYLIDIENE & MIXED SPECTRA	11.00	µg/l
HA37419	BICYCLO[2.2.1]HEPT-2-ENE, 5-ETHYLIDIENE & MIXED SPECTRA	12.00	µg/l
HA37420	HEXANOIC ACID, ANHYDRIDE	11.00	µg/l
HA37420	4,4-DIOXIDE-1,4-OXATHIANE	5.40	µg/l
HA37420	BICYCLO[2.2.1]HEPT-2-ENE, 5-ETHYLIDIENE & MIXED SPECTRA	14.00	µg/l

**Table 4.1: Surface Water Duplicate Sample Agreement
(Concentrations in $\mu\text{g/l}$)**

<u>Analyte</u>	<u>Investigative Results</u>	<u>Duplicate Results</u>	<u>DSA (Percent)</u>
Investigative Sample ID: HA1185SW			
Duplicate Sample ID: HA1189SW Sample Date: 05/10/90			
Calcium	67200.0000	63000.0000	6.45
Chloride	54000.0000	49000.0000	9.71
Fluoride	1020.0000	1030.0000	0.98
Mercury	0.3150	0.5380	52.29
Potassium	5310.0000	4670.0000	12.83
Magnesium	15100.0000	14000.0000	7.56
Sodium	73000.0000	62000.0000	16.30
Nitrite, nitrate (nonspecific)	1800.0000	1800.0000	0.00
Sulfate	120000.0000	130000.0000	8.00
Total organic carbon	7700.0000	9800.0000	24.00

DSA is reported in percent.
Reported values are accurate to three significant figures.

DSA = duplicate sample agreement

**Table 5.1: Metal Concentrations Commonly Found in
Uncontaminated Fresh-Water Sediments
(Concentrations in $\mu\text{g/g}$ dry weight basis)**

<u>Metal</u>	<u>Average</u>	<u>Range</u>
Cadmium	0.17	0.1-0.3
Chromium	72	10-90
Copper	33	5-40
Lead	19	2-50
Zinc	95	20-165
Arsenic	7.7	1-15
Mercury	0.19	0.1-0.5

Source: Environmental Science and Engineering, 1988a

Table 5.2: Stream-Bottom Sediment Duplicate Sample Agreement
(Concentrations in $\mu\text{g/g}$)

<u>Analyte</u>	<u>Investigative Results</u>	<u>Duplicate Results</u>	<u>DSA (percent)</u>
<u>Investigative Sample ID:</u> HA1182SE			
<u>Duplicate Sample ID:</u> HA1192SE <u>Sample Date:</u> 05/16/90			
Hexachlorocyclopentadiene	< 0.0014	0.0528	189.67
Chromium	26.1	30.1	14.23
Copper	13.3	16.9	23.84
Dieldrin	< 0.0018	0.0050	94.12
Mercury	0.188	0.120	44.16
Lead	32.5	40.9	22.89
Total organic carbon	4940	6810	31.83
Trichloroethene	< 0.250	0.383	42.02
Zinc	126	115	9.13
 <u>Investigative Sample ID:</u> HA1187SE			
<u>Duplicate Sample ID:</u> HA1193SE <u>Sample Date:</u> 05/10/90			
Cadmium	< 1.20	1.97	48.58
Chlordane	0.0645	< 0.0230	94.86
Chromium	62.5	71.2	13.01
Copper	54.1	63.5	15.99
Dibromochloropropane	< 0.0050	0.0190	116.67
Dieldrin	0.0102	0.0050	68.42
Endrin	< 0.0047	0.0080	51.97
Mercury	0.1960	0.2400	20.18
Lead	90.6	100	9.86
2,2-Bis(parachlorophenyl)-1,1-Dichloroethene (DDE)	0.0067	< 0.0047	35.09
2,2-Bis(parachlorophenyl)-1,1,1-Trichloroethane (DDT)	0.0118	0.0052	77.65
Total organic carbon	16600	18300	9.74
Zinc	242	280	14.56

DSA is reported in percent.
Reported values are accurate to three significant figures.

DSA = duplicate sample agreement

**Table 6.1: Arithmetic Mean and Upper 95th Percentile Concentrations for Selected Organic Compounds in Offpost Operable Unit Background Surficial Soil
(Concentrations in $\mu\text{g}/\text{kg}$)**

<u>Analyte</u>	<u>Mean Concentration</u>	<u>95th Percentile of Concentration</u>
Aldrin	1	4
Dieldrin	3	8
Endrin	3	4
Isodrin	1	2
DDE	3	4
DDT	2	8

Table 6.2: Residue Levels for Selected Insecticides in Soil
(Page 1 of 4)

Land Use (a)	Aldrin				Dieldrin				References/comments
	Arith. Mean	Est. Geo. Mean	Range	% Pos.(b)	Arith. Mean	Est. Geo. Mean	Range	% Pos.	
Cropland	0.03	0.002	0.01-13.28	8.7	0.04	0.008	0.01-6.18	27.2	Carey and others, 1979
Cropland	0.02	0.002	0.01-1.88	9.7	0.05	0.009	0.01-9.83	27.5	Carey and others, 1978
Cropland (Rice)	0.01	NA (c)	0.01-0.25	39.4	0.04	NA	0.01-0.27	84.8	Carey and others, 1980
Cropland	0.03	0.014	<0.01-0.15	19.4	0.10	0.023	<0.01-1.02	55.0	Gish, 1970
Cropland	0.07	NA	0.07-0.14	70.0	0.08	NA	0.13-0.21	50.0	Trautmann and others, 1968
Cropland (Saskatchewan)	0.03	NA	<0.01-0.28	24.4	0.06	NA	<0.01-0.77	61.0	Saha and others, 1971
Cropland (Colorado)	0.41	NA	NA	16.0	0.07	NA	NA	28.0	Mullins and others, 1971
Pasture (Grassland)	NA	NA	NA	NA	0.03	NA	ND(d)-2.2	NA	Fahey and others, 1965
Non Use (No pesticide use)	NA	NA	NA	NA	0.01	NA	ND-0.31	17.4	Lang and others, 1975 - 6 U.S. Air Bases
Non Use (No pesticide use)	NA	NA	NA	NA	0.01	NA	ND-0.1	24.0	Lang and others, 1976 - 6 U.S. Air Bases
Golf Course	NA	NA	NA	NA	0.01	NA	ND-0.05	23.5	Lang and others, 1975 - 6 U.S. Air Bases
Golf Course	NA	NA	NA	NA	0.01	NA	ND-0.03	23.5	Lang and others, 1976 - 6 U.S. Air Bases
Residential	NA	NA	NA	NA	0.01	NA	ND-0.04	55.0	Lang and others, 1975 - 6 U.S. Air Bases
Residential	NA	NA	NA	NA	<0.01	NA	ND-0.02	47.6	Lang and others, 1976 - 6 U.S. Air Bases
Urban	NA	NA	NA	NA	NA	NA	0.06-2.2	7.5	Fahey and others, 1965

Table 6.2 (Page 2 of 4)

Land Use	Endrin				Isodrin				References/comments
	Arith. Mean	Est. Geo. Mean	Range	% Pos.	Arith. Mean	Est. Geo. Mean	Range	% Pos.	
Cropland	<0.01	<0.001	0.01-2.13	0.07	NA	NA	NA	NA	Cary and others, 1979
Cropland	<0.01	<0.001	0.02-1.00	0.09	<0.01	<0.001	0.01-0.02	0.02	Carey and others, 1978
Cropland (Rice)	<0.01	NA	ND-0.17	1.1	NA	NA	NA	NA	Carey and others, 1980
Cropland	0.49	0.079	0.01-3.47	23.9	NA	NA	NA	NA	Gish, 1970
Cropland	NA	NA	NA	NA	NA	NA	NA	NA	Trautmann and others, 1968
Cropland (Saskatchewan)	NA	NA	<0.01-0.48	2.4	NA	NA	NA	NA	Saha and others, 1971
Cropland (Colorado)	<0.02	NA	NA	4.0	NA	NA	NA	NA	Mullins and others, 1971
Pasture (Grassland)	NA	NA	NA	NA	NA	NA	NA	NA	Fahey and others, 1965
Non Use (No pesticide use)	NA	NA	NA	NA	NA	NA	NA	NA	Lang and others, 1975 - 6 U.S. Air Bases
Non Use (No pesticide use)	NA	NA	NA	NA	NA	NA	NA	NA	Lang and others, 1976 - 6 U.S. Air Bases
Golf Course	NA	NA	NA	NA	NA	NA	NA	NA	Lang and others, 1975 - 6 U.S. Air Bases
Golf Course	<0.01	NA	ND-0.04	5.9	NA	NA	NA	NA	Lang and others, 1976 - 6 U.S. Air Bases
Residential	<0.01	NA	ND-0.01	5.0	NA	NA	NA	NA	Lang and others, 1975 - 6 U.S. Air Bases
Residential	NA	NA	NA	NA	NA	NA	NA	NA	Lang and others, 1976 - 6 U.S. Air Bases
Urban	NA	NA	NA	NA	NA	NA	NA	NA	Fahey and others, 1965

Table 6.2 (Page 3 of 4)

Land Use (a)	DDT				DDE				References/comments
	Arith. Mean	Est. Geo. Mean	Range	% Pos.(b)	Arith. Mean	Est. Geo. Mean	Range	% Pos.	
Cropland	0.13	0.007	0.01-18.93	18.5	0.05	0.006	0.01-7.16	20.2	Carey and others, 1979
Cropland	0.37	0.01	0.01-245.2	20.5	0.11	0.007	0.01-54.98	22.5	Carey and others, 1978
Cropland (Rice)	0.02	NA (c)	0.01-0.04	25.3	0.02	NA	0.01-0.57	31.3	Carey and others, 1980
Cropland	0.59	0.041	<0.005-12.73	98	0.36	0.036	<0.005-5.33	98.0	Gish, 1970
Cropland (Saskatchewan)	NA	NA	<0.01-5.57	NA	NA	NA	<0.01-0.98	NA	Saha and others, 1971
Cropland (Colorado)	5.57	NA	NA	54.0	NA	NA	NA	NA	Mullins and others, 1971
Pasture (Grassland)	NA	NA	0.07-79.98	70	0.03	NA	0.03-7.33	47	Fahey and others, 1965
Non Use (No pesticide use)	0.06	0.024	ND-0.32	48	NA	NA	NA	NA	Lang and others, 1975 - 6 U.S. Air Bases (Summation DDT)
Non Use (No pesticide use)	0.94	0.036	ND-13.93	45	NA	NA	NA	NA	Lang and others, 1976 - 6 U.S. Air Bases (Summation DDT)
Golf Course	0.19	0.06	<0.05-1.07	71	NA	NA	NA	NA	Lang and others, 1975 - 6 U.S. Air Bases (Summation DDT)
Golf Course	0.16	0.044	<0.05-0.69	59	NA	NA	NA	NA	Lang and others, 1976 - 6 U.S. Air Bases (Summation DDT)
Residential	0.86	0.23	ND-3.83	80	NA	NA	NA	NA	Lang and others, 1975 - 6 U.S. Air Bases (Summation DDT)
Residential	0.63	0.08	ND-3.83	67	NA	NA	NA	NA	Lang and others, 1976 - 6 U.S. Air Bases (Summation DDT)

Table 6.2 (Page 4 of 4)

Land Use	Chlordane				References/comments
	Arith. Mean	Est. Geo. Mean	Range	% Pos.	
Cropland	0.05	0.003	0.01-7.89	7.9	Carey and others, 1979
Cropland	0.06	0.003	0.01-6.98	8	Carey and others, 1978
Cropland (Rice)	0.02	NA	0.01-0.27	21.2	Carey and others, 1980
Cropland	0.02	0.0096	<0.005-0.076	10	Gish, 1970
Cropland (Saskatchewan)	NA	NA	0.01-3.91	17	(gamma-Chlordane) Saha and others, 1971
Cropland (Colorado)	0.02	NA	NA	16.0	Mullins and others, 1971
Pasture (Grassland)	NA	NA	0.1-120	38	Fahey and others, 1965
Non Use (No pesticide use)	0.09	0.016	ND(d)-1.76	24	Lang and others, 1975 - 6 U.S. Air Bases (Summation DDT)
Non Use (No pesticide use)	0.18	0.018	ND-3.44	14	Lang and others, 1976 - 6 U.S. Air Bases (Summation DDT)
Golf Course	0.67	0.105	ND-4.57	59	Lang and others, 1975 - 6 U.S. Air Bases (Summation DDT)
Golf Course	0.56	0.032	ND-3.05	35	Lang and others, 1976 - 6 U.S. Air Bases (Summation DDT)
Residential	5.43	0.188	ND-52.11	65.0	Lang and others, 1975 - 6 U.S. Air Bases (Summation DDT)
Residential	0.16	0.015	ND-1.2	9.5	Lang and others, 1976 - 6 U.S. Air Bases (Summation DDT)

All values in ppm

(a) Cropland designation includes a variety crop types for several states.

(b) Percent positive detections for all samples in the individual study

(c) Not available

(c) Not detected

20000,350.10 - RIA
1101030192

Table 6.3: Surficial Soil Duplicate Sample Agreement (DSA)
(Concentrations in $\mu\text{g/g}$)
(Page 1 of 2)

Analyte	Investigative Results	Duplicate Results	DSA (Percent)
<u>Investigative Sample ID:</u> HA1233WB			
<u>Duplicate Sample ID:</u> HA1237WB <u>Sample Date:</u> 06/18/90			
Calcium	2260.0000	2250.0000	0.44
Chromium	15.7000	15.7000	0.00
Copper	12.0000	11.8000	1.68
Dieldrin	0.0055	0.0044	22.22
Iron	16800.0000	17000.0000	1.18
Potassium	3860.0000	3870.0000	0.26
Magnesium	2650.0000	2690.0000	1.50
Manganese	351.0000	356.0000	1.41
Sodium	68.2000	66.8000	2.07
Lead	20.6000	19.9000	3.46
Zinc	47.2000	47.7000	1.05
 <u>Investigative Sample ID:</u> HA1201WB			
<u>Duplicate Sample ID:</u> HA1238WB <u>Sample Date:</u> 06/18/90			
Arsenic	4.6200	4.3400	6.25
Dieldrin	< 0.0018	0.0090	133.33
2,2-Bis(parachlorophenyl)-1,1,1-Trichloroethane (DDT)	0.0063	0.0091	36.36
 <u>Investigative Sample ID:</u> HA1209WB			
<u>Duplicate Sample ID:</u> HA1240WB <u>Sample Date:</u> 06/18/90			
Dieldrin	0.0111	0.0053	70.73
2,2-Bis(parachlorophenyl)-1,1,1-Trichloroethane (DDT)	0.0074	0.0103	32.77
 <u>Investigative Sample ID:</u> HA1220WB			
<u>Duplicate Sample ID:</u> HA1242WB <u>Sample Date:</u> 06/15/90			
Arsenic	2.8400	3.7400	27.36
 <u>Investigative Sample ID:</u> HA1267WB			
<u>Duplicate Sample ID:</u> HA1268WB <u>Sample Date:</u> 07/02/90			
Dieldrin	0.0063	0.0063	0.00
Mercury	0.0896	0.1110	21.34

Table 6.3: (Page 2 of 2)
(Concentrations in $\mu\text{g/g}$)

Analyte	Investigative Results	Duplicate Results	DSA (Percent)
<u>Investigative Sample ID:</u> HA1244WB			
<u>Duplicate Sample ID:</u> HA1260WB <u>Sample Date:</u> 07/03/90			
Aldrin	< 0.0021	0.0036	52.63
Chromium	14.1000	15.9000	12.00
Copper	7.9500	9.0200	12.61
Dieldrin	< 0.0018	0.0108	142.86
Endrin	< 0.0047	0.0065	32.14
Lead	18.2000	19.6000	7.41
2,2-Bis(parachlorophenyl)-1,1,1-Trichloroethane	< 0.0028	0.0072	88.00
Zinc	47.9000	57.2000	17.70
<u>Investigative Sample ID:</u> HA0994WB			
<u>Duplicate Sample ID:</u> HA0995WB <u>Sample Date:</u> 02/24/89			
Aldrin	0.034	0.020	51.85
Chlordane	0.042	0.052	21.28
Dieldrin	0.250	0.210	17.39
Endrin	0.029	0.019	41.67
2,2-Bis(parachlorophenyl)-1,1-Dichloroethene (DDE)	< 0.002	0.004	66.67
2,2-Bis(parachlorophenyl)-1,1,1-Trichloroethane (DDT)	0.018	0.020	10.53

Reported values are accurate to three significant figures.

Table 6.4: Summary of Compounds Detected in Collocated Harding Lawson Associates and Colorado Department of Health Surficial Soil Samples from the 96th Avenue Residential Area in Offpost Operable Unit
Concentrations of organic compounds in $\mu\text{g}/\text{kg}$.
Concentrations of arsenic and mercury in $\mu\text{g}/\text{g}$.

<u>Analyte</u>	<u>HA0989WB</u>		<u>HA0990WB</u>		<u>HA0993WB</u>		<u>HA0997WB</u>	
	<u>HLA⁽¹⁾</u>	<u>CDH⁽²⁾</u>	<u>HLA</u>	<u>CDH</u>	<u>HLA</u>	<u>CDH</u>	<u>HLA</u>	<u>CDH</u>
Aldrin	16.0	<10	10.0	<10	8.00	<10	3.00	<10
Chlordane	<23.0	<10	151	<10	100	60.0	<23.0	<10
Dieldrin	130	90.0	120	40.0	89.0	40.0	44.0	20.0
Endrin	<6.0	<10	15.0	<10	16.0	<10	<6.0	<10
DDE	36.0	<10	73.0	<10	11.0	<10	<2.0	<10
DDT	53.0	<10	230	120	23.0	<10	4.00	<10
Arsenic	<2.50	7.00	<2.50	7.00	2.89	9.00	<2.50	10.0
Mercury	<0.050	<0.02	0.127	<0.02	<0.050	<0.02	<0.050	<0.02

All samples were collected during February 1989.

Less than values listed for HLA represent certified reporting limits.

Less than values listed for CDH represent detection limits.

(1) HLA Surficial Soil Analytical Results are provided in Appendix E.

(2) CDH Surficial Soil Analytical Results are provided in Appendix G.

CDH = Colorado Department of Health

HLA = Harding Lawson Associates

DDE = 2,2-bis (parachlorophenyl)-1,1-dichloroethane

DDT = 2,2-bis(parachlorophenyl)-1,1,1-trichloroethane

Table 7.1: Aquatic Vertebrates and Invertebrates Found in the First Creek Impoundment

<u>Common Name</u>	<u>Scientific Name</u>	<u>Relative Abundance</u>
Fathead Minnow	<u>Pimephales promelas</u>	Common
Crayfish	<u>Orconectes</u> spp.	Common
Carp	<u>Cyprinus carpio</u>	Absent ¹
Waterbug	<u>Notonecta</u> spp.	Common
Bloodworm	<u>Nematoda</u> spp.	Uncommon
Leech	<u>Planaria</u> spp.	Uncommon

¹ Collected during high water in 1988, but not present during this study

Table 7.2: Comparisons of Target Analytes Detected in Biota Samples with Analytes Detected in Samples from Nearby Soil and Surface-Water Sampling Locations
(Page 1 of 2)

Species	Tissue	Biota Sampling Location	Analyte	Biota Concentration (µg/g)	Soil (µg/g)/Water (µg/l) Concentration		Soil/Water Sampling Location
Cow	Body Fat	HA1012BF	Dieldrin	0.053	0.110 µg/g, 0.110 µg/g		HA0991WB, HA0992WB(1)
Cow	Body Fat	HA1013BF	Dieldrin	0.078	0.110 µg/g, 0.110 µg/g		HA0991WB, HA0993WB
Chicken	Fat+Skin	HA1042BP	Dieldrin	0.230	0.010 µg/g, 0.020 µg/g		OHLE3WB(CDH), OHLE4WB(CDH)(2)
Chicken	Liver	HA1017BP	Dieldrin	0.023	0.010 µg/g, 0.020 µg/g		OHLE3WB(CDH), OHLE4WB(CDH)
Chicken	Egg	HA1006BE	Dieldrin	0.0179	0.010 µg/g, 0.020 µg/g		OHLE3WB(CDH), OHLE4WB(CDH)
Chicken	Fat+Skin	HA1042BP	DDE	0.106	<0.010 µg/g		OHLE3WB(CDH), OHLE4WB(CDH)
Catfish	Composite	HA0982B	Dieldrin	0.251	0.025 µg/g, 0.147 µg/l		HA0981SE, HA0973SW
Carp	Composite	HA0983BA	Dieldrin	0.026	0.025 µg/g, 0.147 µg/l		HA0981SE, HA0973SW
Carp	Composite	HA0984BA	Dieldrin	0.235	0.025 µg/g, 0.147 µg/l		HA0981SE, HA0973SW
Carp	Composite	HA0983BA	Mercury	0.052	<0.050 µg/g		HA0981SE, HA0973SW
Carp	Composite	HA0984BA	Mercury	0.155	<0.050 µg/g		HA0981SE, HA0973SW
Fathead Minnow	Composite	HA1061B	Mercury	0.0897	<0.050 µg/g		HA0981SE, HA0973SW
Crayfish	Composite	HA1062B	Arsenic	0.573	3.7 µg/g, 20.9 µg/l		HA0974SE, HA0980SW
Algal Mats	Composite	HA1253B	Arsenic	1.02	3.7 µg/g, 20.9 µg/l		HA0974SE, HA0980SW
Earthworms	Composite	HA1247B	Dieldrin	0.0282	0.044 µg/g		HA0997WB
Earthworms	Composite	HA1053B	Dieldrin	0.023	0.020 µg/g		OHLE4WB (CDH)
Earthworms	Composite	HA1057B	Dieldrin	0.0211	0.0128 µg/g		HA1229WB
Earthworms	Composite	HA1254B	Dieldrin	0.0221	0.008 µg/g		HA1211WB
Earthworms	Composite	HA1053B	Arsenic	1.36	7.0 µg/g		OHLE4WB (CDH)
Earthworms	Composite	HA1250B	Arsenic	1.85	3.24 µg/g		HA1205WB
Earthworms	Composite	HA1057B	Arsenic	1.33	<2.50 µg/g		HA1229WB
Earthworms	Composite	HA1254B	Arsenic	0.965	<2.50 µg/g		HA1211WB
Earthworms	Composite	HA1063B	Arsenic	1.69	<2.50 µg/g		HA1209WB
Earthworms	Composite	HA1250B	Mercury	0.0767	<0.05 µg/g		HA1205WB
Earthworms	Composite	HA1057B	Mercury	0.0612	<0.05 µg/g		HA1229WB
Earthworms	Composite	HA1063B	Mercury	0.0612	<0.05 µg/g		HA1211WB
Deer mouse	Composite	HA1051B	Dieldrin	0.571	0.0148 µg/g		HA1210WB
Deer mouse	Composite	HA1251B	Dieldrin	0.0267	0.0167 µg/g		HA1205WB
Deer mouse	Composite	HA1059B	Dieldrin	0.140	0.0128 µg/g		HA1229WB

Table 7.2: (Page 2 of 2)

Species	Tissue	Biota Sampling Location	Analyte	Biota Concentration ($\mu\text{g/g}$)	Soil ($\mu\text{g/g}$)/Water ($\mu\text{g/l}$) Concentration		Soil/Water Sampling Location
Prairie dog	Composite	HA1055B	Dieldrin	0.0327	0.020 $\mu\text{g/g}$		OHLE4WB (CDH)
Prairie dog	Composite	HA1049B	Arsenic	0.771	<2.50 $\mu\text{g/g}$		HA1226WB
Ring-necked pheasant	Liver	HA1257BL	Dieldrin	0.380	0.0148 $\mu\text{g/g}$		HA1210WB

$\mu\text{g/g}$ = micrograms per gram
 $\mu\text{g/l}$ = micrograms per liter

(1) Letters at the end of sample numbers represent sample type as follows:

WB = surficial soil

SE = stream-bottom sediment

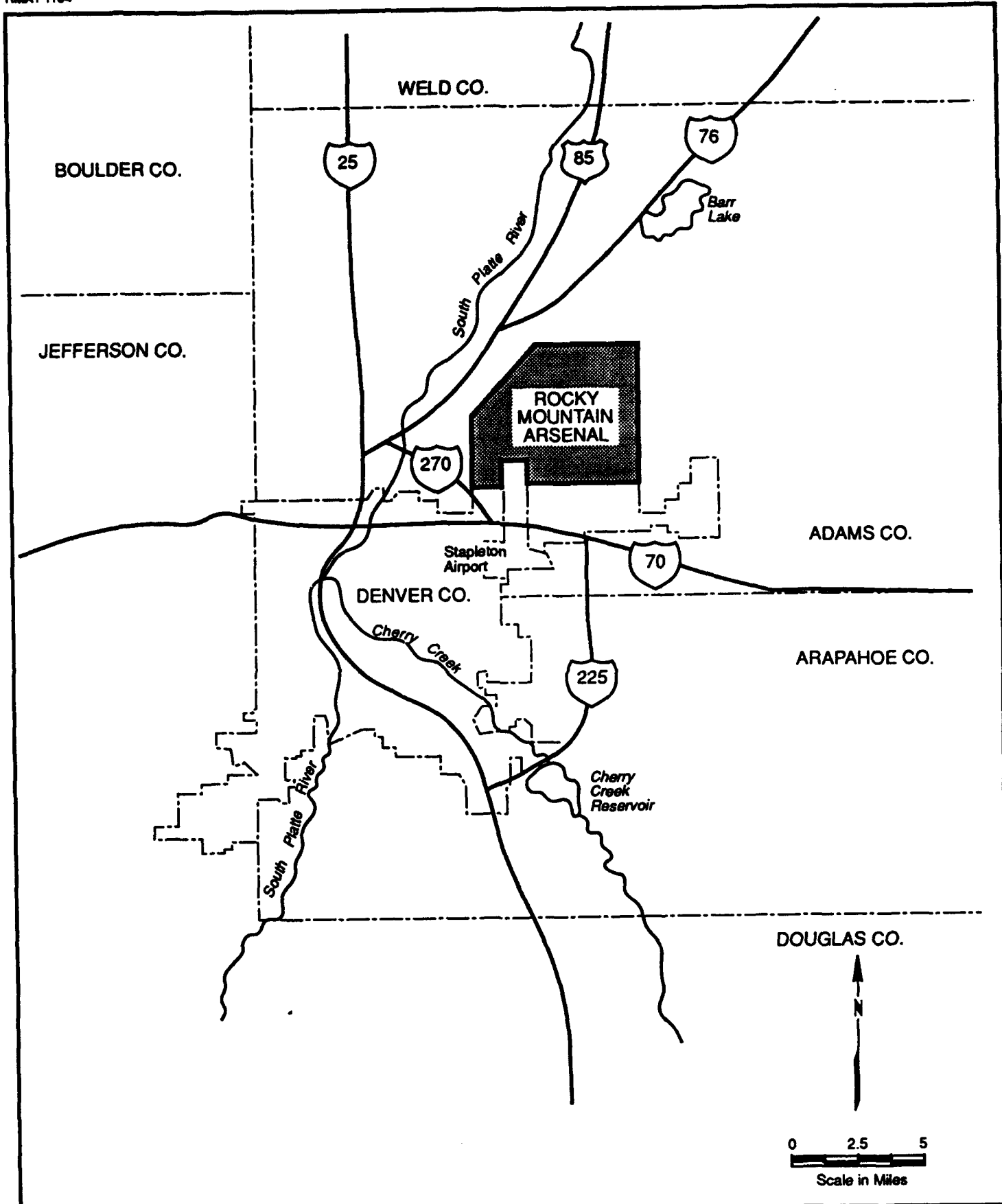
SW = surface water

B, BA, BE, BF, BL, BP = Biota

(2) (CDH) = Sample collected by Colorado Department of Health

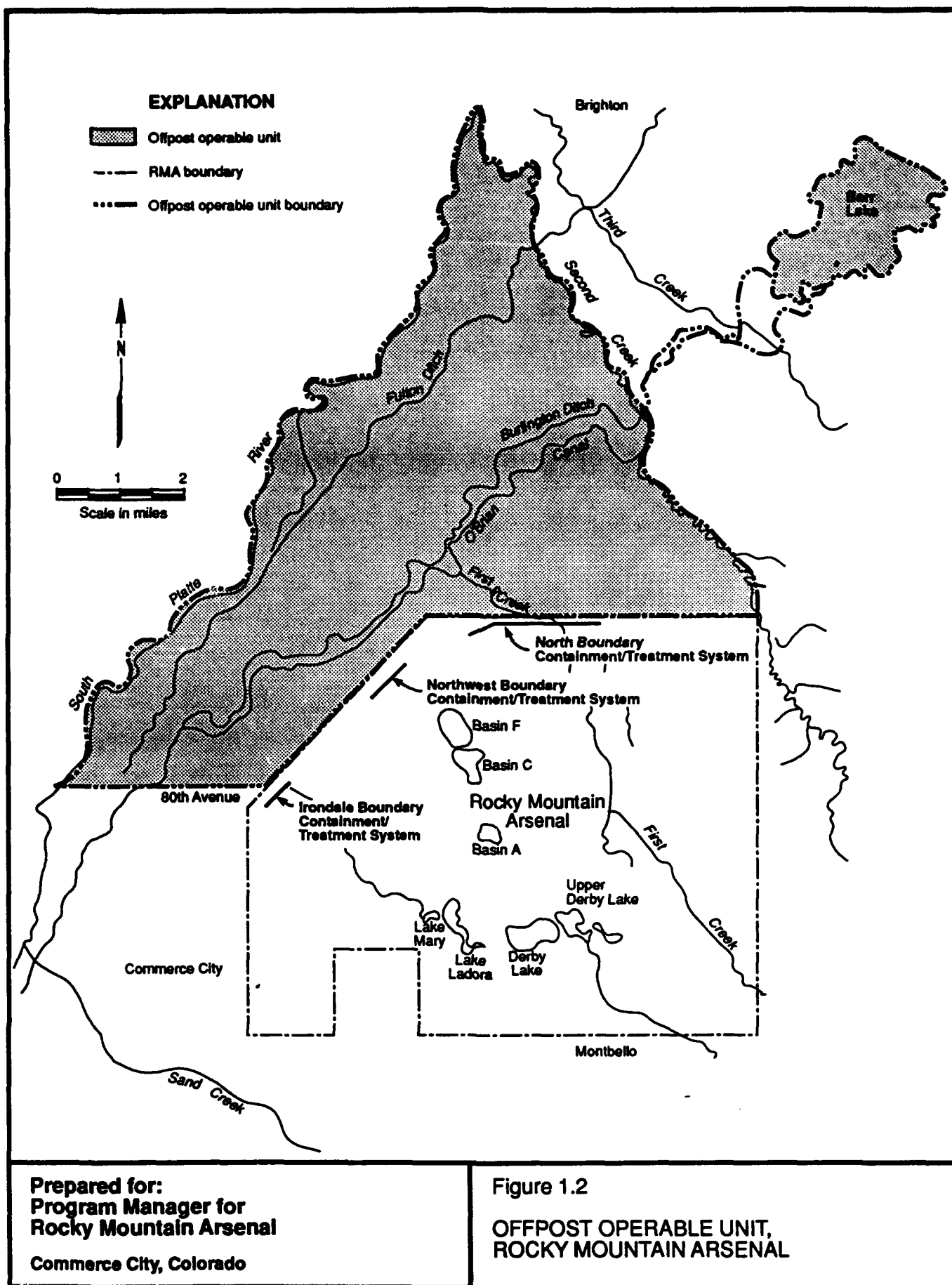
20000,350.10 - RIA

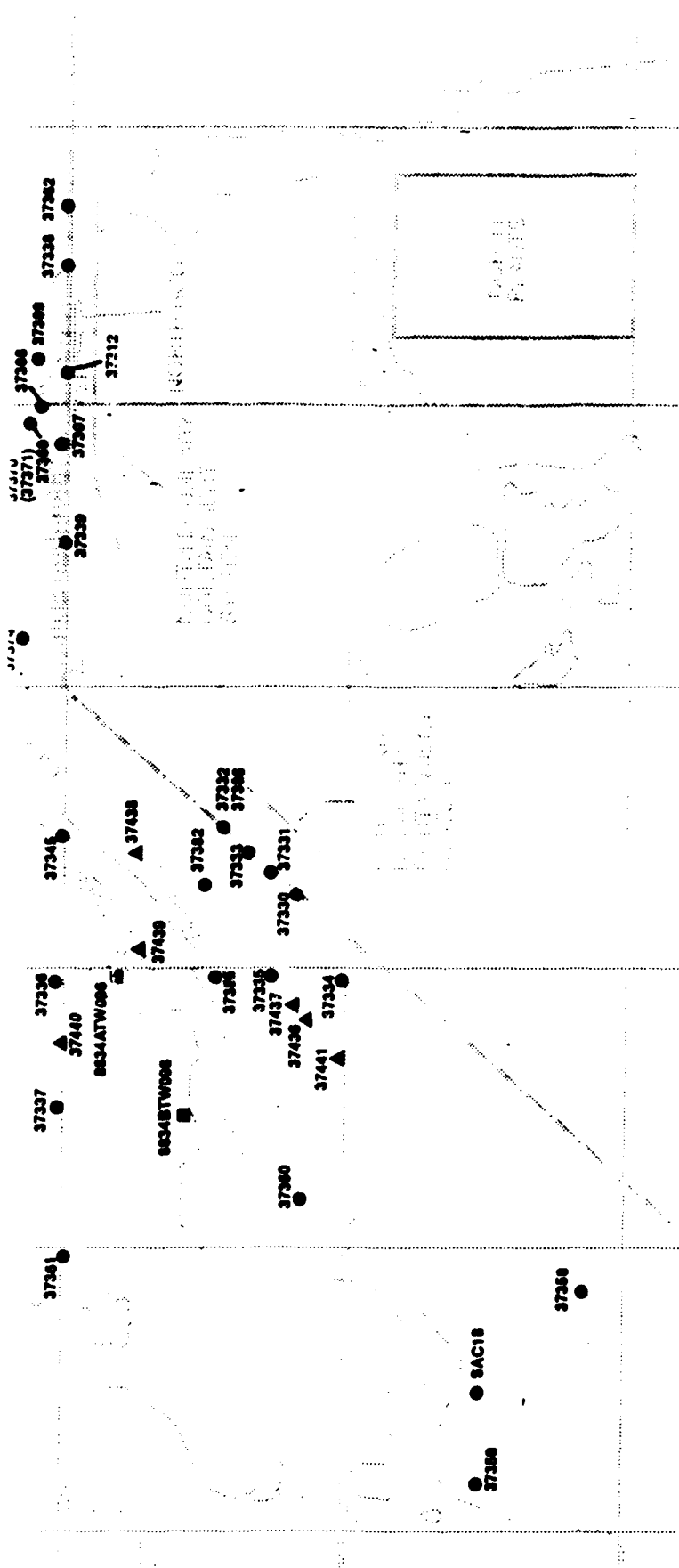
0802030102



Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 1.1
LOCATION MAP OF
ROCKY MOUNTAIN ARSENAL





EXPLANATION

- ▲ Monitoring Well Installed and Sampled Under Oilpost RI Addendum Programs and IRA A
- Domestic Well Sampled Under Oilpost RI Addendum Program
- Monitoring Wells Sampled Under CMP (Fall 1989)
- () Piezometer

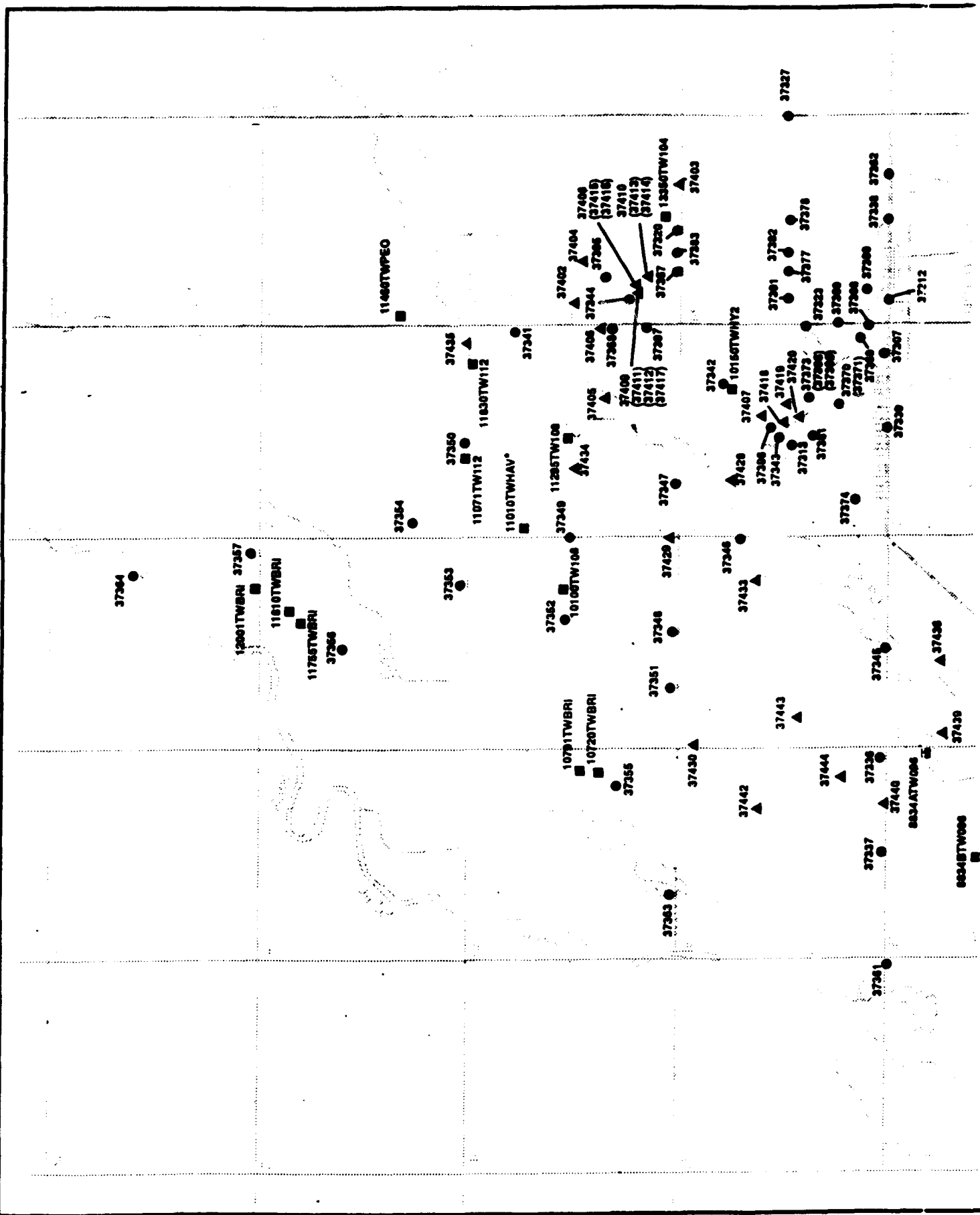
() Piezometer



A vertical scale bar with markings at 0, 1500, and 3000 feet.

Figure 2.1
OFFPOST OPERABLE UNIT UNCONFINED FLOW SYSTEM WELL NETWORK

**Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado**



(1)

13701TW104

Δ 37431

10021TWPEO

00010TWPEO

11041TW008

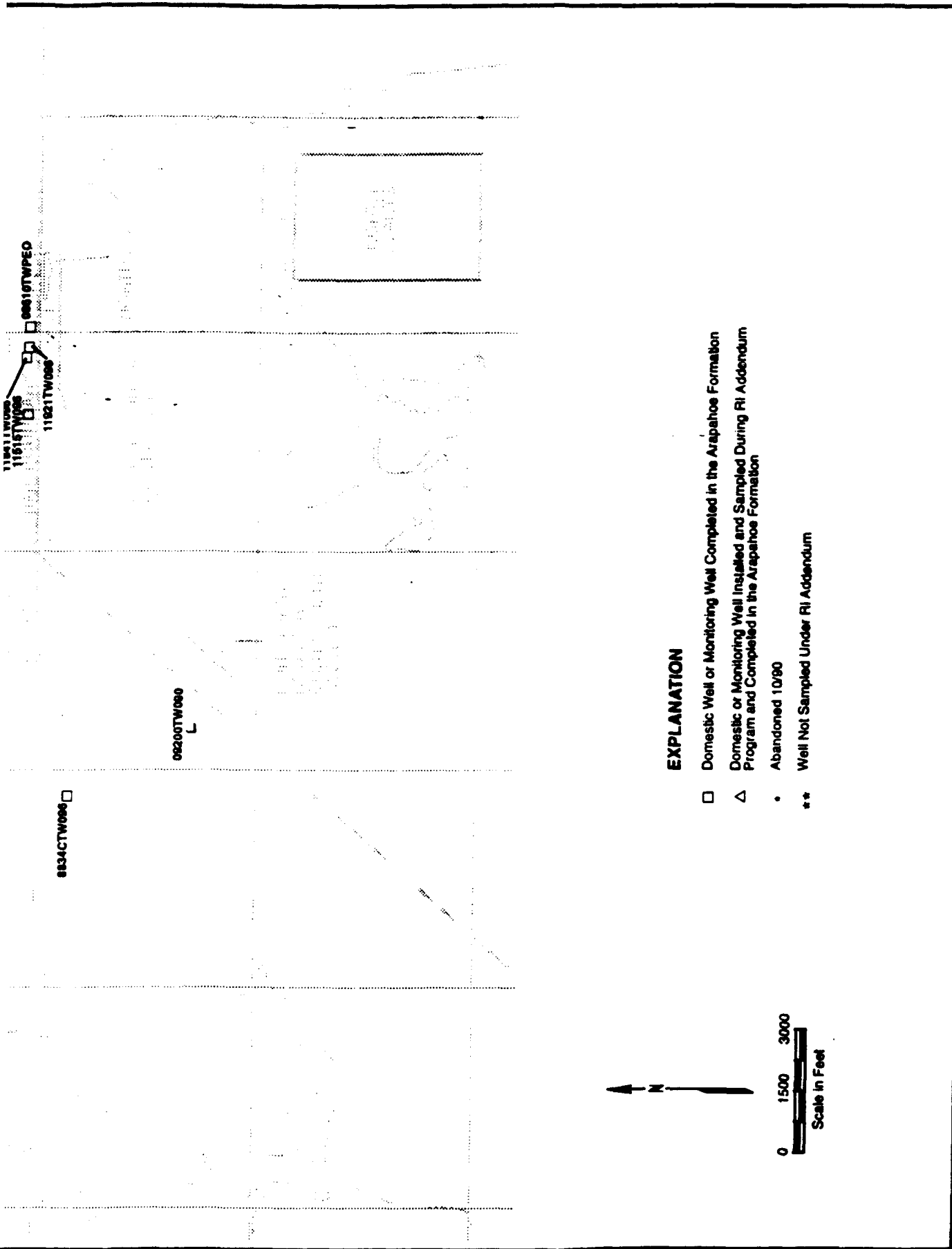
11051TW008

11021TW008

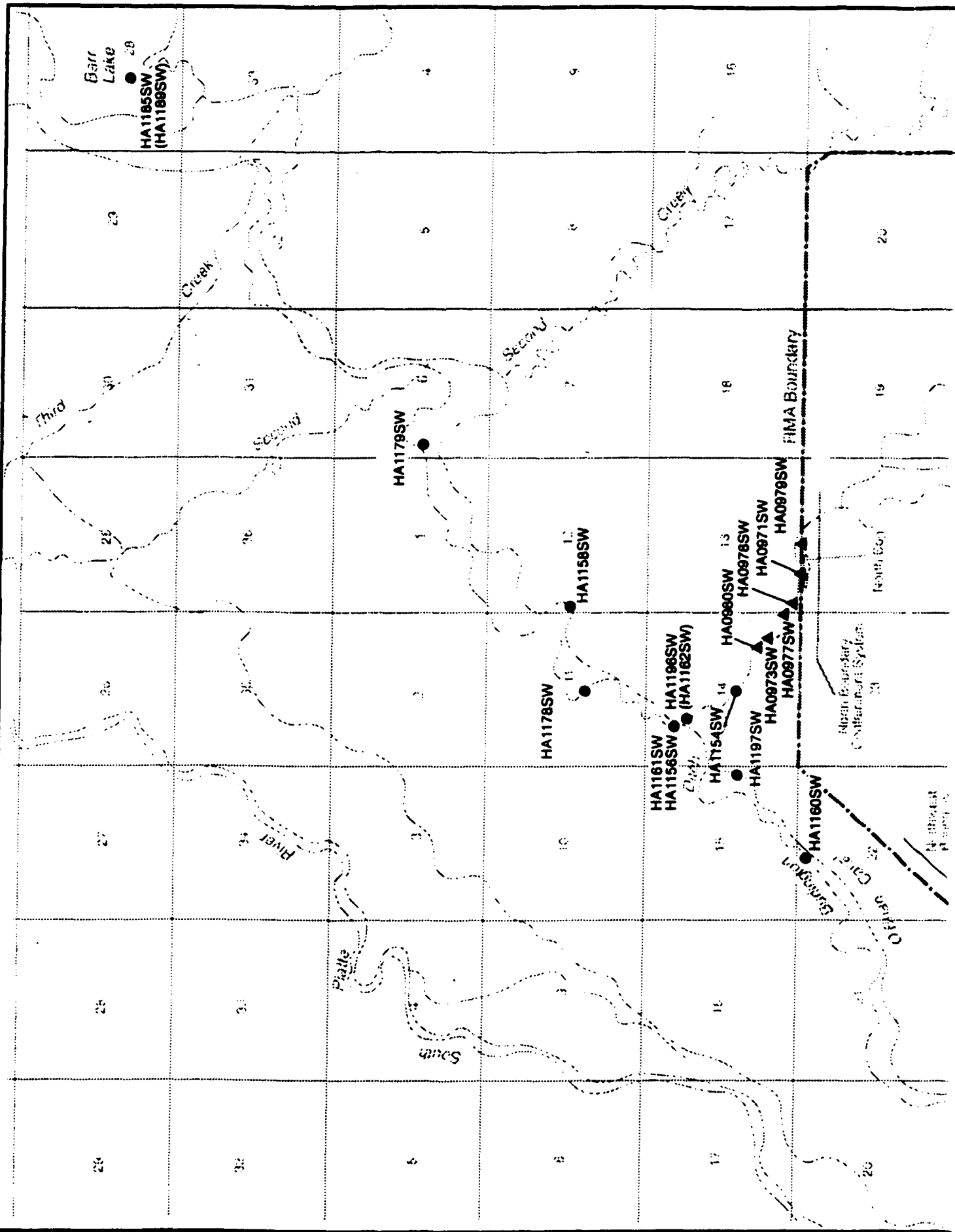
Δ 37445

37446 Δ **

0034CTW008



Prepared for: Program Manager for Rocky Mountain Arsenal Commerce City, Colorado	Figure 2.2 OFFPOST OPERABLE UNIT ARAPAHOE FORMATION WELL MONITORING NETWORK
---	--



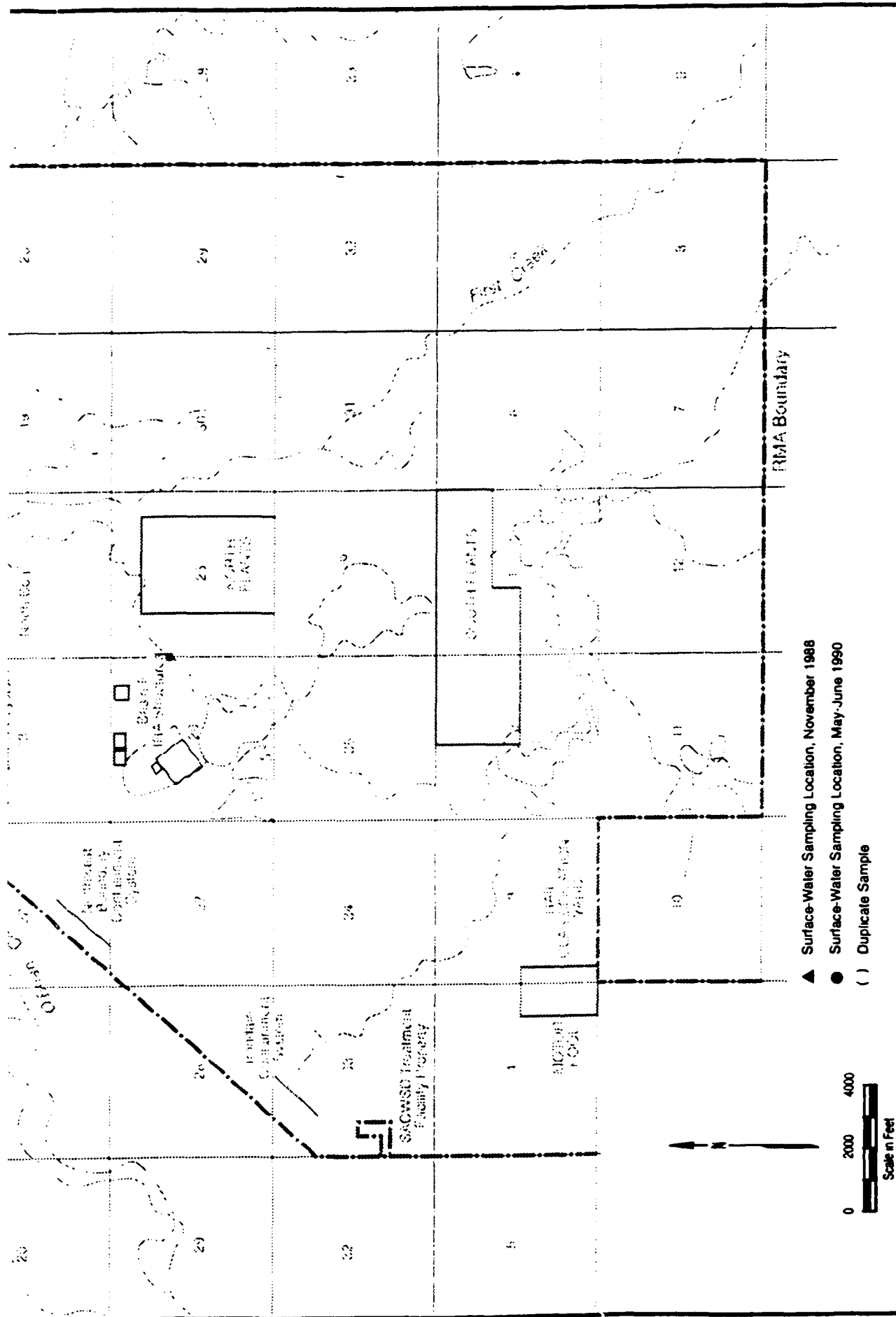
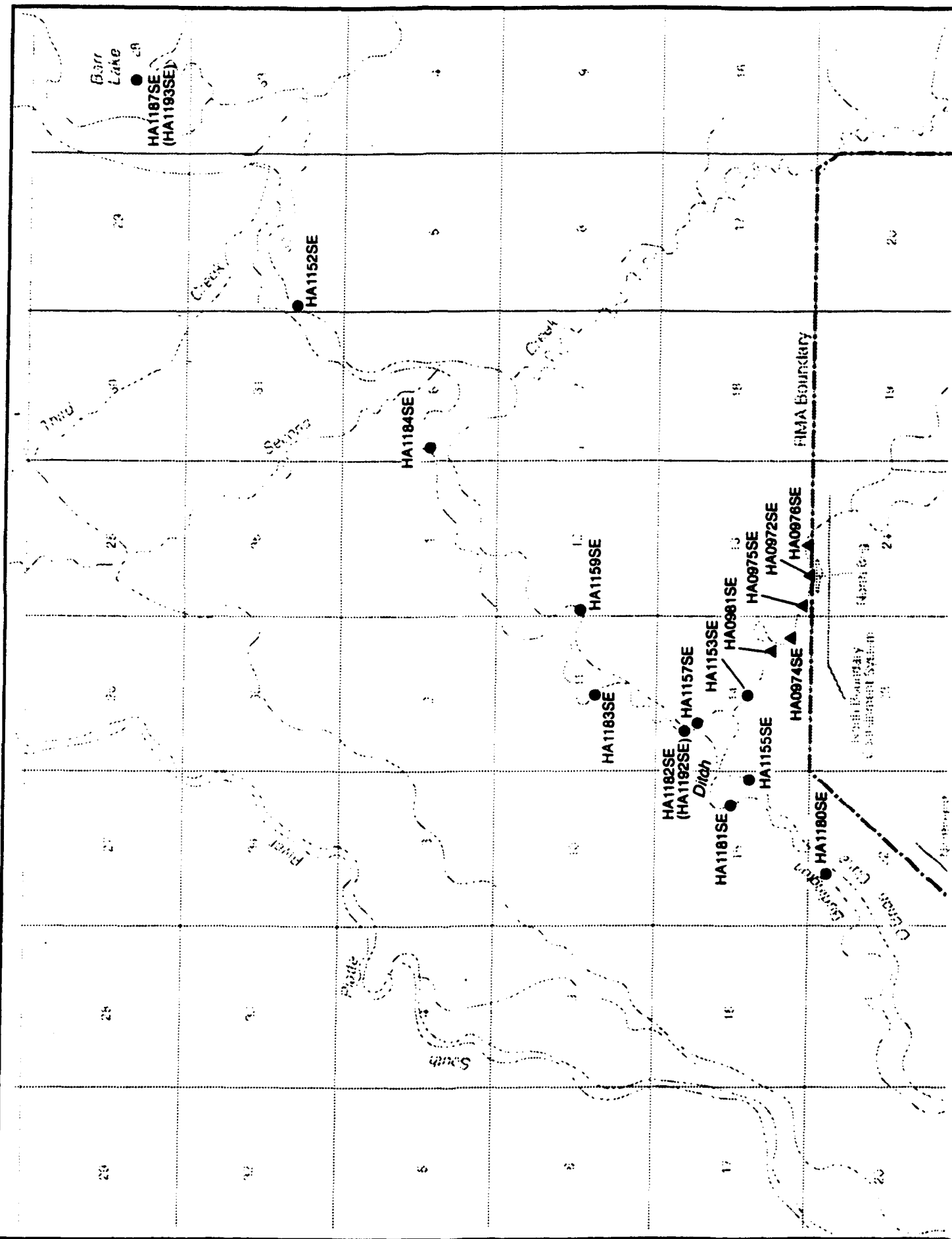


Figure 2.3
OFFPOST OPERABLE UNIT SURFACE-WATER SAMPLING LOCATIONS

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado



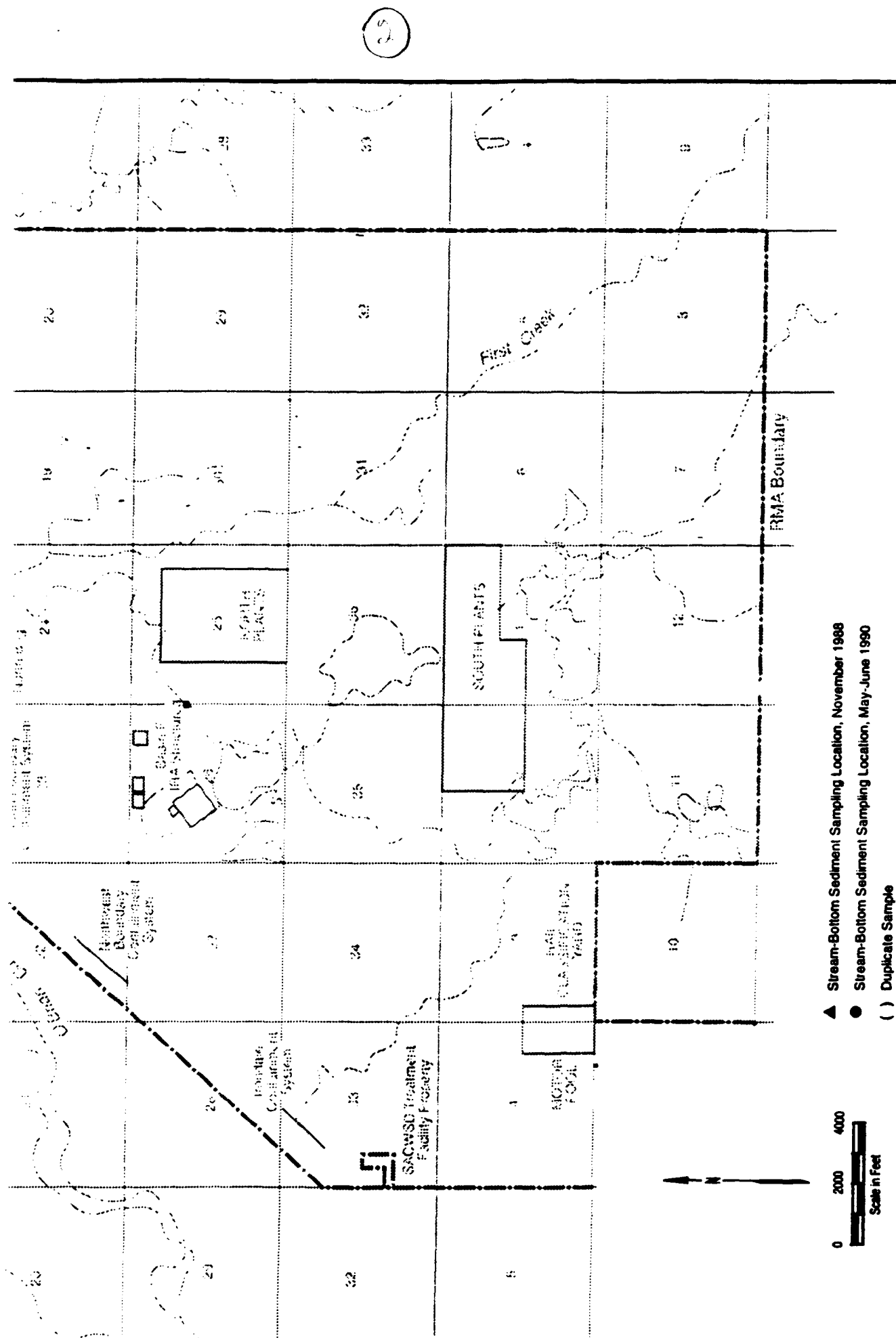


Figure 2.4
OFFPOST OPERABLE UNIT STREAM-BOTTOM SEDIMENT SAMPLING LOCATIONS

**Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado**

①

② Highway

14

First
Creek

Peoria St.

HA0987S0
HA0987S050

HA0988WB

WERT-2WB
WERT-3WB

HA0985S
HA0985S

HA0986S0

HA0986S0

COLL-2WB

HA0997WB (COLL-1WB)

96th Ave.

HA0988WB

HA0982WB

HA0981WB

LAMB-4WB

LAMB-5WB

HA0989WB

SMAL-3WB

HA0990WB (SMAL-1WB)

SMAL-4WB
HA0989WB (SMAL-1WB)

CHLE-1WB

HA0993WB (LAMB-1WB)

CHLE-3WB

HA0994WB
(HA0985WB)

23

Rocky Mountain Arsenal

Peoria St.

13

• A0885S0
• A0885S045

• SMAL-3WB
HA0889WB (SMAL-2WB)
• SMAL-4WB
HA0889WB (SMAL-1WB)

24

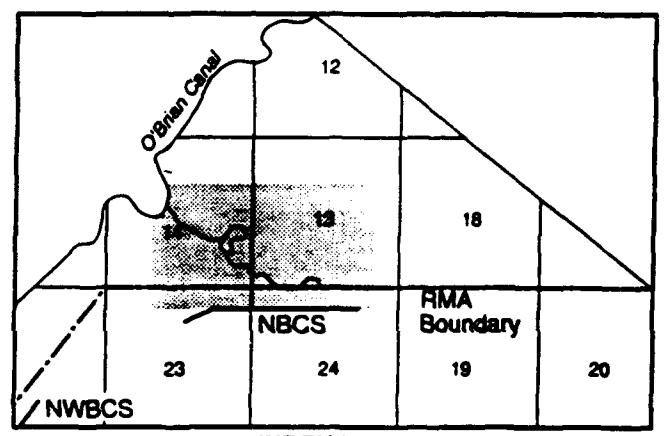
arsenal

EXPLANATION

- Subsurface Soil Sampling Location (0-1', 4-5'), February 1989
- Surficial Soil Sampling Location, February 1989
- CDH Surficial Soil Sampling Location, February 1989
- [] CDH Surficial Soil Sampling Location Colocated w/ HLA Sampling Location, February 1989
- () Sample is a Duplicate

CDH Colorado Department of Health

13 Section Number



INDEX MAP

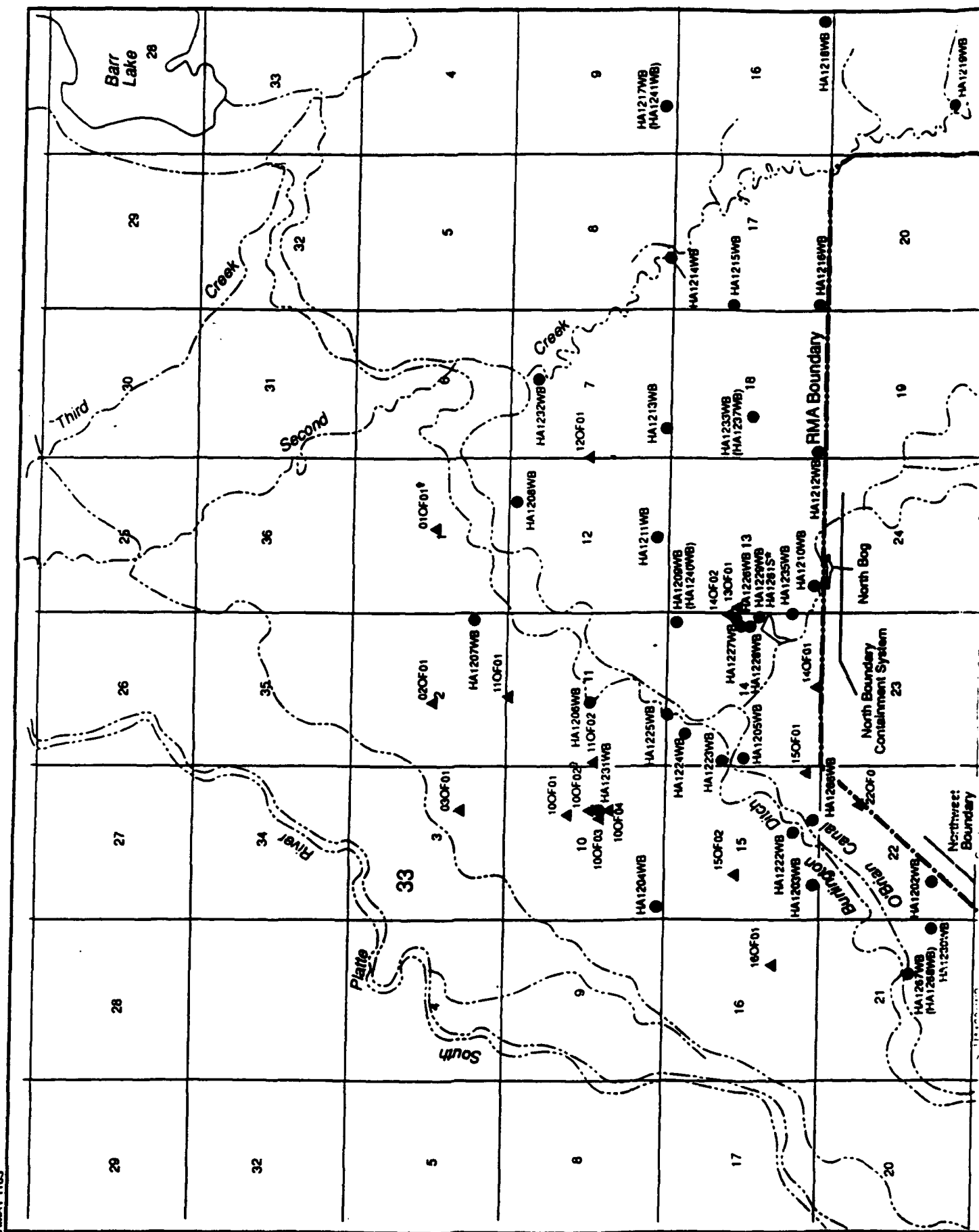


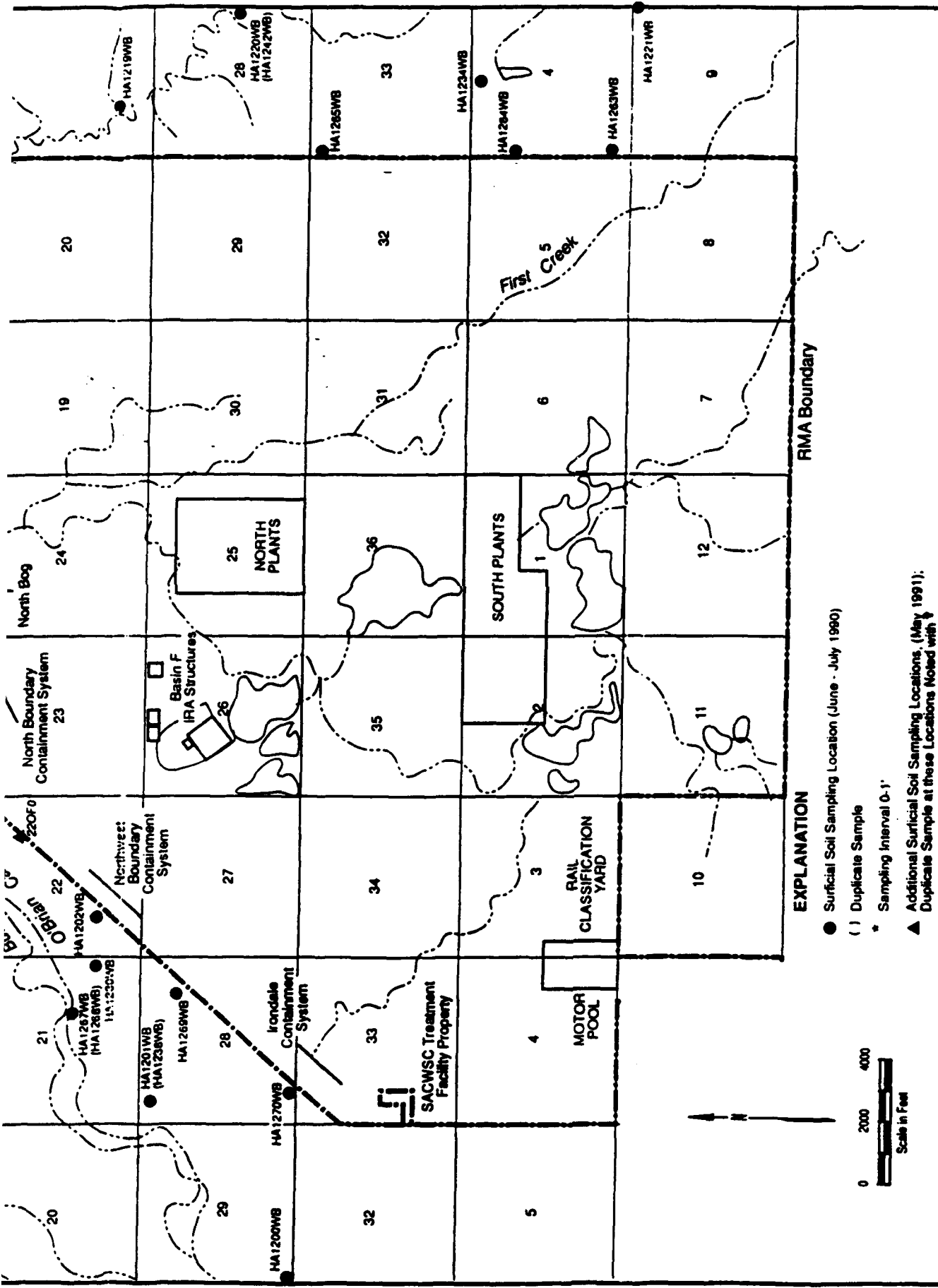
**Prepared for:
Program Manager for
Rocky Mountain Arsenal**

Commerce City, Colorado

Figure 2.5

**OFFPOST OPERABLE UNIT SOIL SAMPLING
LOCATIONS IN THE 96TH AVENUE
RESIDENTIAL AREA, FEBRUARY 1989**

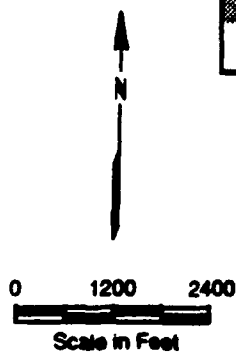
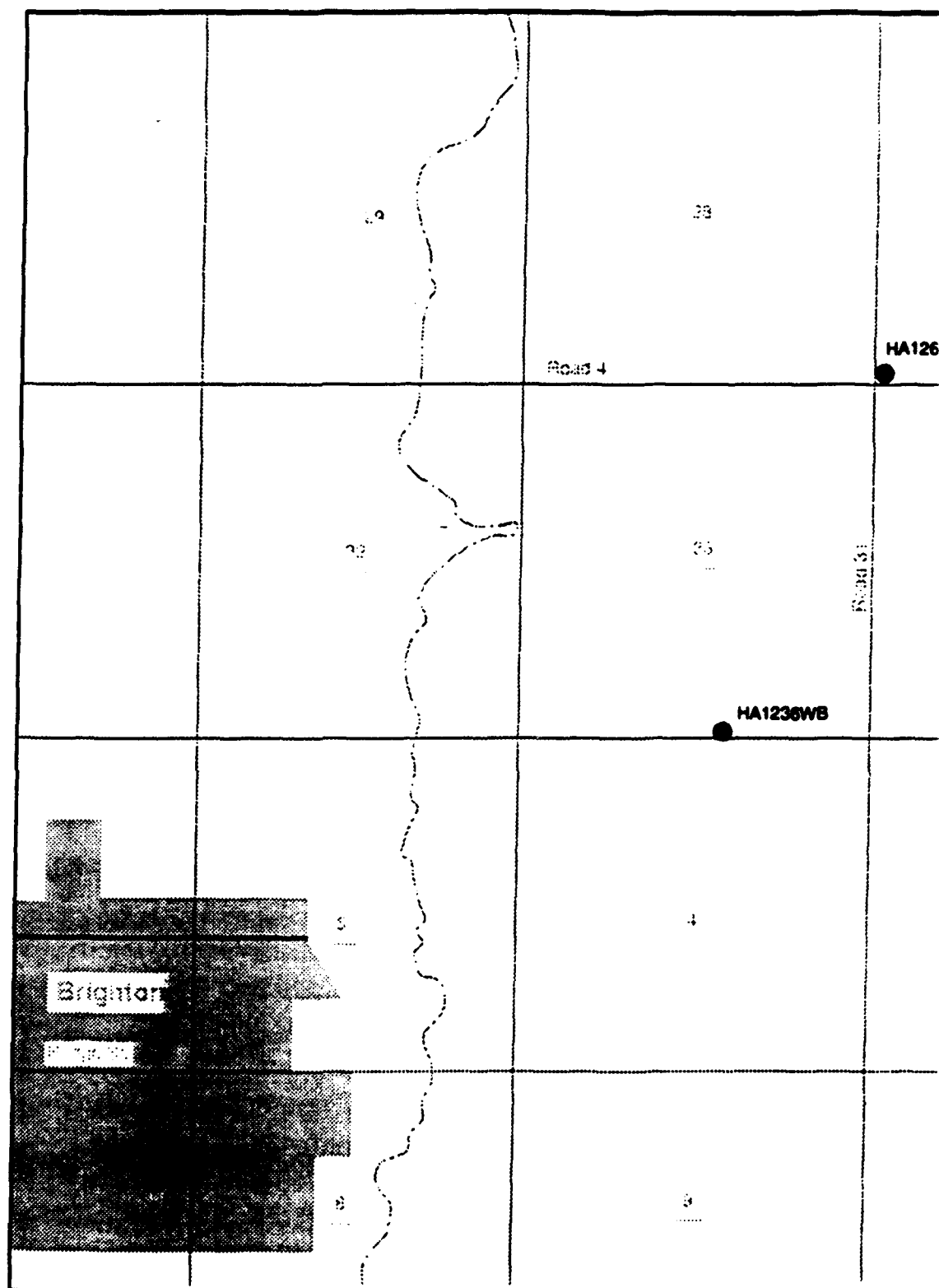




Prepared for:
 Program Manager for
 Rocky Mountain Arsenal
 Commerce City, Colorado

Figure 2.6
 OFFPOST OPERABLE UNIT SUBSURFACE AND SURFICIAL SOIL
 SAMPLING LOCATIONS, JUNE - JULY 1990 AND MAY 1991

(1)



EXPLANATION

- Soil Sampling Location, July 1990
- () Duplicate Sample
- 13 Section Number

Prepared for:
**Program Manager for
 Rocky Mountain Arsenal**
 Commerce City, Colorado

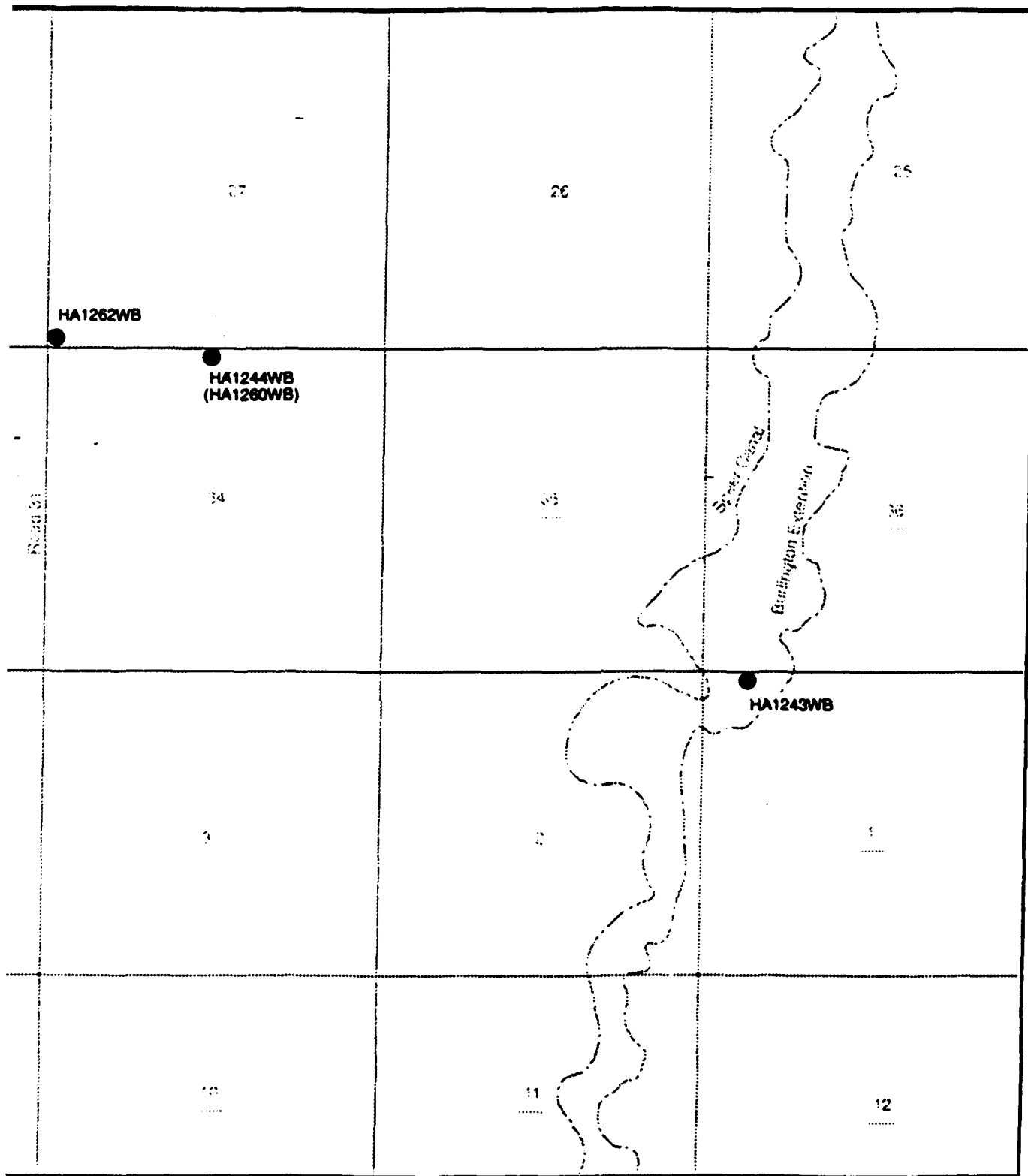
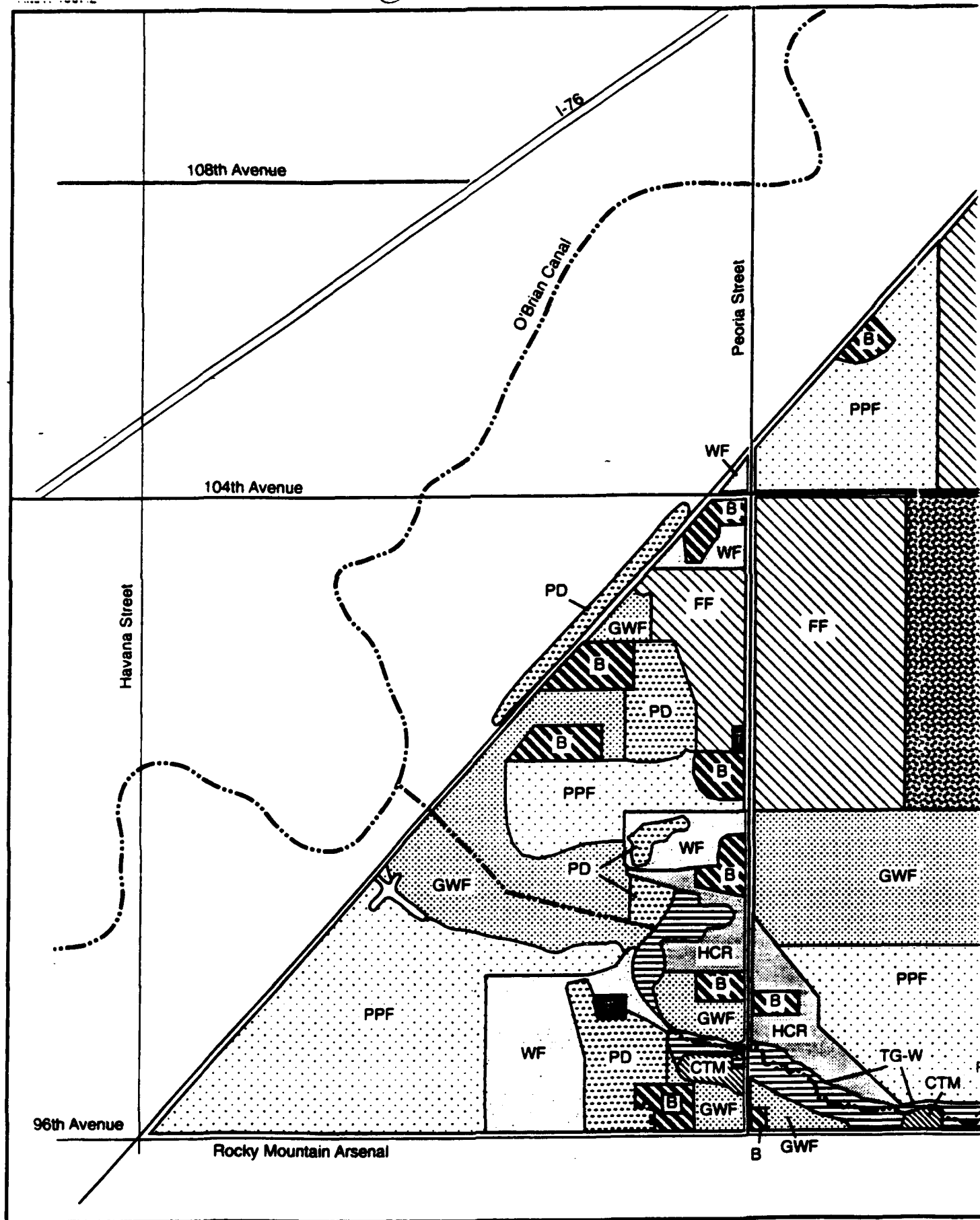
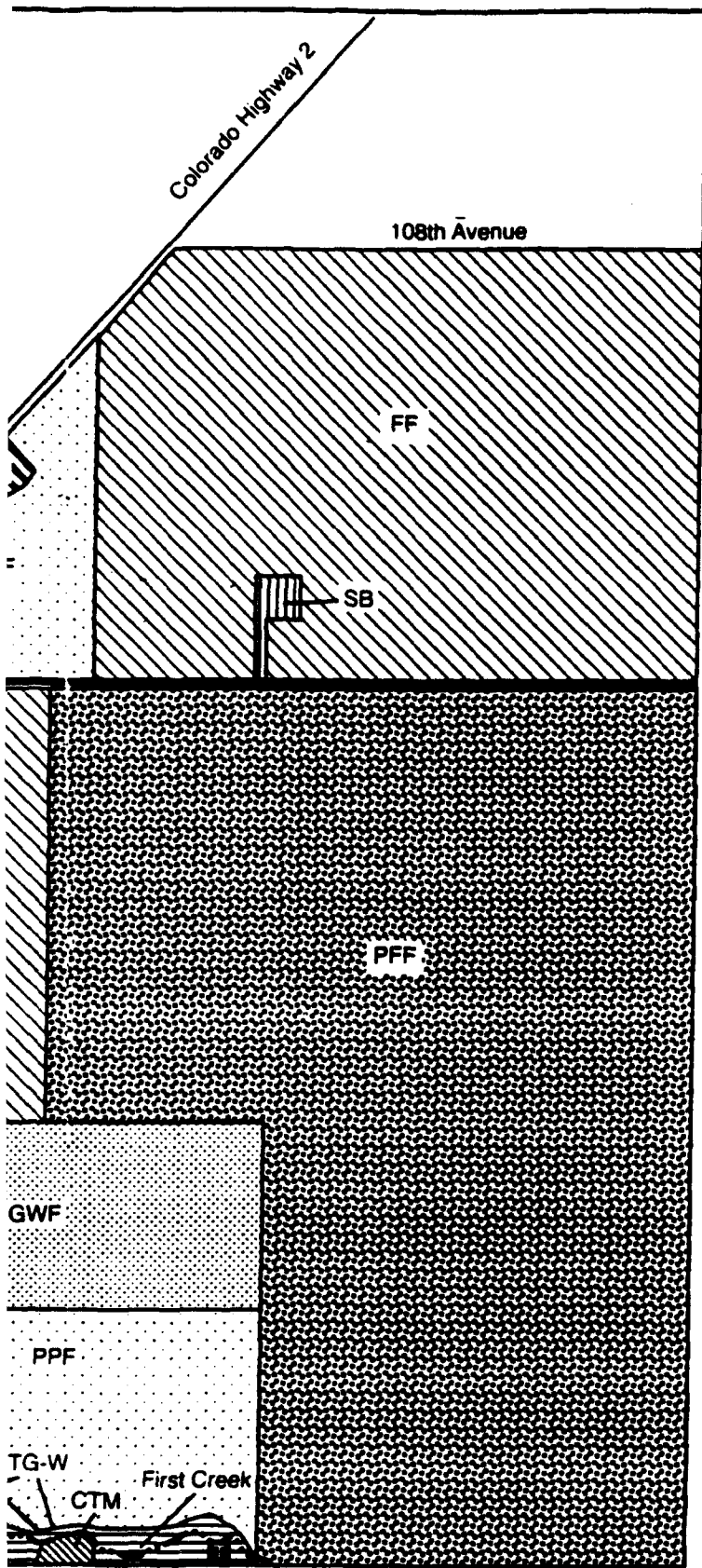


Figure 2.7

OFFPOST OPERABLE UNIT BACKGROUND SOIL
SAMPLING LOCATIONS NEAR BRIGHTON, CO

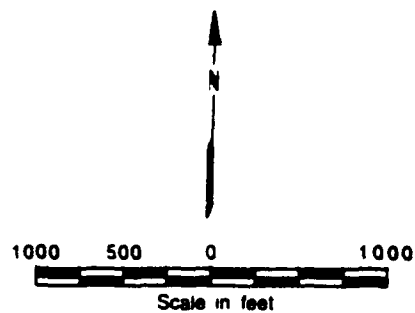
①





EXPLANATION

	B	Buildings, fences, parking areas
	T	Trash dumps, small abandoned landfills
	FF	Fallow Field; Not planted for at least a season
	PD	Prairie dog colonies (forbs and short grasses)
	SB	Shelterbelts, ornamental plants/trees around residences
	WF	Weedy forbs
	PPF	Planted, plowed field; winter grain crop
	GWF	Grasses, weedy forbs
	PFF	Plowed, fallow field
	HCR	Horse and cattle range
	CTM	Cattail marsh
	TG-W	Tall grasses, forbs (wetlands)



Prepared for:
Program Manager for
Rocky Mountain Arsenal

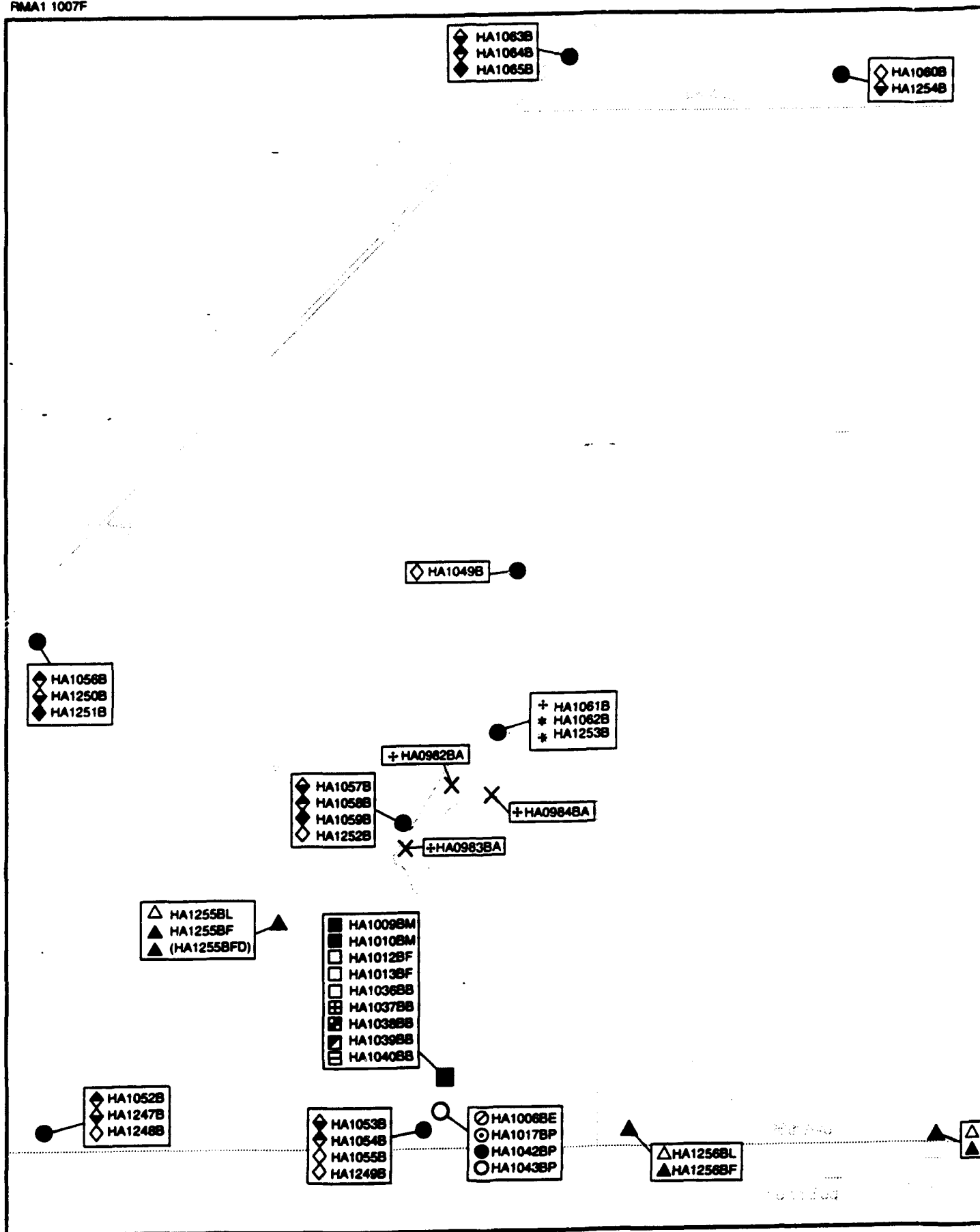
Commerce City, Colorado

Figure 2.8

OFFPOST OPERABLE UNIT BIOTA HABITAT
MAP

(1)

RMA1 1007F



2

HA1060B
HA1254B

EXPLANATION

● Terrestrial Biota Sampling Locations

- ◆ Field Mice
- ◆ Prairie Dogs
- ◆ Grasshoppers
- ◆ Earthworms

○ Chicken Sampling Locations

- Chicken Egg
- Chicken Liver
- Chicken Fat/Skin
- Chicken Muscle

✕ Aquatic Biota Sampling Locations

- + Fish
- * Crayfish
- * Algae

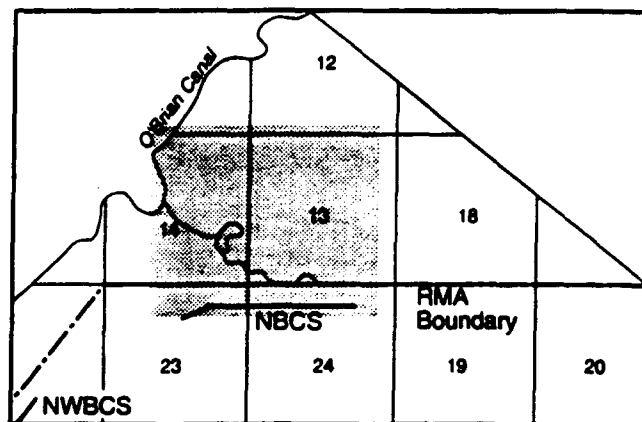
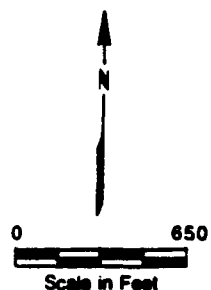
■ Cow Sampling Locations

- Cow Milk
- Cow Fat
- ▨ Cow Brain
- ▩ Cow Muscle
- ▧ Cow Liver
- ▦ Cow Kidney

▲ Pheasant Sampling Locations

- △ Pheasant Liver
- ▲ Pheasant Flesh

- () Sample is a Duplicate
- 13 Section Number



INDEX MAP

Prepared for:
Program Manager for
Rocky Mountain Arsenal

Commerce City, Colorado

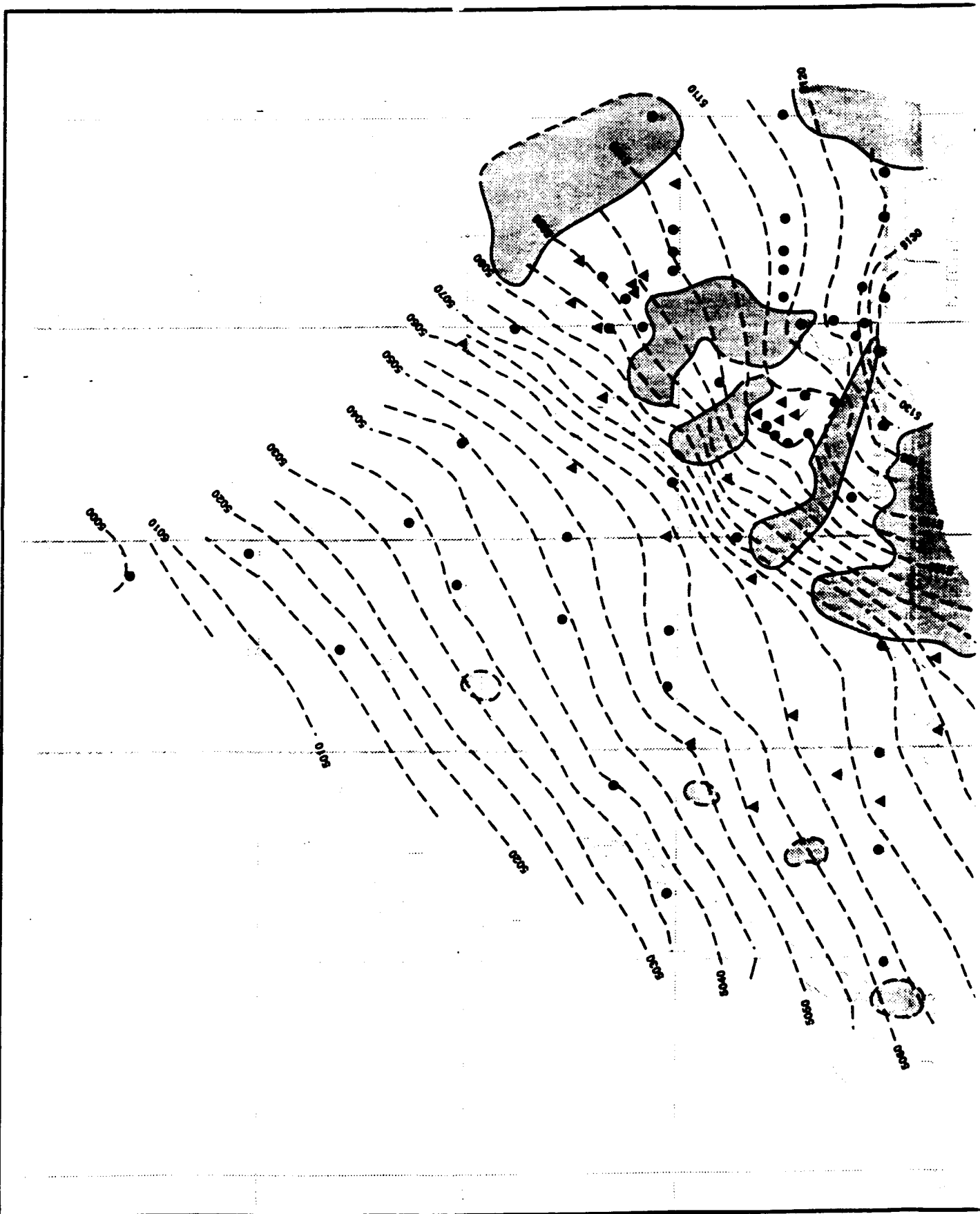
Figure 2.9

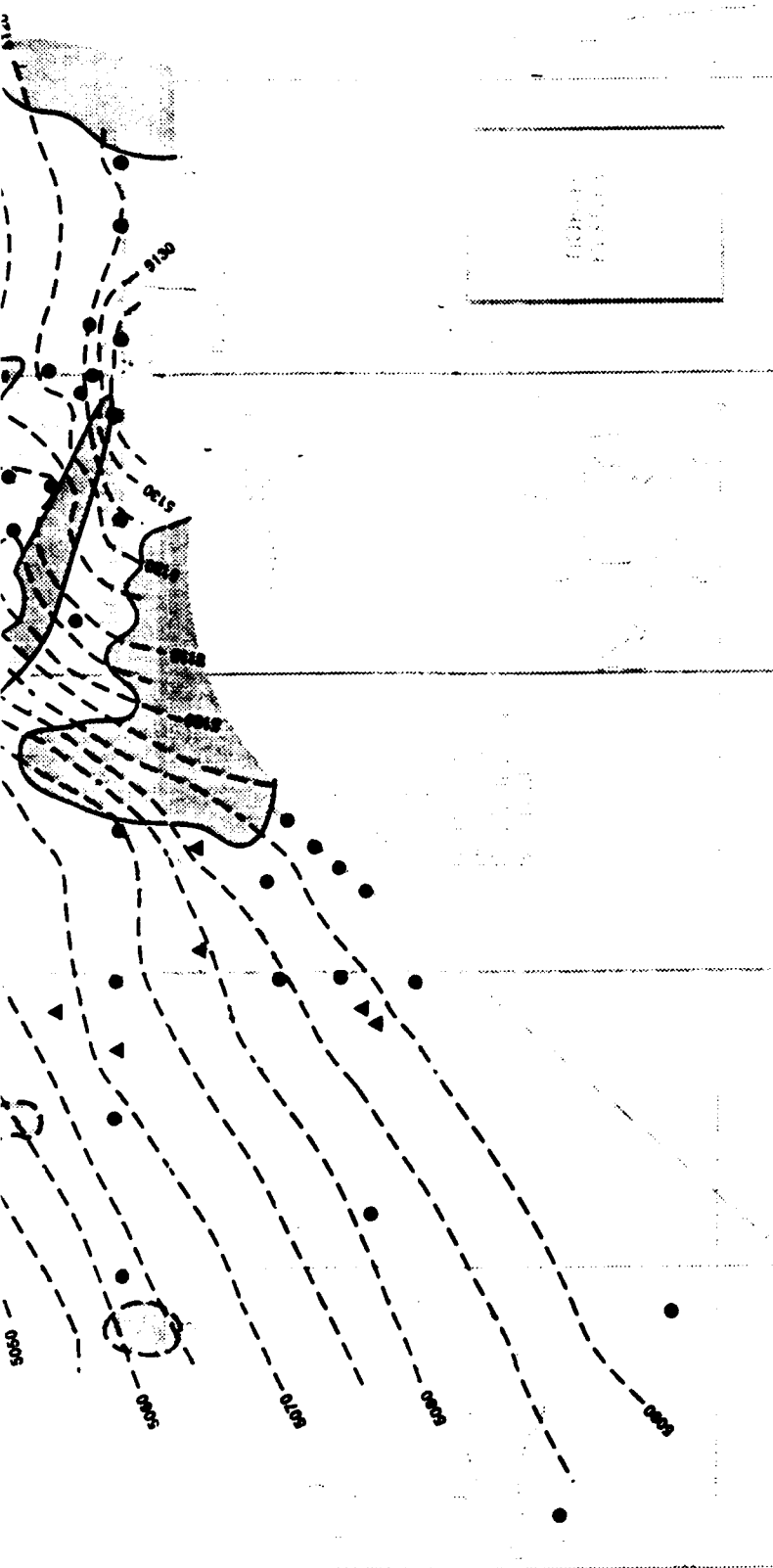
OFFPOST OPERABLE UNIT BIOTA SAMPLING
LOCATIONS

HA1050B
HA1051B
HA1246B

HA1257BL
HA1257BF

①





EXPLANATION

Contour Line, Dashed where Inferred (Feet Above Mean Sea Level)
Contour Interval = 5 Feet

Area of Unsaturated Alluvium,
Dashed Where Inferred

▲ Monitoring Well Installed and Sampled Under Offpost RI Addendum
Program (February 1990)

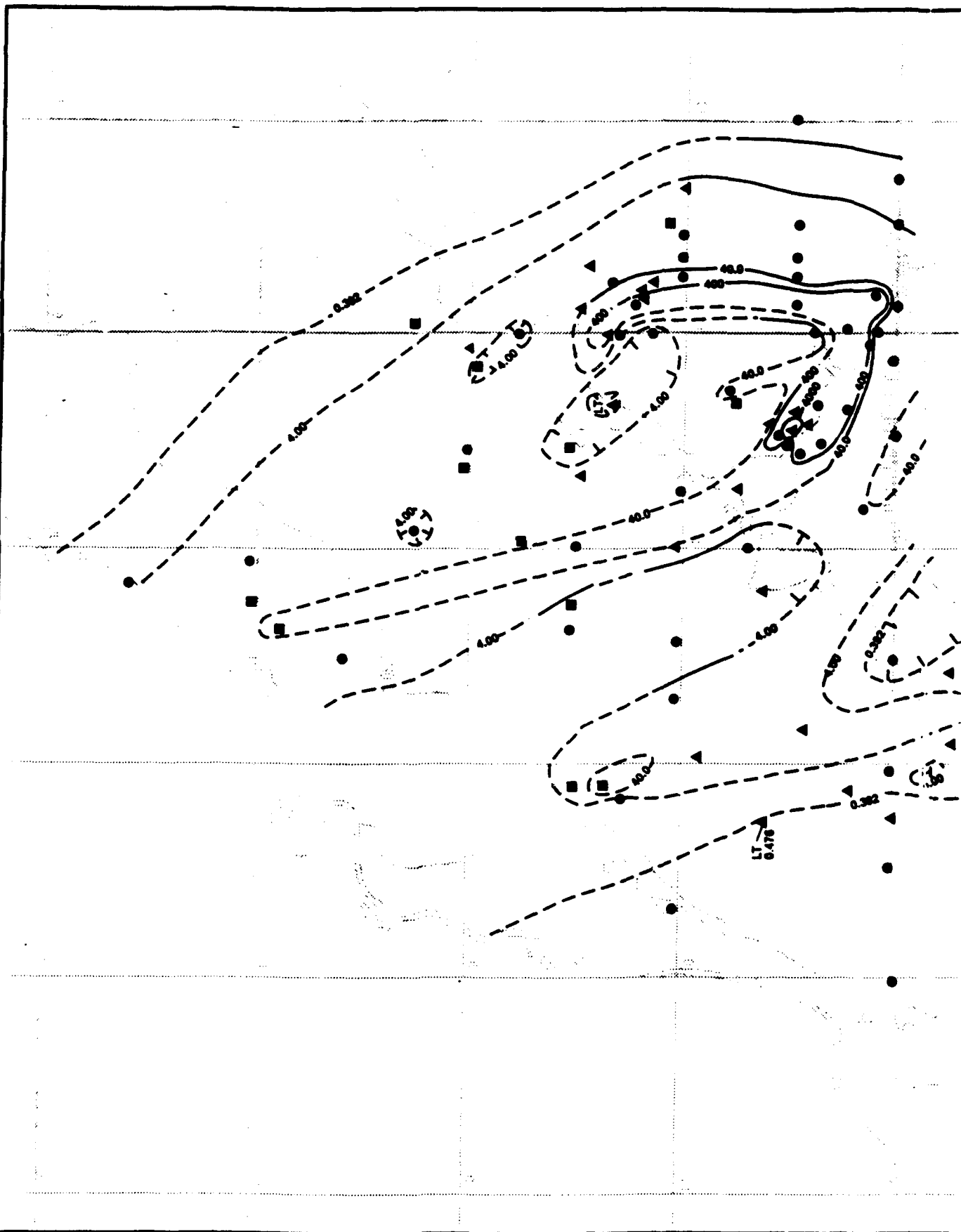
● Monitoring Well Sampled Under CMP (February 1990)

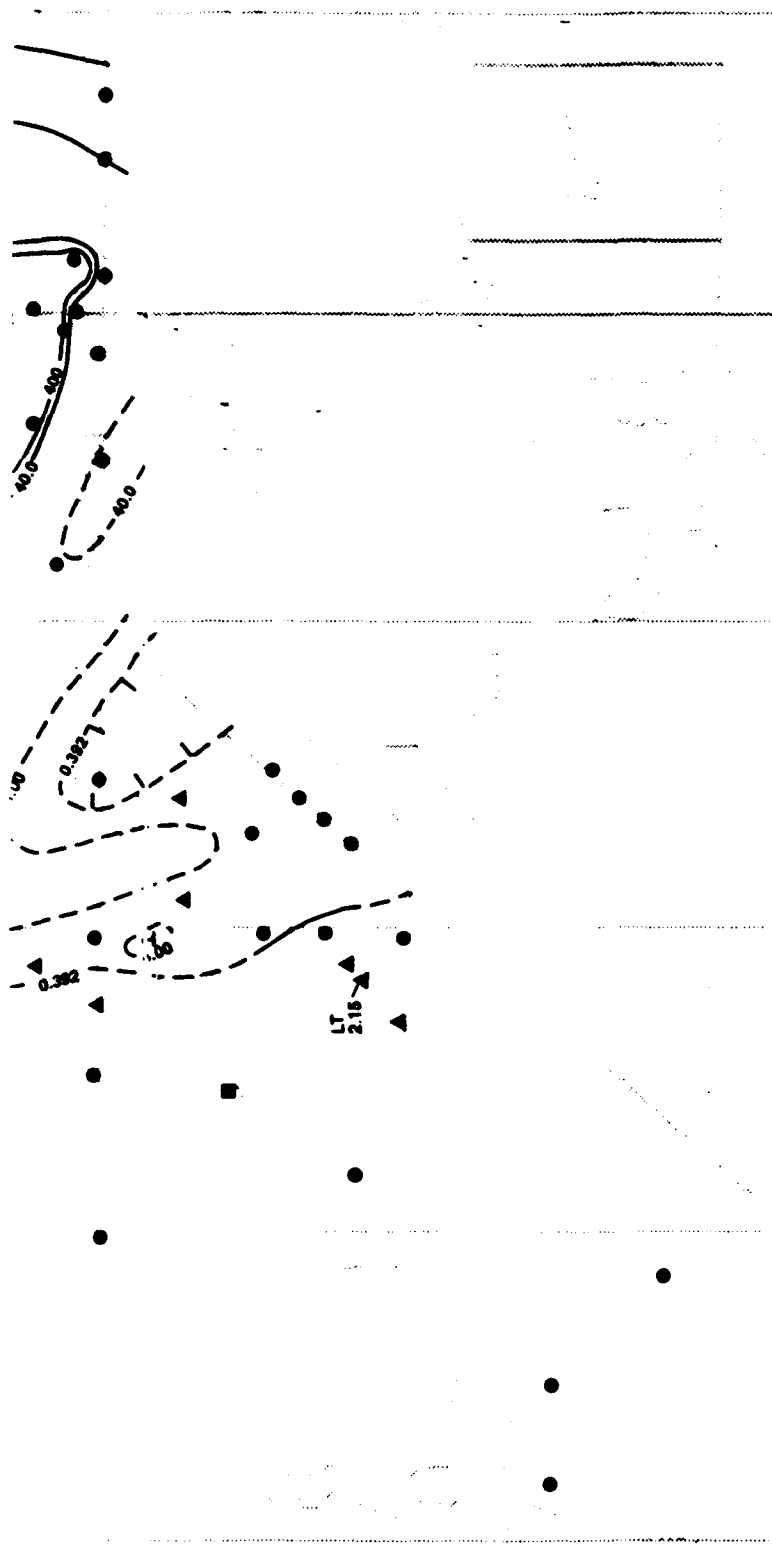
Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.1

POTENTIOMETRIC SURFACE MAP OF THE UNCONFINED FLOW SYSTEM
IN THE OFFPOST OU

①





EXPLANATION

- Concentrations in micrograms per liter ($\mu\text{g/l}$)
- Isoconcentration Line, Dashed where Inferred
- Isolated Detection, in $\mu\text{g/l}$. Two Values Shown if Sampled Twice. LT - Indicates Analyte was not Detected Above the Certified Reporting Limit.
- Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990)
- Monitoring Well Sampled Under CMP (Fall 1989)
- Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)

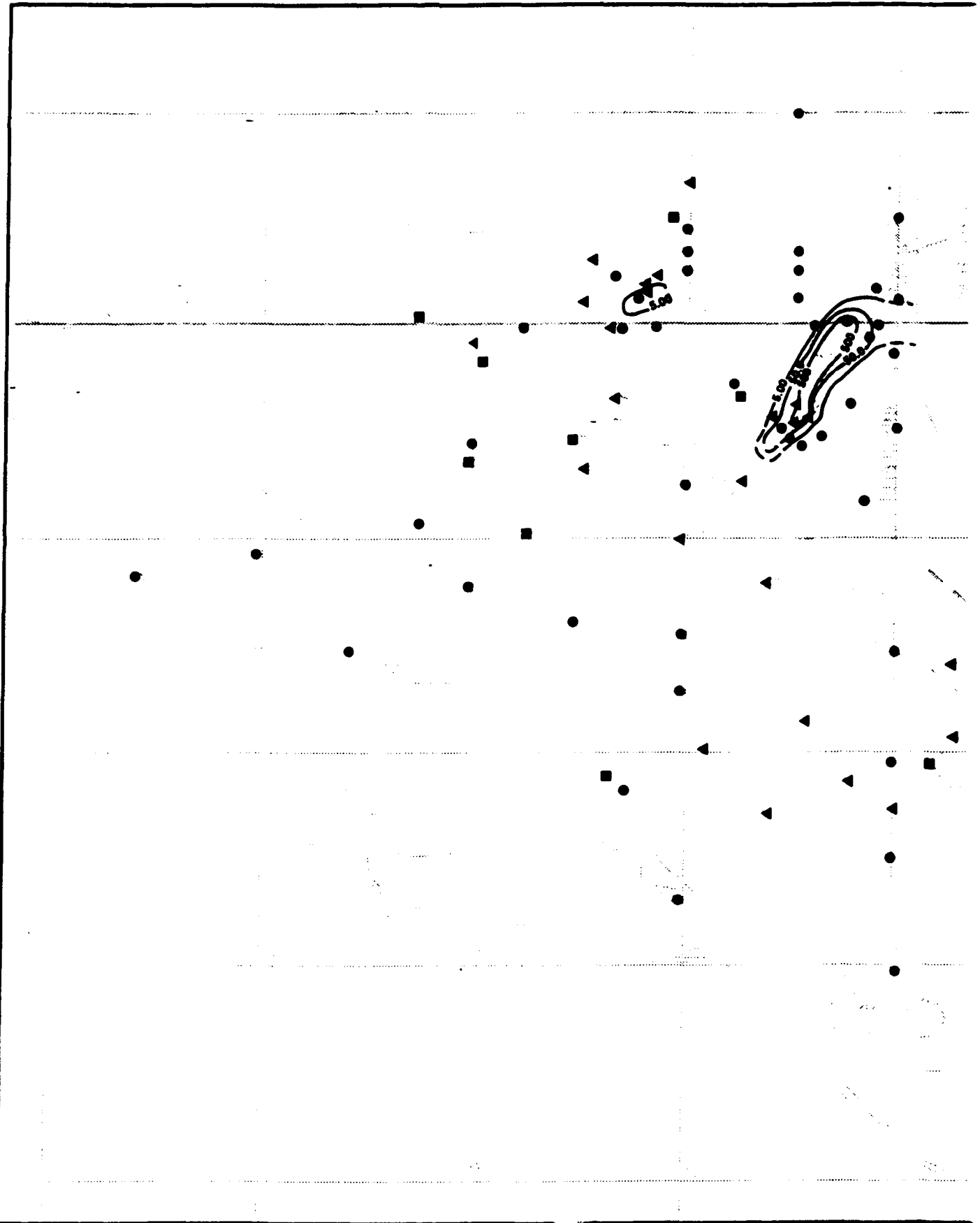
Isoconcentration Value ($\mu\text{g/l}$)

0.392
4.00
40.0
400
4000

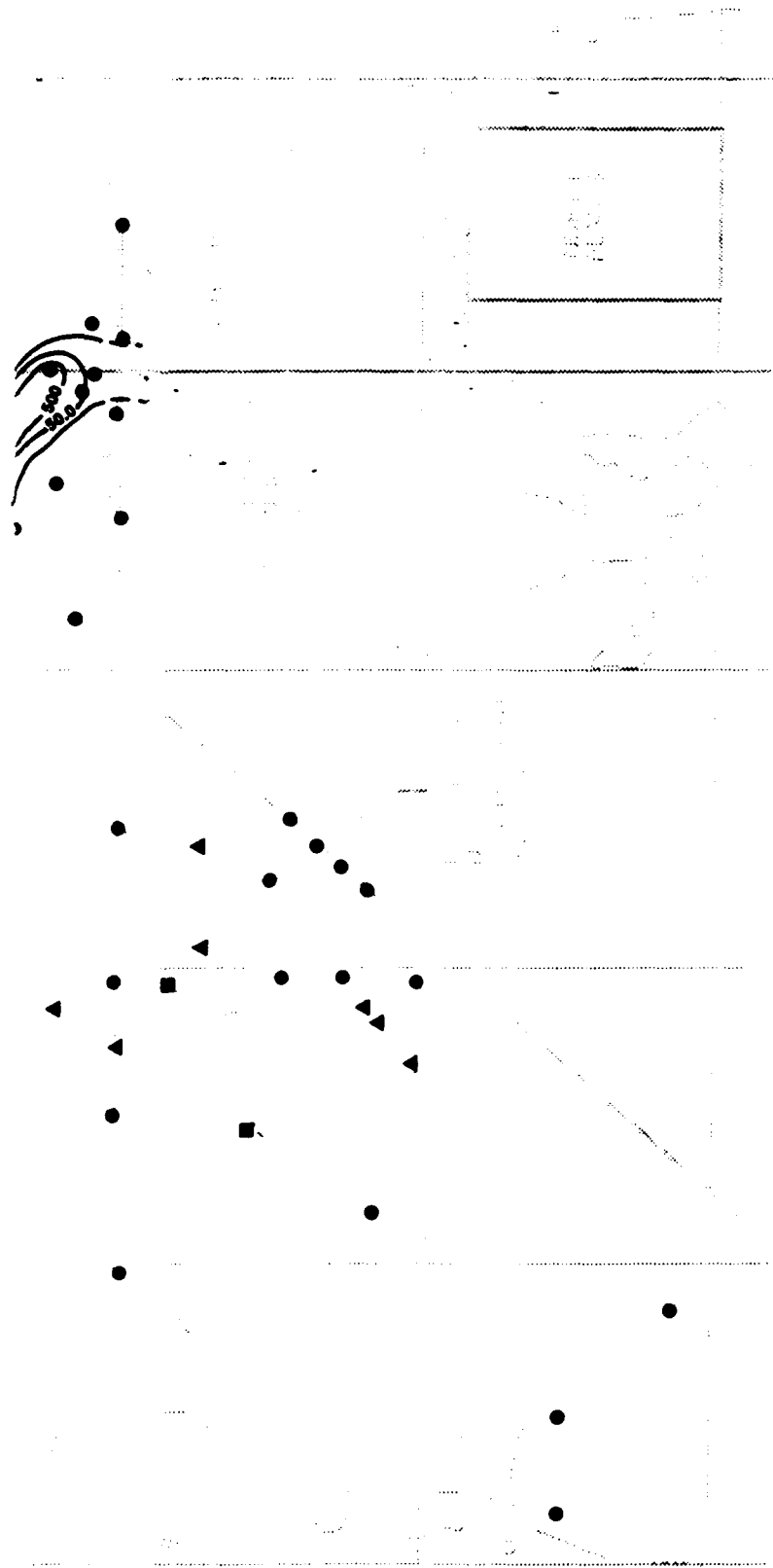
Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.2
DISTRIBUTION OF DIISOPROPYLMETHYL PHOSPHONATE (DIMP) IN THE
OFFPOST UNCONFINED FLOW SYSTEM

①



2



EXPLANATION

Concentrations in micrograms per liter (mg/l)

(---) Isoconcentration Line, Dashed where Inferred

○ Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990)

— Monitoring Well Sampled Under CMP (Fall 1989)

■ Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)

Isoconcentration Value (mg/l)

5.00
50.0
500



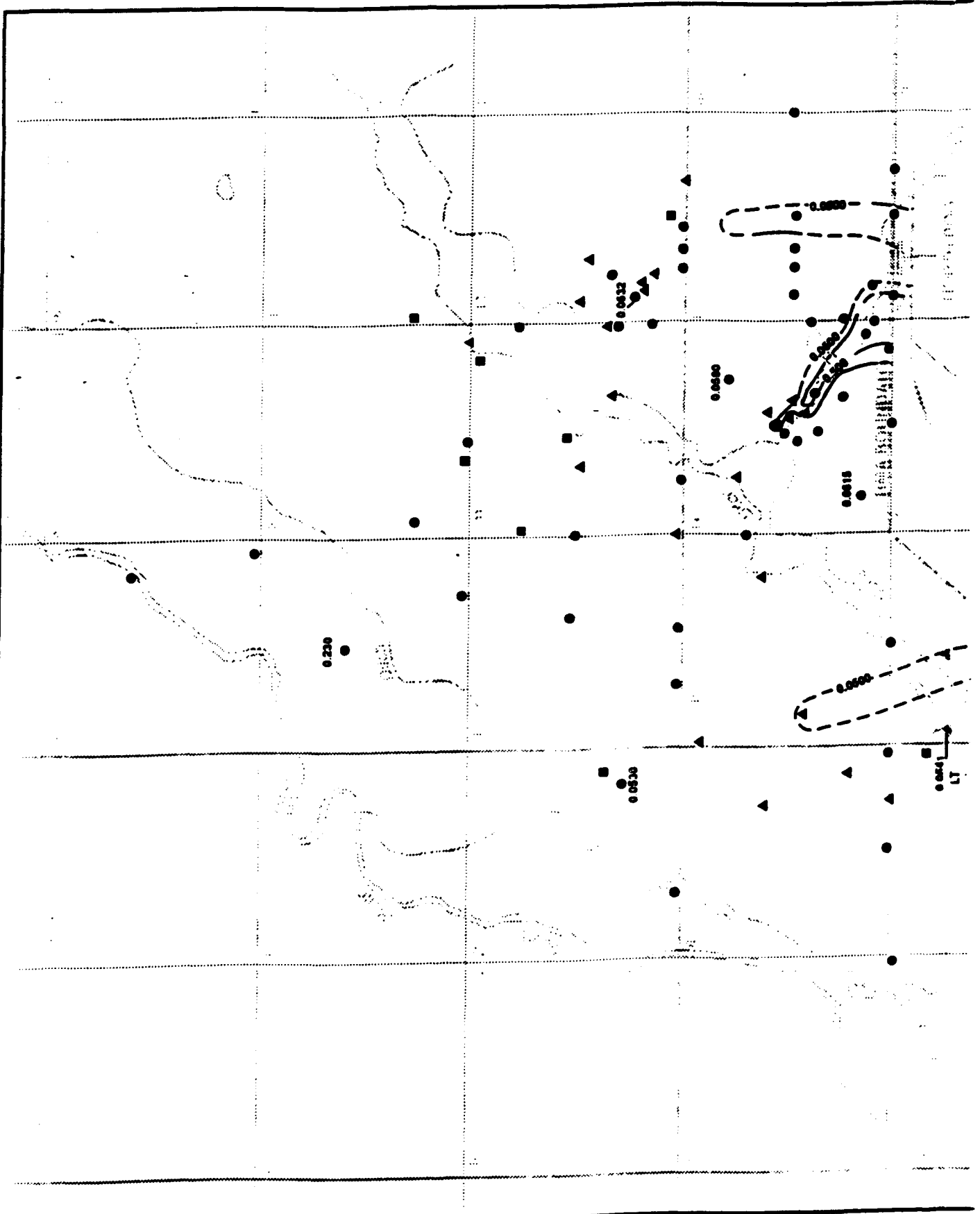
0 1500 3000
Scale in Feet

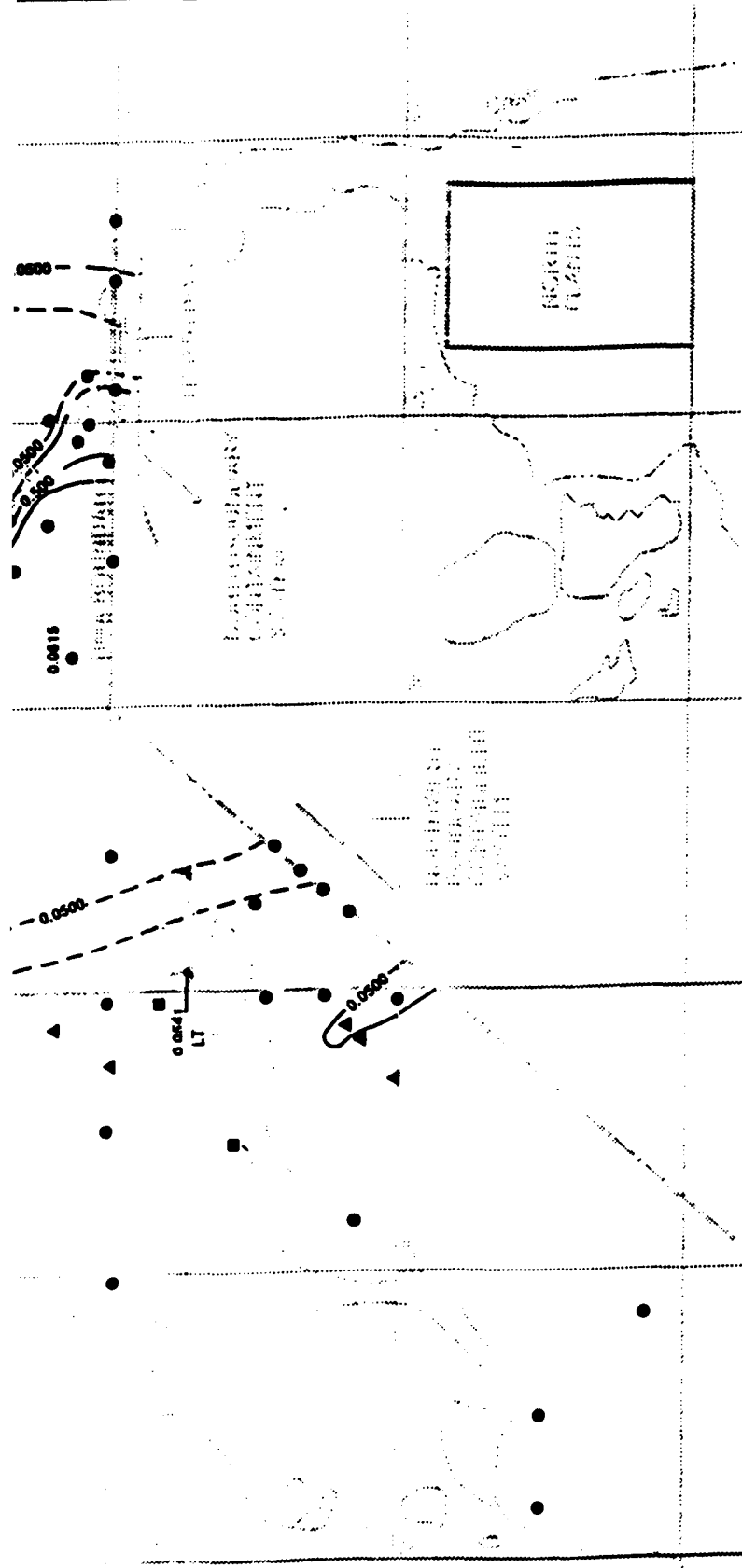
Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.3

DISTRIBUTION OF DICYCLOPENTADIENE (DCPD) IN THE OFFPOST
UNCONFINED FLOW SYSTEM

(1)





EXPLANATION

Concentrations in micrograms per liter ($\mu\text{g/l}$)

Isoconcentration Line, Dashed where Inferred

- 2.65 Isolated Detection in $\mu\text{g/l}$ Two Values Shown if Sampled Twice LT - Indicates Analyte was not Detected Above the Certified Reporting Limit
- LT

Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990)

Monitoring Well Sampled Under CMP (Fall 1989)

Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)

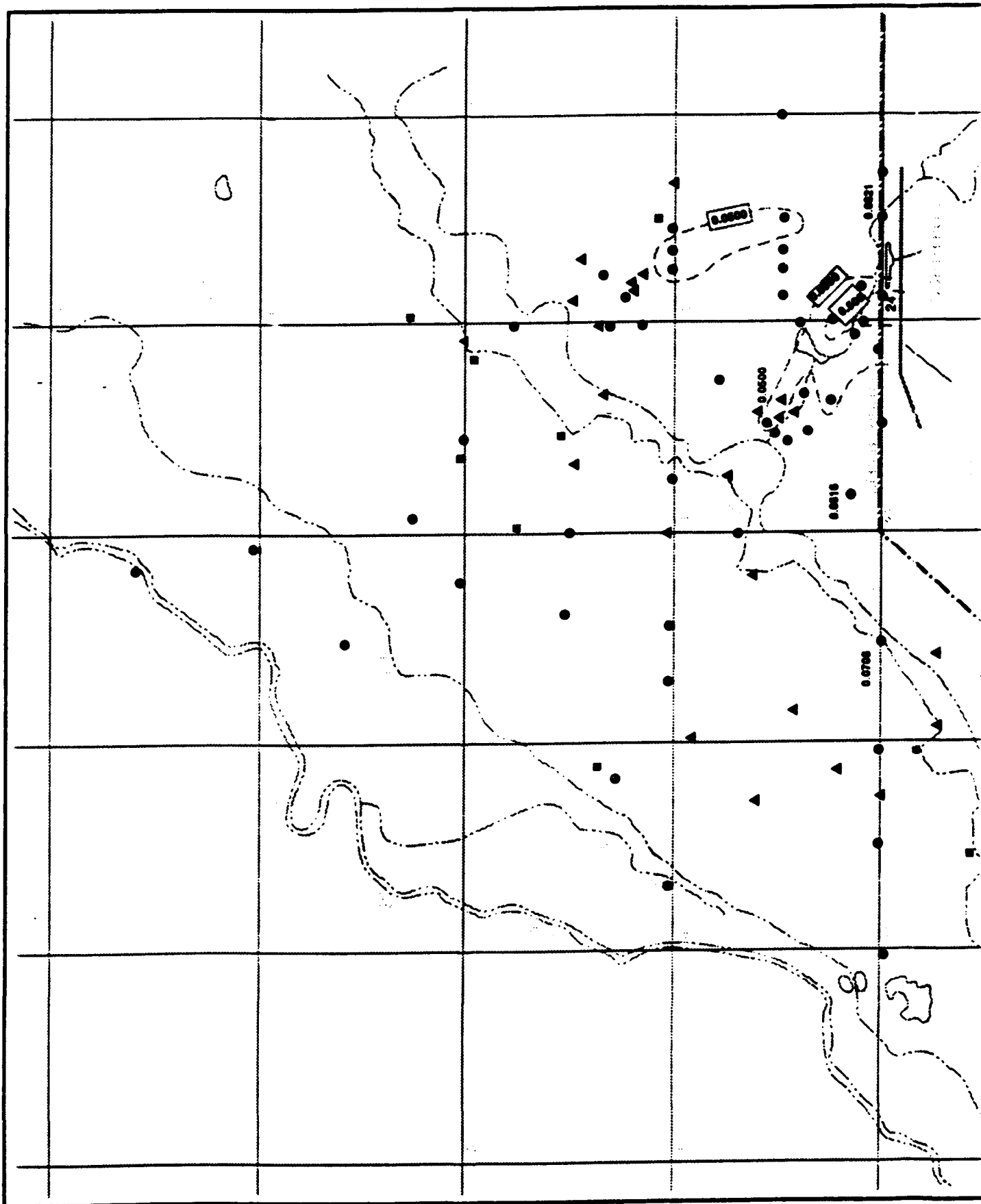
Isoconcentration Value ($\mu\text{g/l}$)

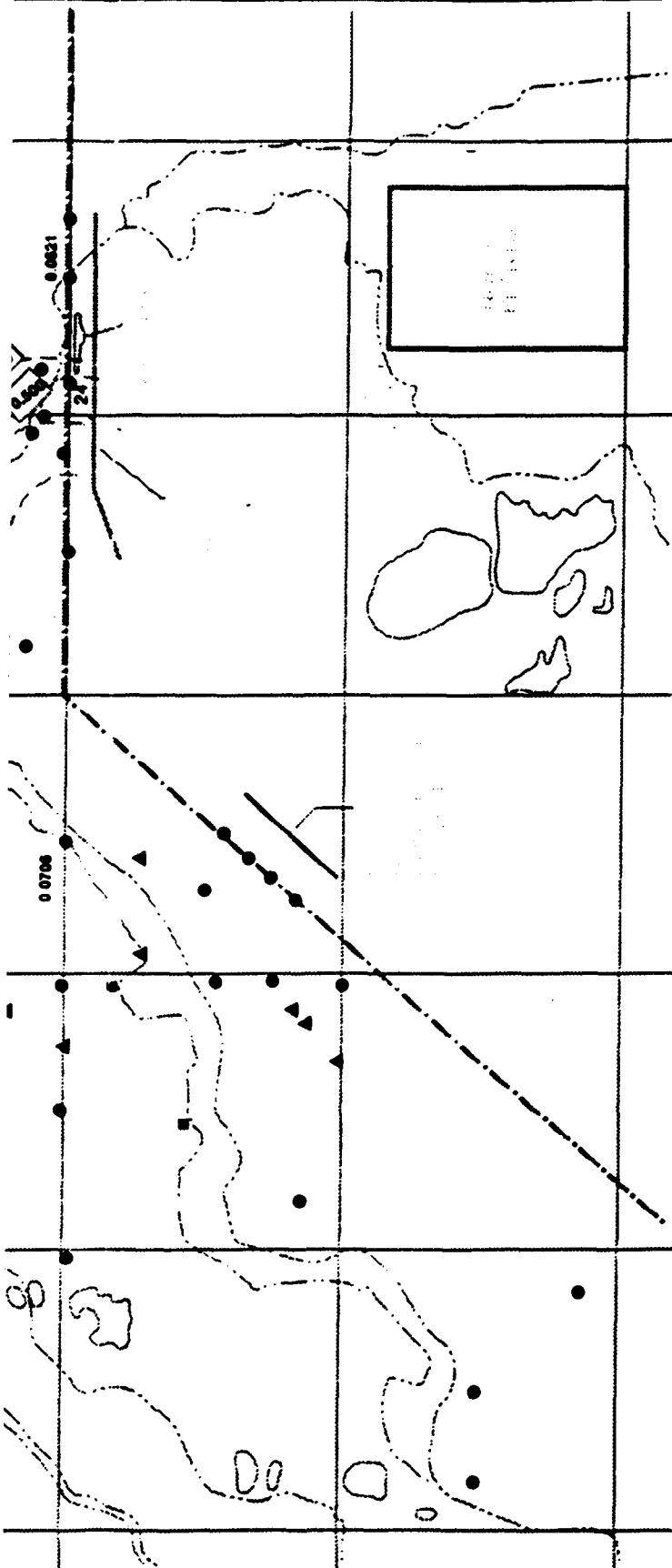
- 0.0500
- 0.500
- 5.00

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.4
DISTRIBUTION OF DIELDRIN IN THE OFFPOST UNCONFINED FLOW
SYSTEM

①





EXPLANATION

Concentrations in micrograms per liter (µg/l)

Isococoncentration Line, Dashed where Inferred

Isolated Detection, in µg/l

- ▲ Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990)
- Monitoring Well Sampled Under CMP (Fall 1988)
- Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)

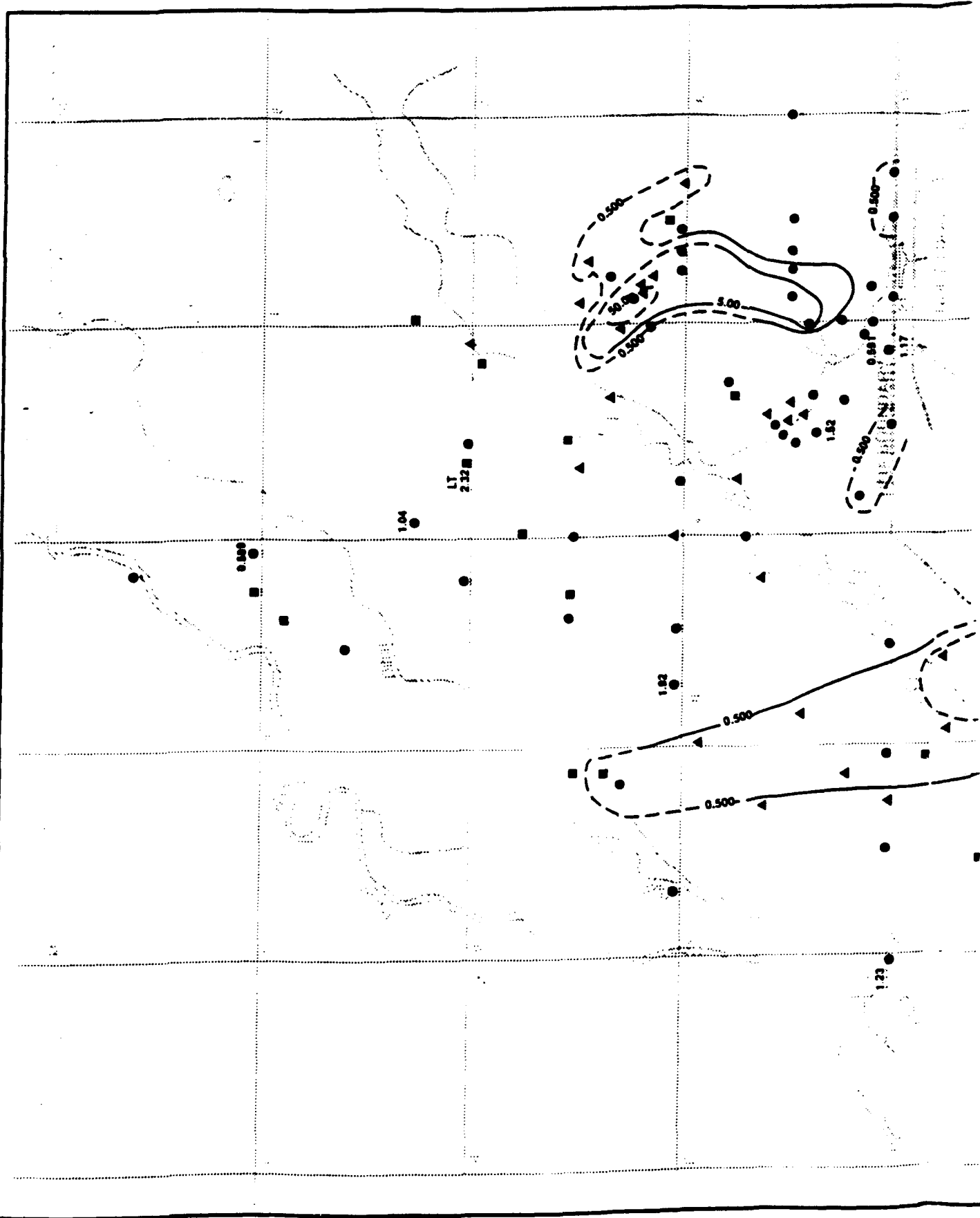
Isococoncentration Value (µg/l)

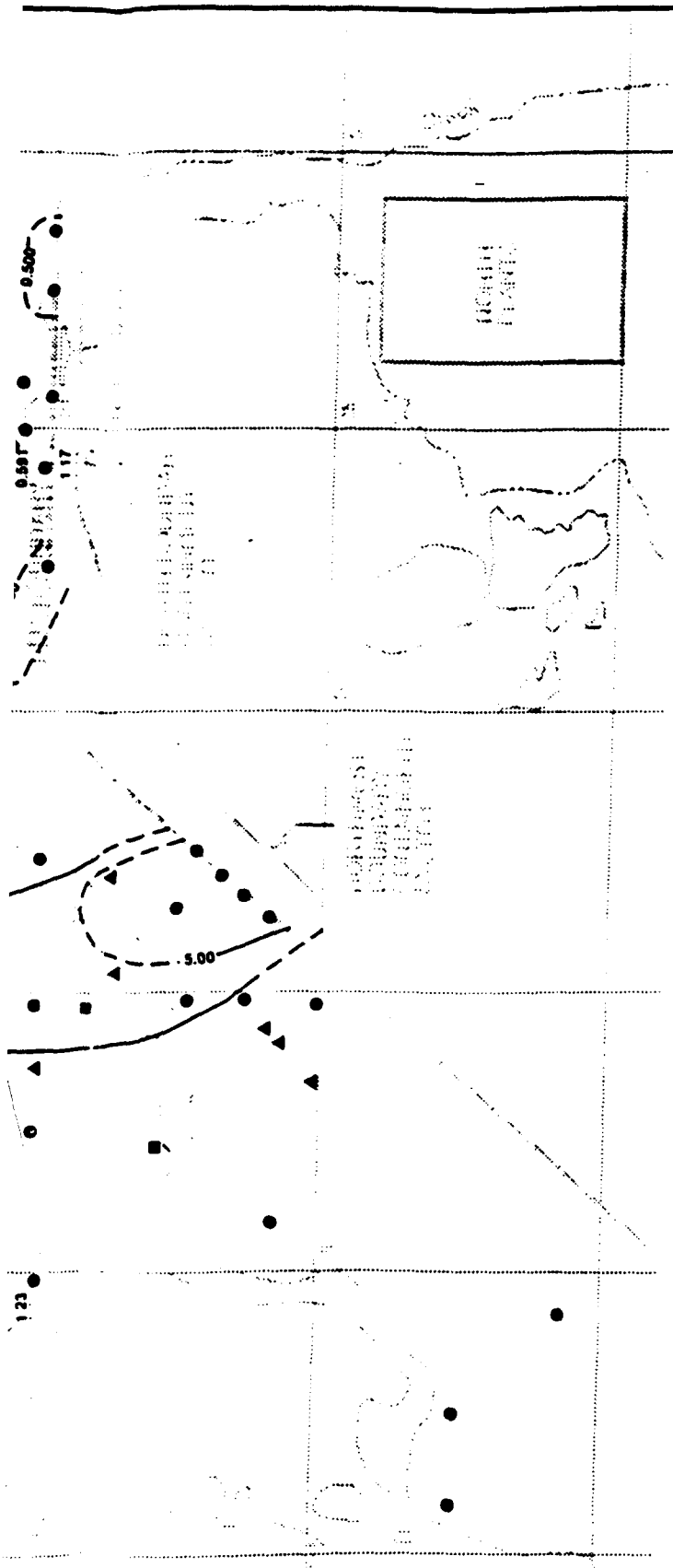
0.0500
0.500

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.5
DISTRIBUTION OF ENDRIN IN THE OFFPOST UNCONFINED
FLOW SYSTEM

①





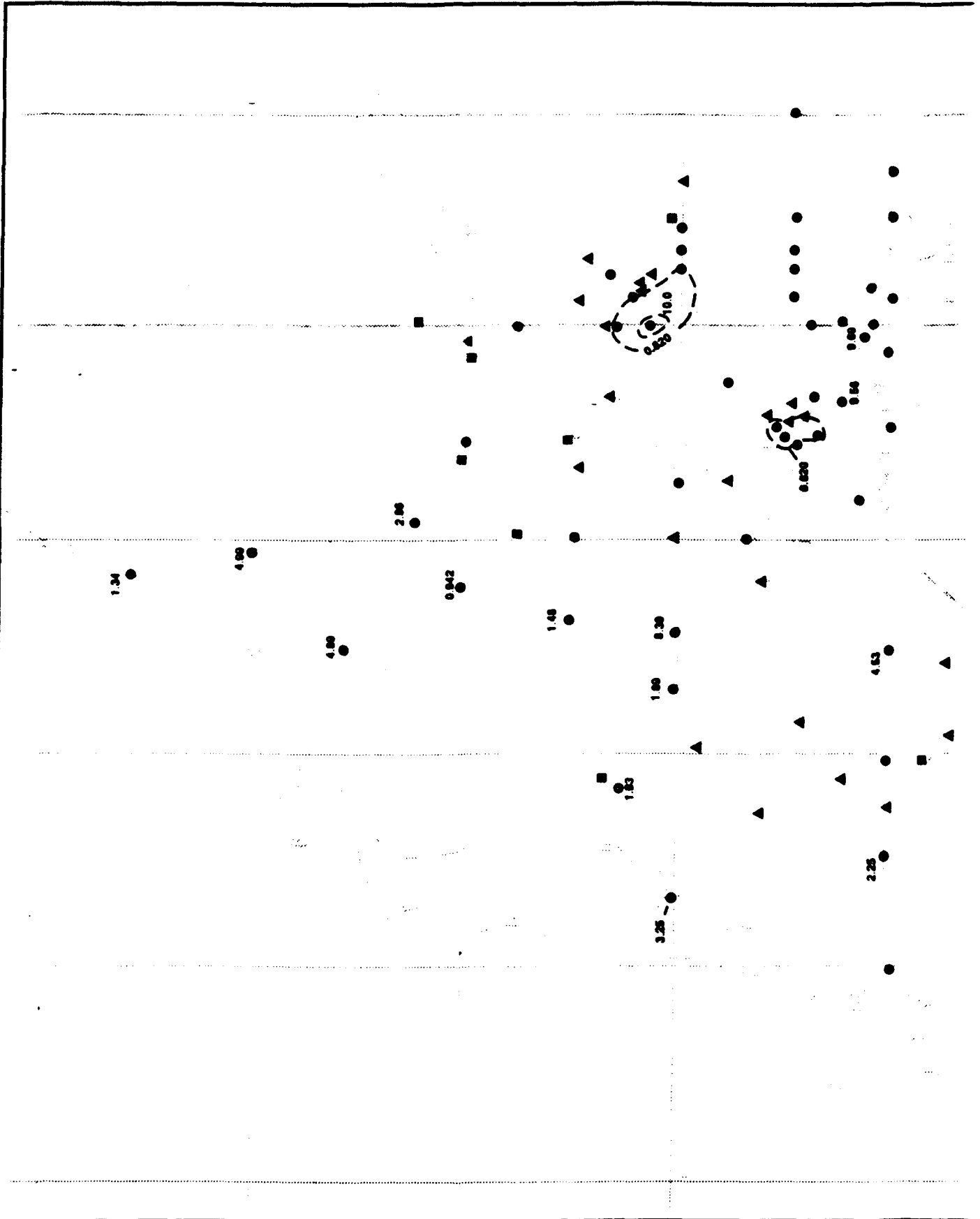
EXPLANATION

- Concentrations in micrograms per liter (µg/l)
- Isocentration Line, Dashed where Inferred
- Isolated Detection, in µg/l. Two Values Shown if Sampled Twice. LT - Indicates Analyte was not Detected Above the Certified Reporting Limit
- Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990)
- February 1991 CMP Data for these Wells were Considered during Construction of Plume Contours
- Monitoring Well Sampled Under CMP (Fall 1989)
- Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)
- Isocentration Value (µg/l)
- 0.500
- 5.00
- 50.0

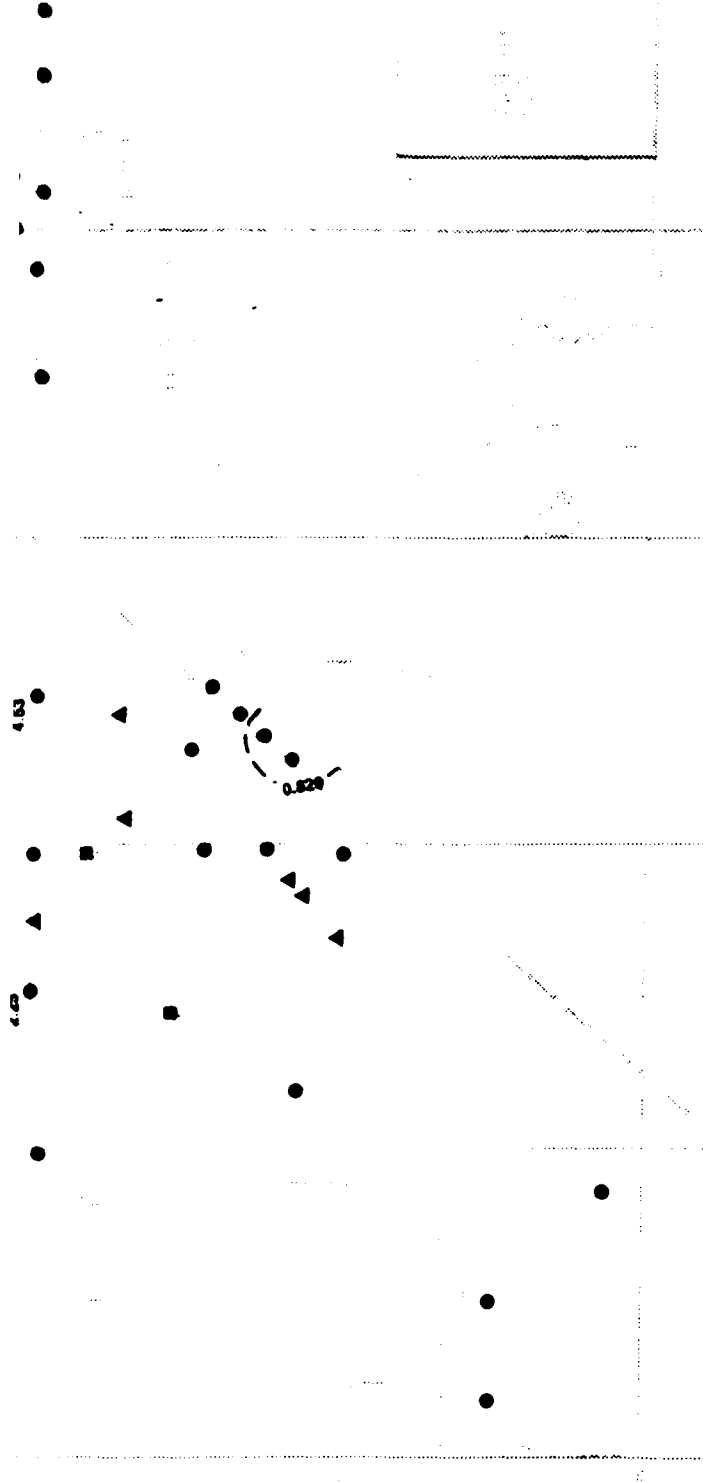
Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.6
DISTRIBUTION OF CHLOROFORM IN THE OFFPOST UNCONFINED FLOW
SYSTEM

①



2



N

0 1500 3000
Scale in Feet

EXPLANATION

Concentrations in micrograms per liter ($\mu\text{g/l}$)

Isoconcentration Line, Dashed where Inferred

Isolated Detection, in $\mu\text{g/l}$

Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990).
February 1991 CMP Data for these Wells were Considered
during Construction of Plume Contours.

Monitoring Well Sampled Under CMP (Fall 1989)

Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)

Isoconcentration Value ($\mu\text{g/l}$)

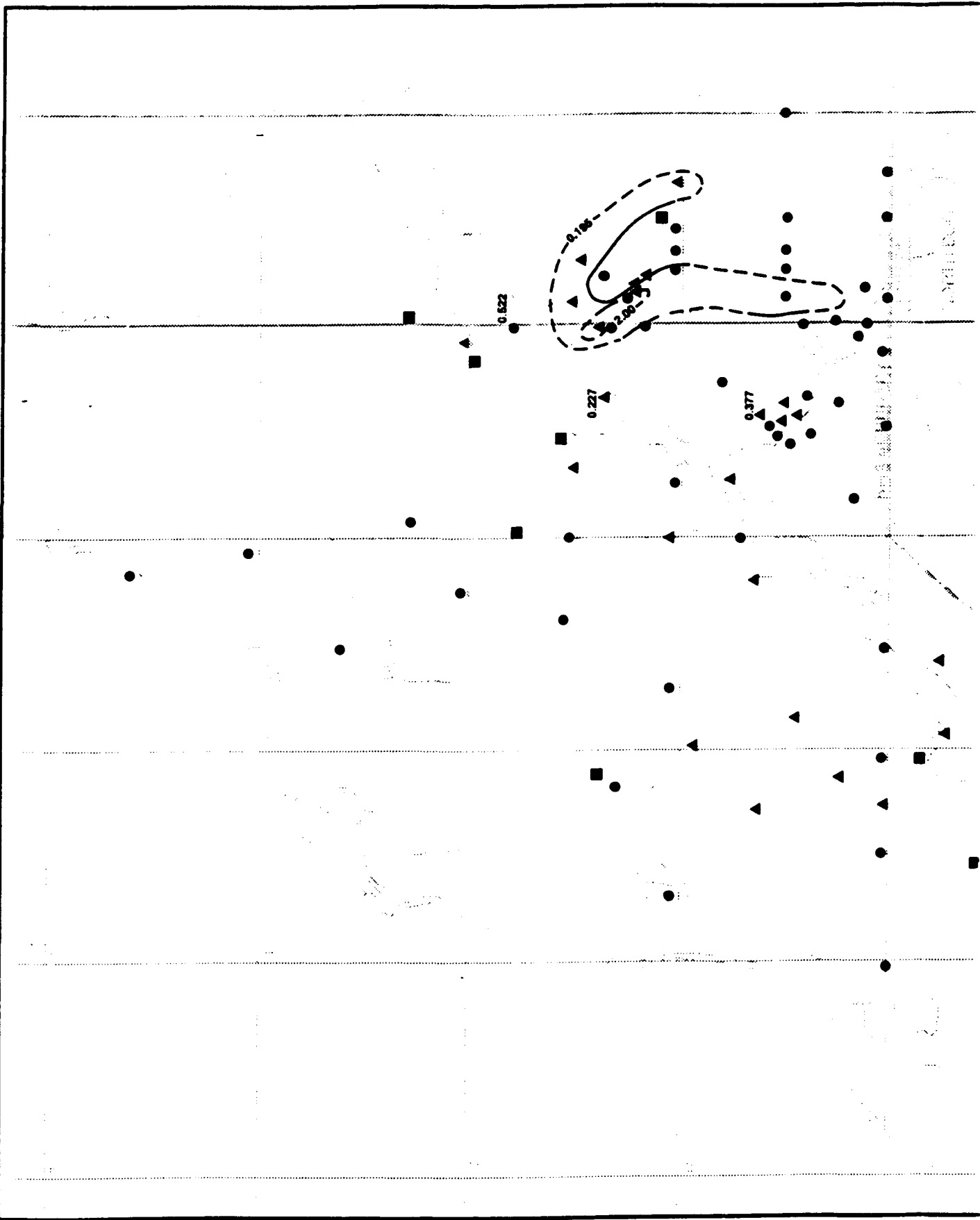
0.820
10.0

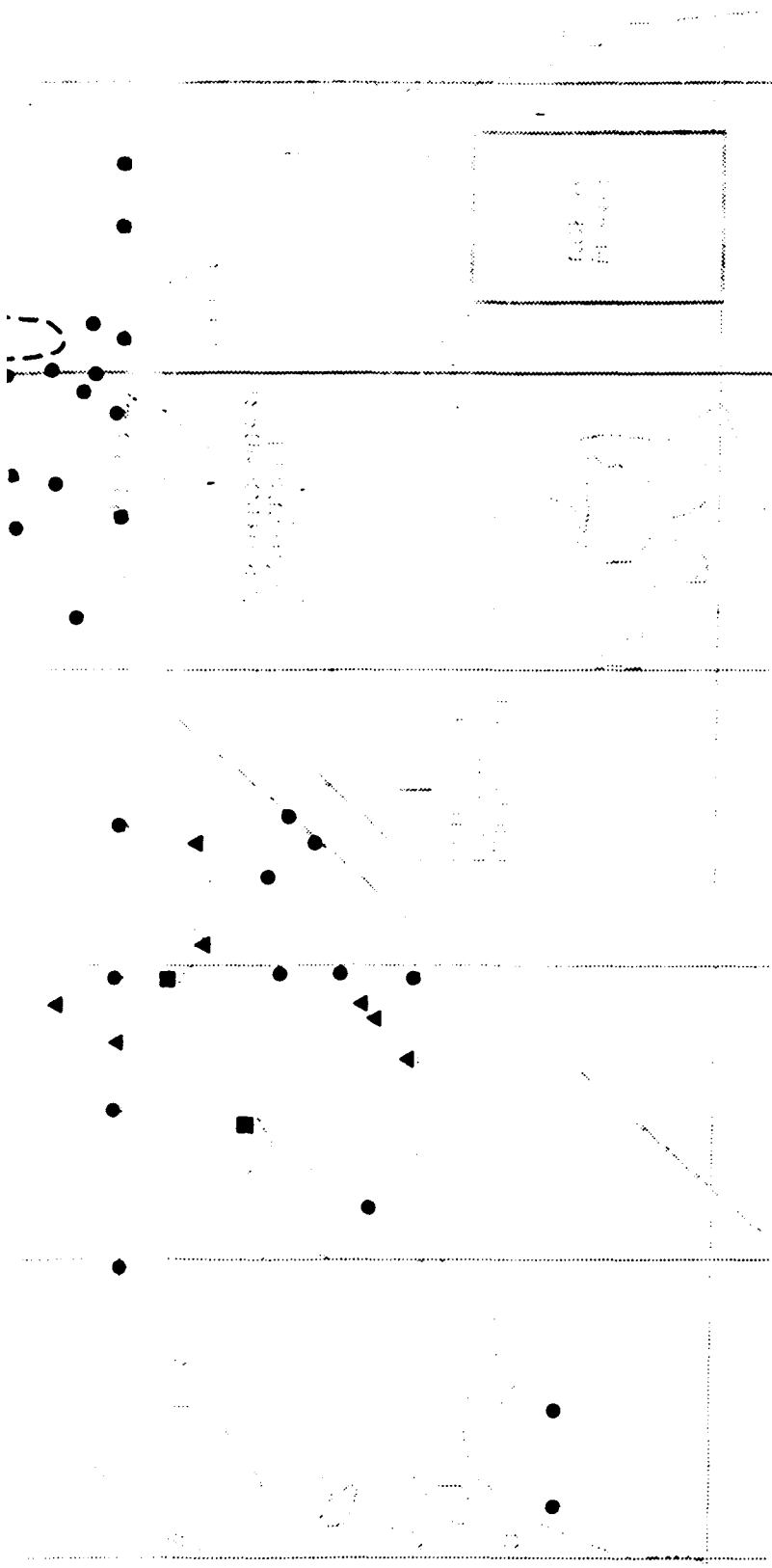
Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.7

DISTRIBUTION OF CHLOROBENZENE IN THE OFFPOST UNCONFINED FLOW SYSTEM

1





EXPLANATION

Concentrations in micrograms per liter (µg/l)

Isoconcentration Line, Dashed where Inferred

Isolated Detection, in µg/l

Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990), February 1991 CMP Data for these Wells were Considered during Construction of Plume Contours.

Monitoring Well Sampled Under CMP (Fall 1989)

Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)

Isoconcentration Value (µg/l)

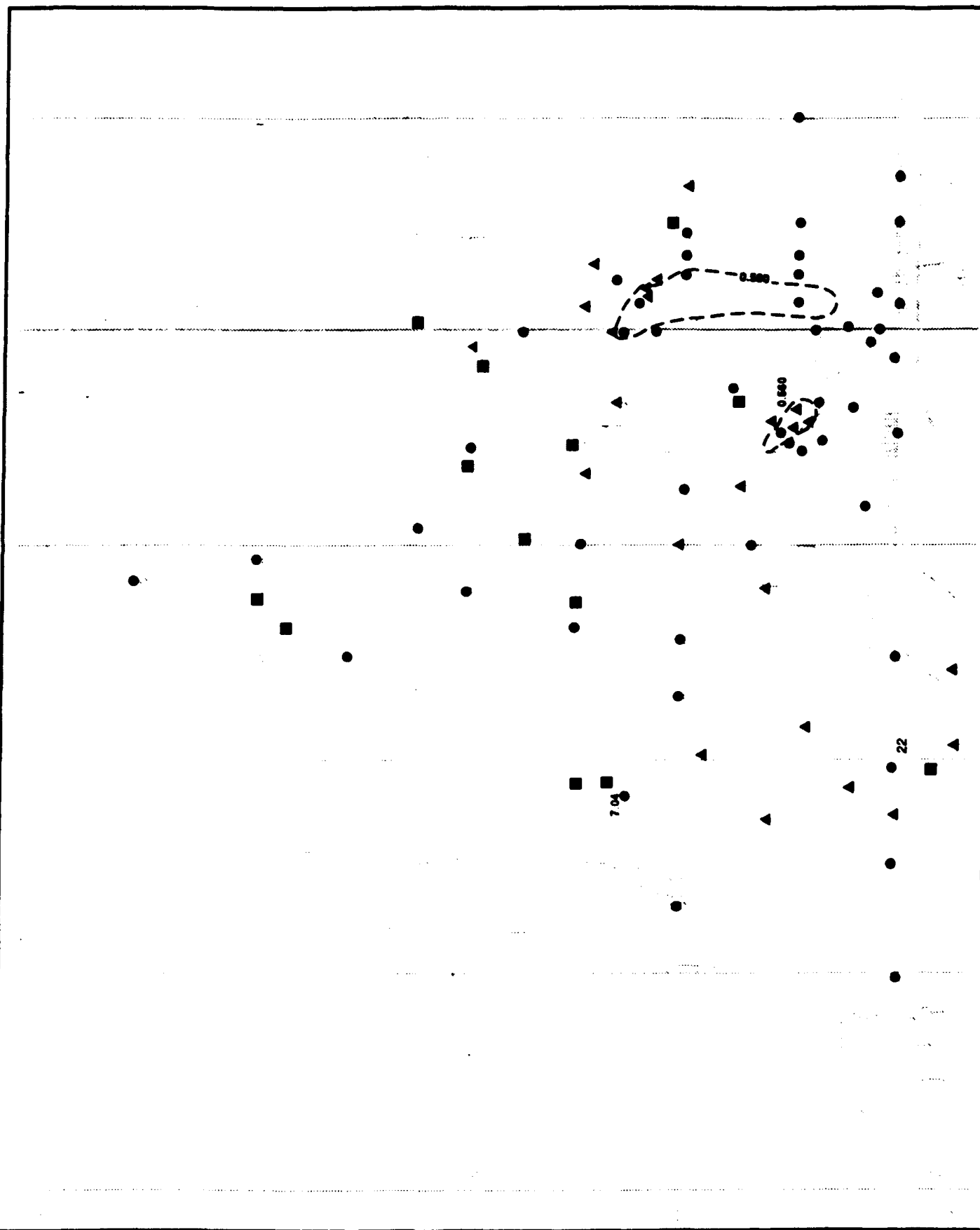
0.195
2.00

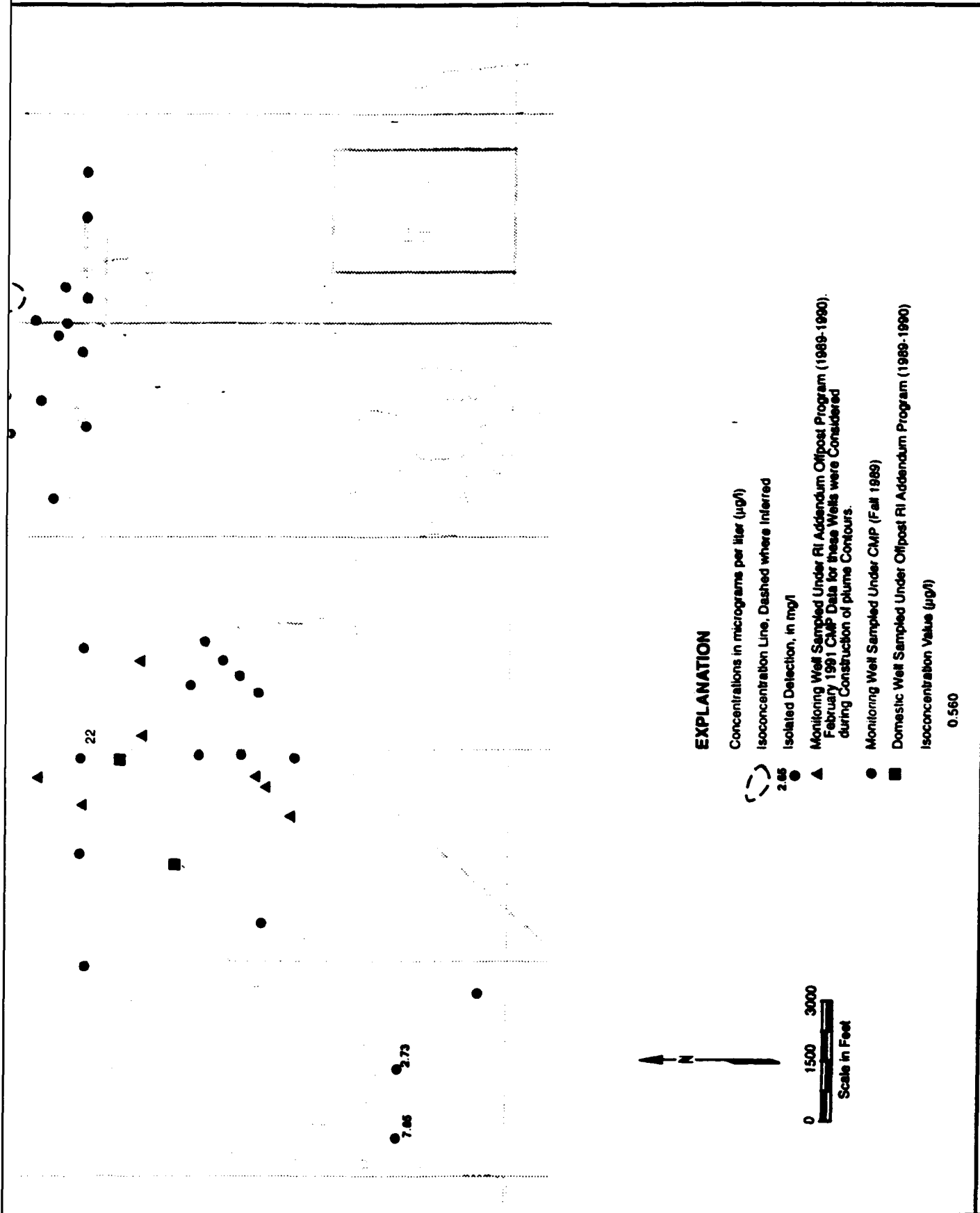
Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.8

DISTRIBUTION OF DIBROMOCHLOROPROPANE (DBCP) IN THE OFFPOST UNCONFINED FLOW SYSTEM

①

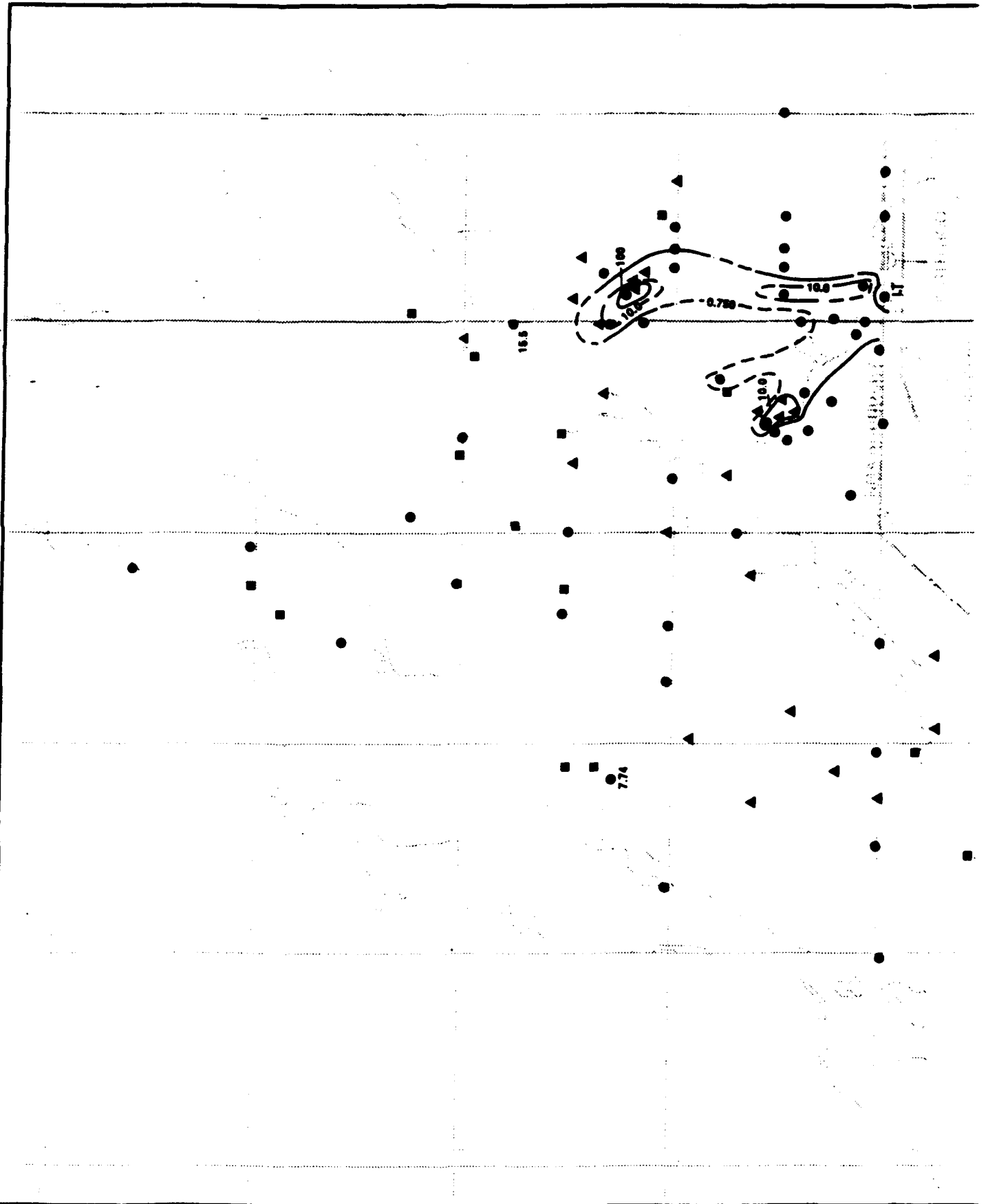


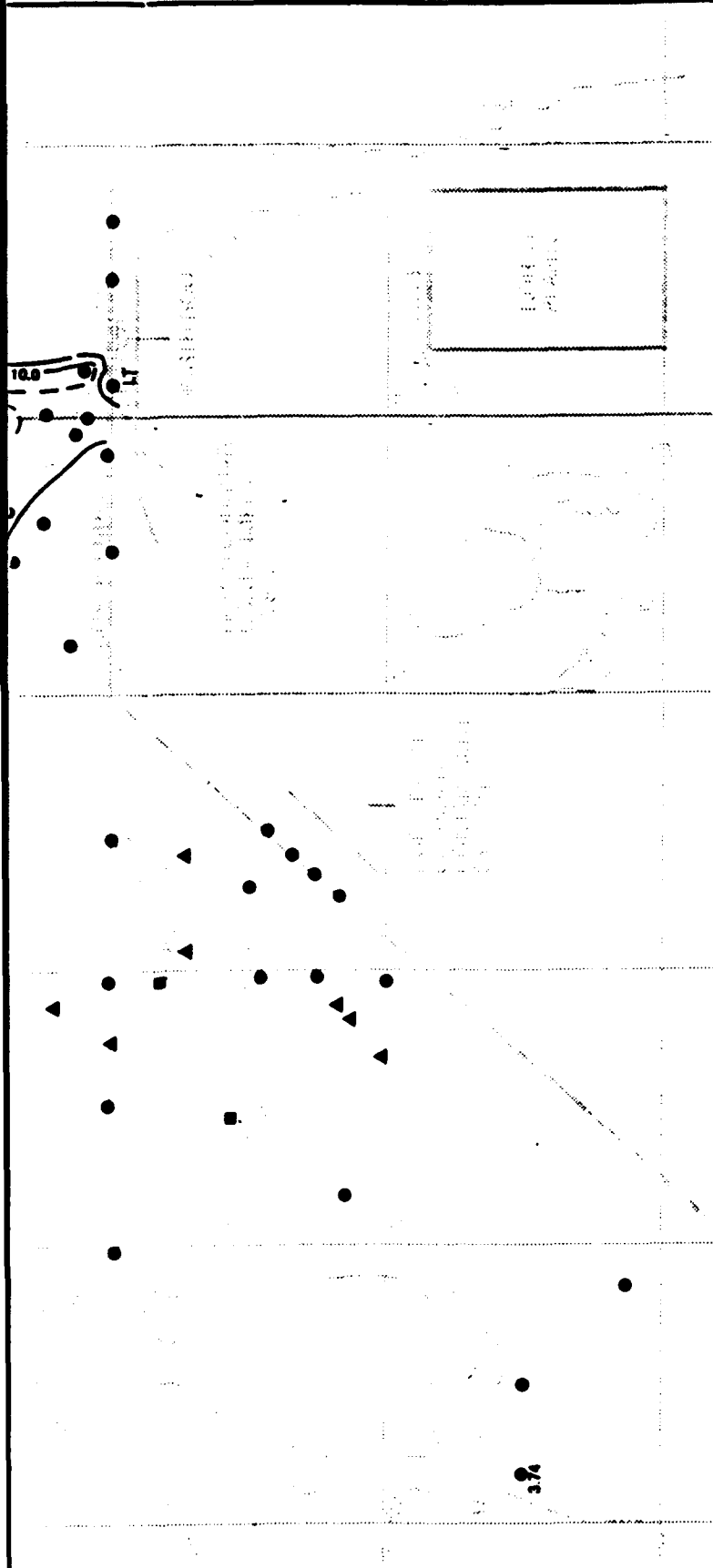


Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.9
DISTRIBUTION OF TRICHLOROETHENE (TRCLE) IN THE OFFPOST
UNCONFINED FLOW SYSTEM

①





EXPLANATION

Concentrations in micrograms per liter (µg/l)

Isocentration Line, Dashed where Inferred

Isolated Detection, in µg/l

▲ Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990). February 1991 CMP Delta for these Wells were Considered during Construction of Plume Contours.

● Monitoring Well Sampled Under CMP (Fall 1989)

■ Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)

Isocentration Value (µg/l)

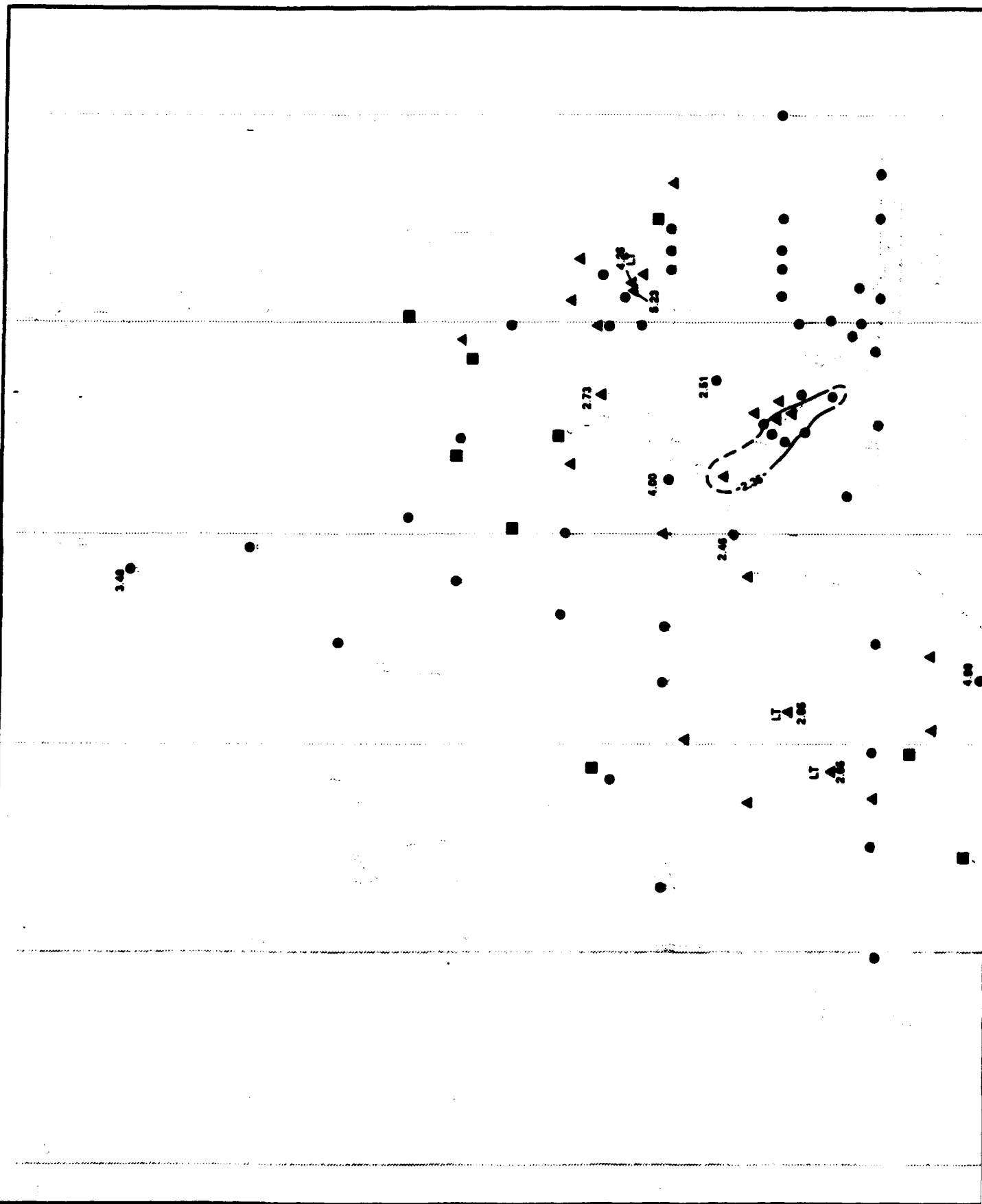
0.750
10.0
100

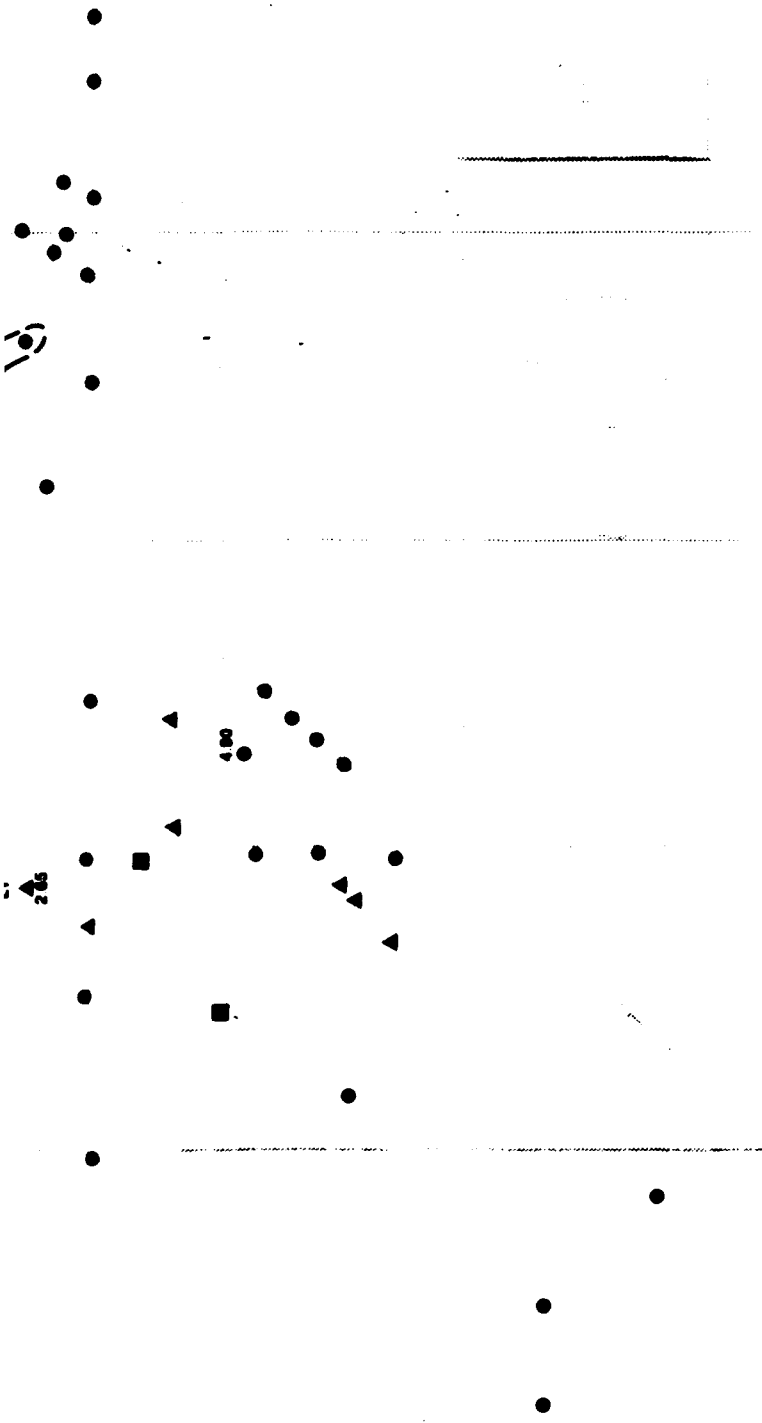
Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.10

DISTRIBUTION OF TETRACHLOROETHENE (TCLEE) IN THE OFFPOST UNCONFINED FLOW SYSTEM

(1)





EXPLANATION

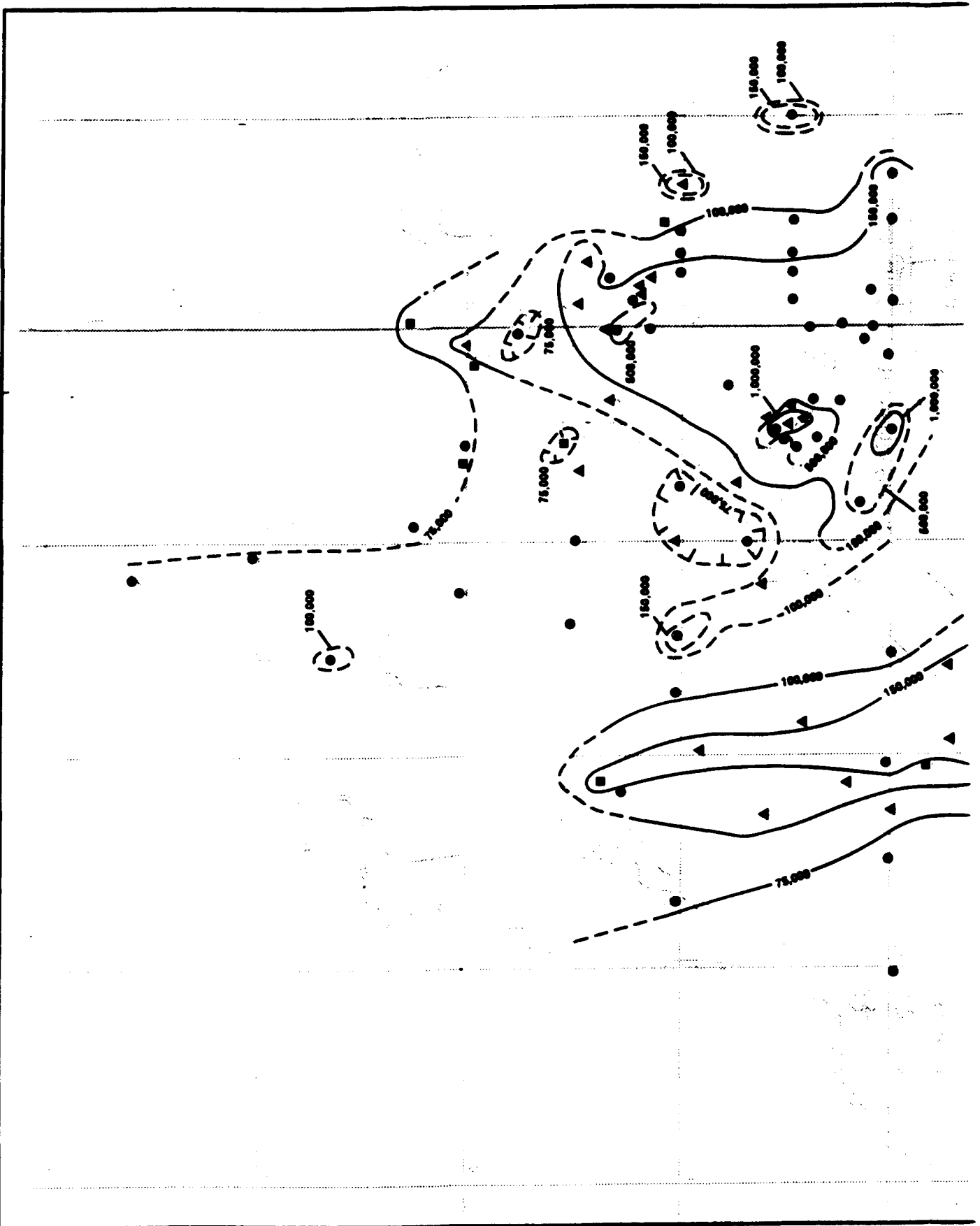
- Concentrations in micrograms per liter (µg/l)
- Isococoncentration Line, Dashed where Inferred
- Isolated Detection, in µg/l. Two Values Shown if Sampled Twice. LT - Indicates Analyte was not Detected Above the Certified Reporting Limit.
- ▲ Monitoring Well Sampled Under Offpost RI Addendum Program (1989-1990)
- Monitoring Well Sampled Under CMP (Fall 1989)
- Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)
- Isococoncentration Value (µg/l)

2.35

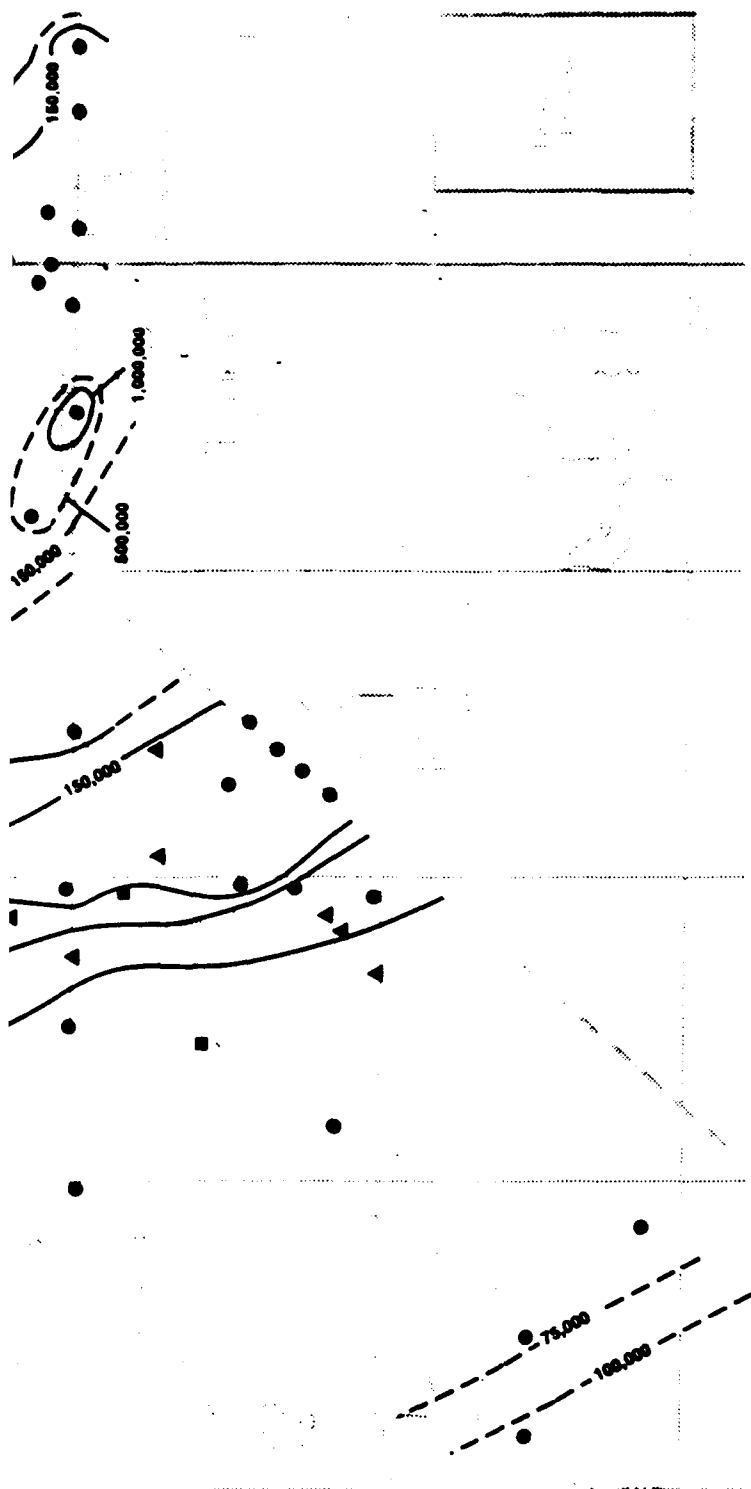
Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.11
DISTRIBUTION OF ARSENIC IN THE OFFPOST UNCONFINED FLOW
SYSTEM

①



2



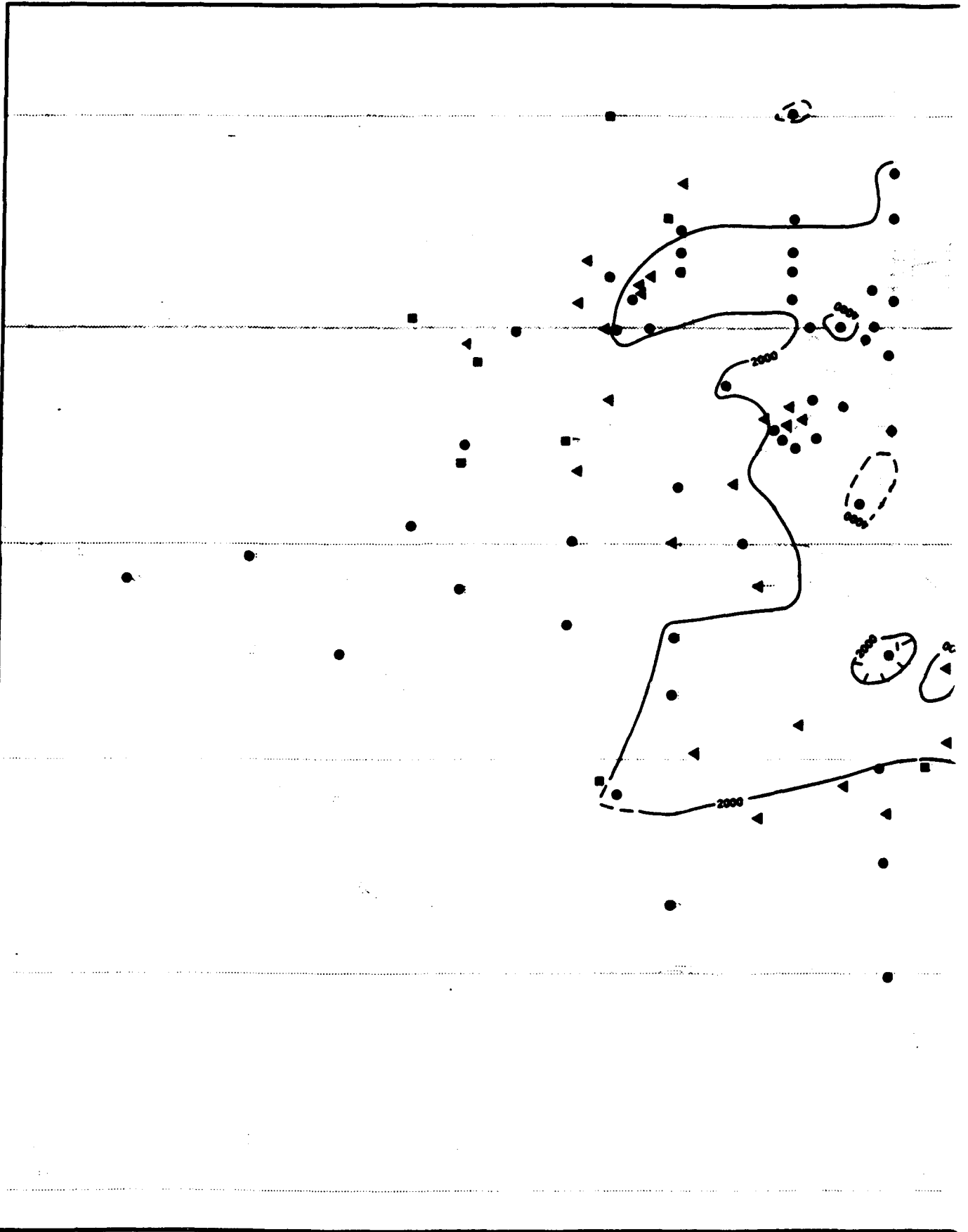
EXPLANATION

- Concentrations in micrograms per liter (µg/l)
- Isocentration Line, Dashed where Inferred
- Monitoring Well Sampled Under Oilpost RI Addendum Program (1989-1990)
- Monitoring Well Sampled Under CAMP (Fall 1989)
- Domestic Well Sampled Under Oilpost RI Addendum Program (1989-1990)
- Isocentration Value (µg/l)
- 75,000
150,000
500,000
1,000,000

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.12
DISTRIBUTION OF CHLORIDE IN THE OFFPOST UNCONFINED FLOW
SYSTEM

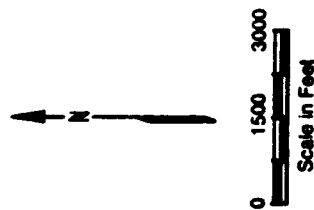
①





EXPLANATION

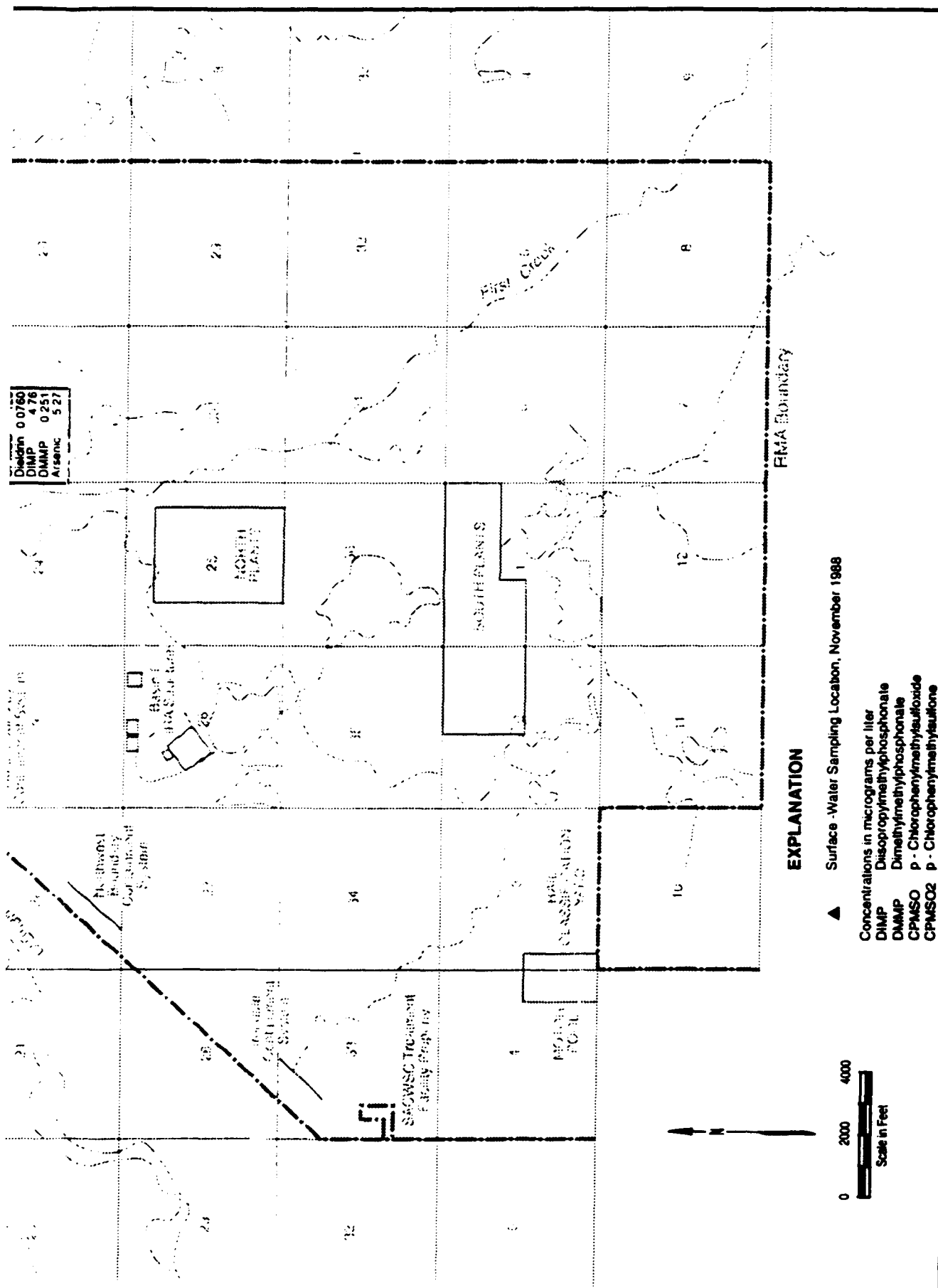
- Concentration in micrograms per liter ($\mu\text{g/l}$)
- Isoconcentration Line, Dashed where inferred
- Isolated Detection or Concentration Less Than Lowest Isoconcentration Value, in $\mu\text{g/l}$
- Monitoring Well Sampled Under Offpost RI Addendum Program (IRIA-A and RI Addendum, 1989-1990)
- Monitoring Well Sampled Under CMP (Fall 1989)
- Domestic Well Sampled Under Offpost RI Addendum Program (1989-1990)
- Isoconcentration Value ($\mu\text{g/l}$)
- 2000
- 4000



Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

Figure 3.13
DISTRIBUTION OF FLUORIDE IN THE OFFPOST UNCONFINED FLOW
SYSTEM





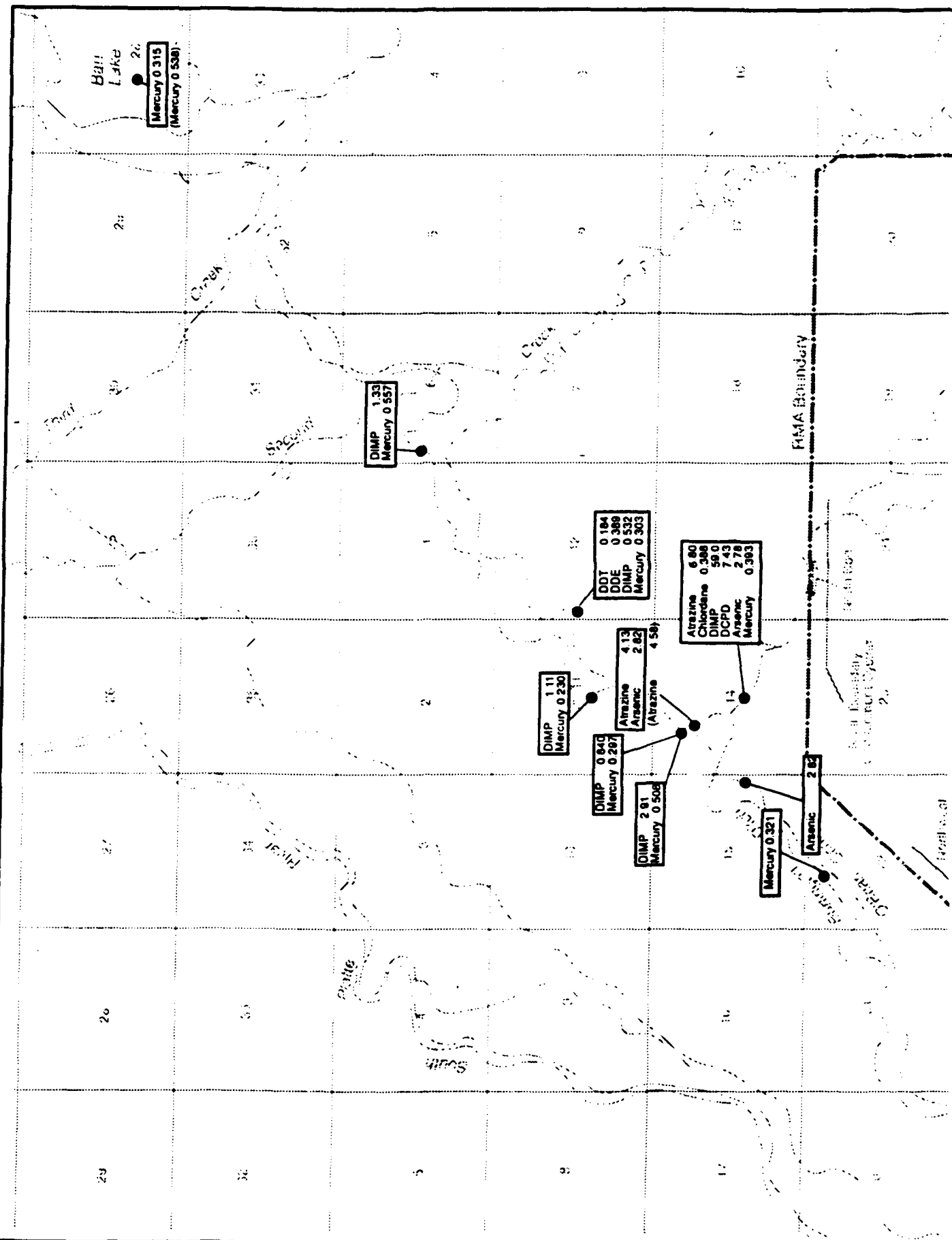
EXPLANATION

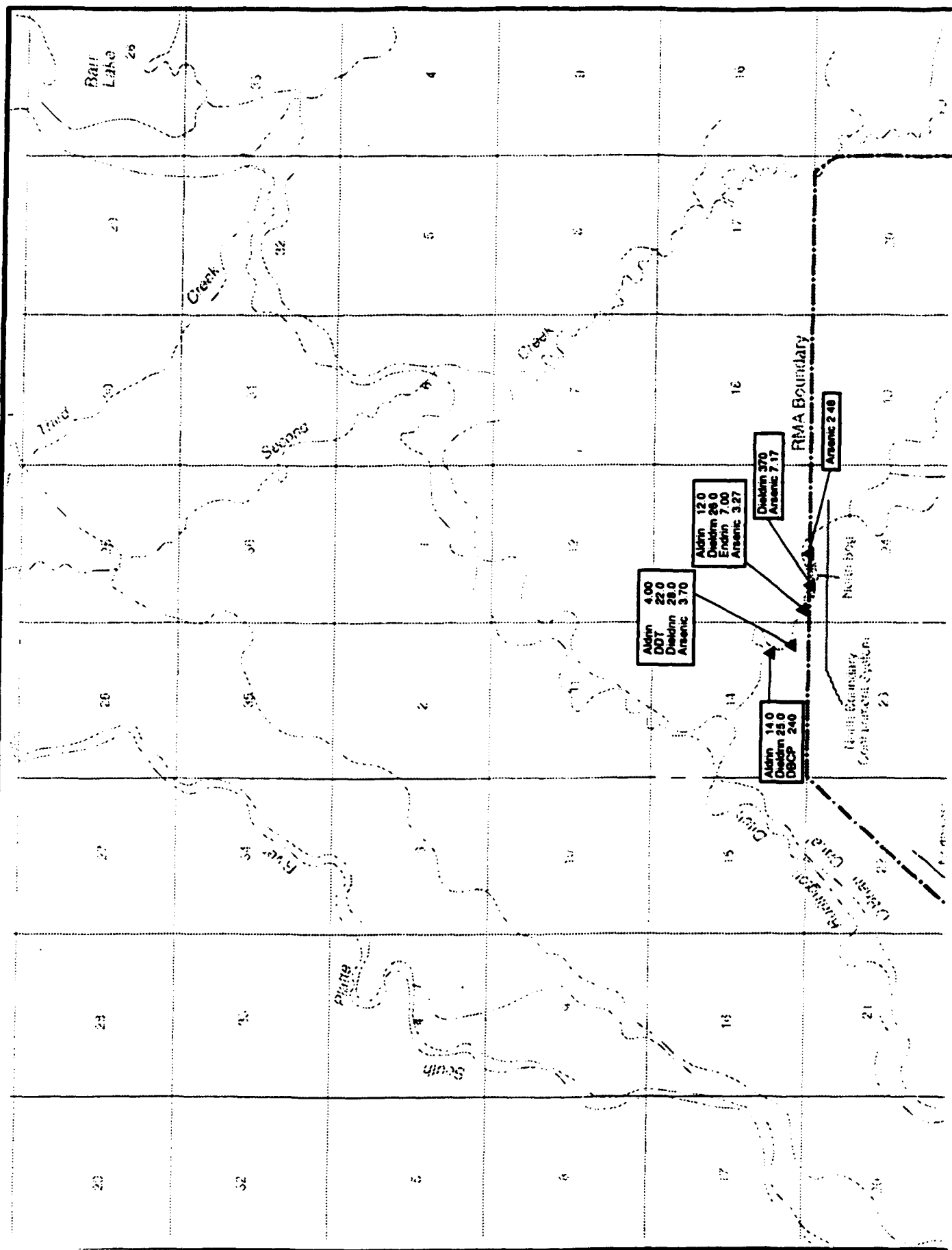
▲ Surface Water Sampling Location, November 1988

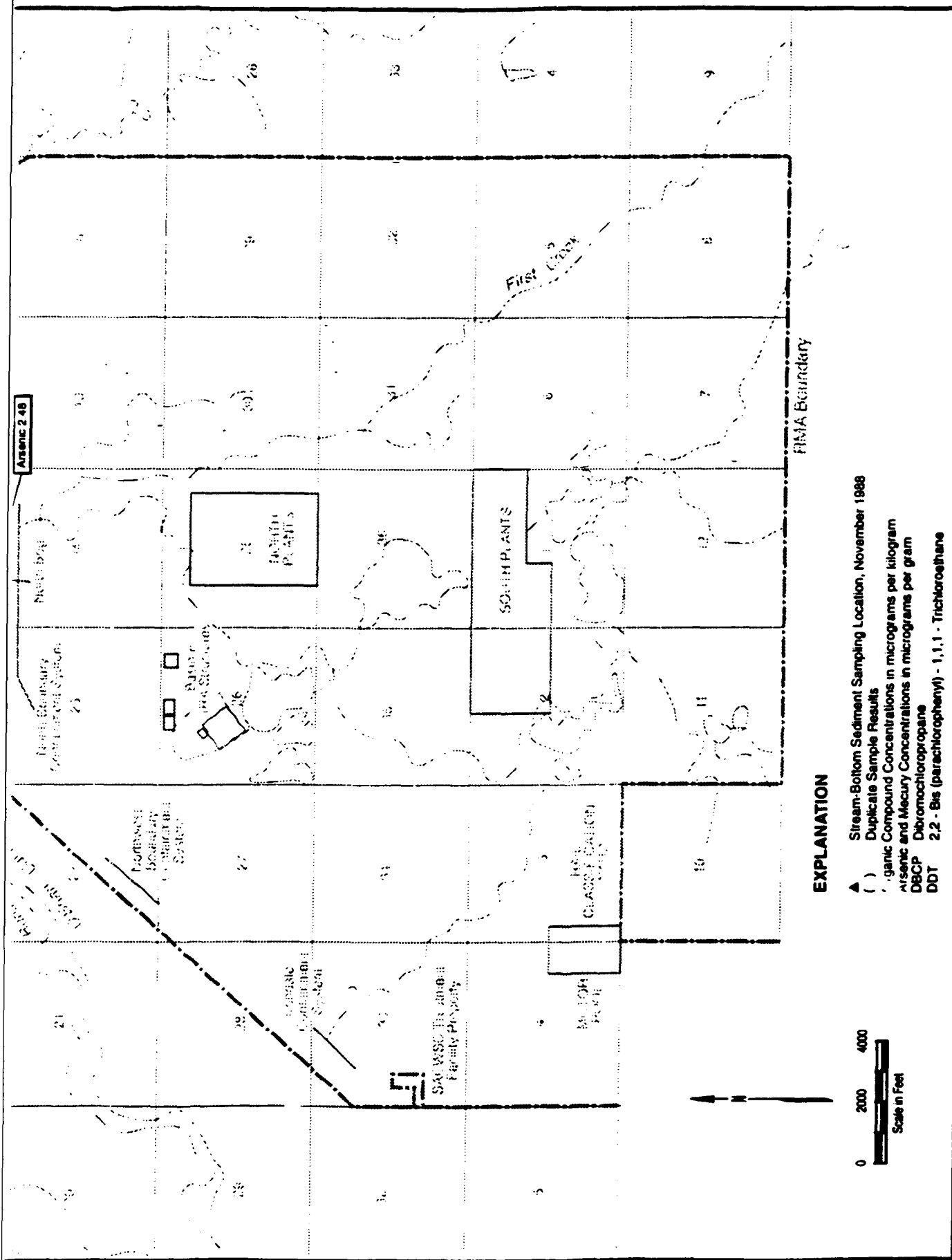
Concentrations in micrograms per liter
DIMP Diisopropylmethylphosphonate
DMMP Dimethylmethylphosphonate
CPMSO p - Chlorophenylmethylsulfide
CPMSO2 p - Chlorophenylmethylsulfone

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

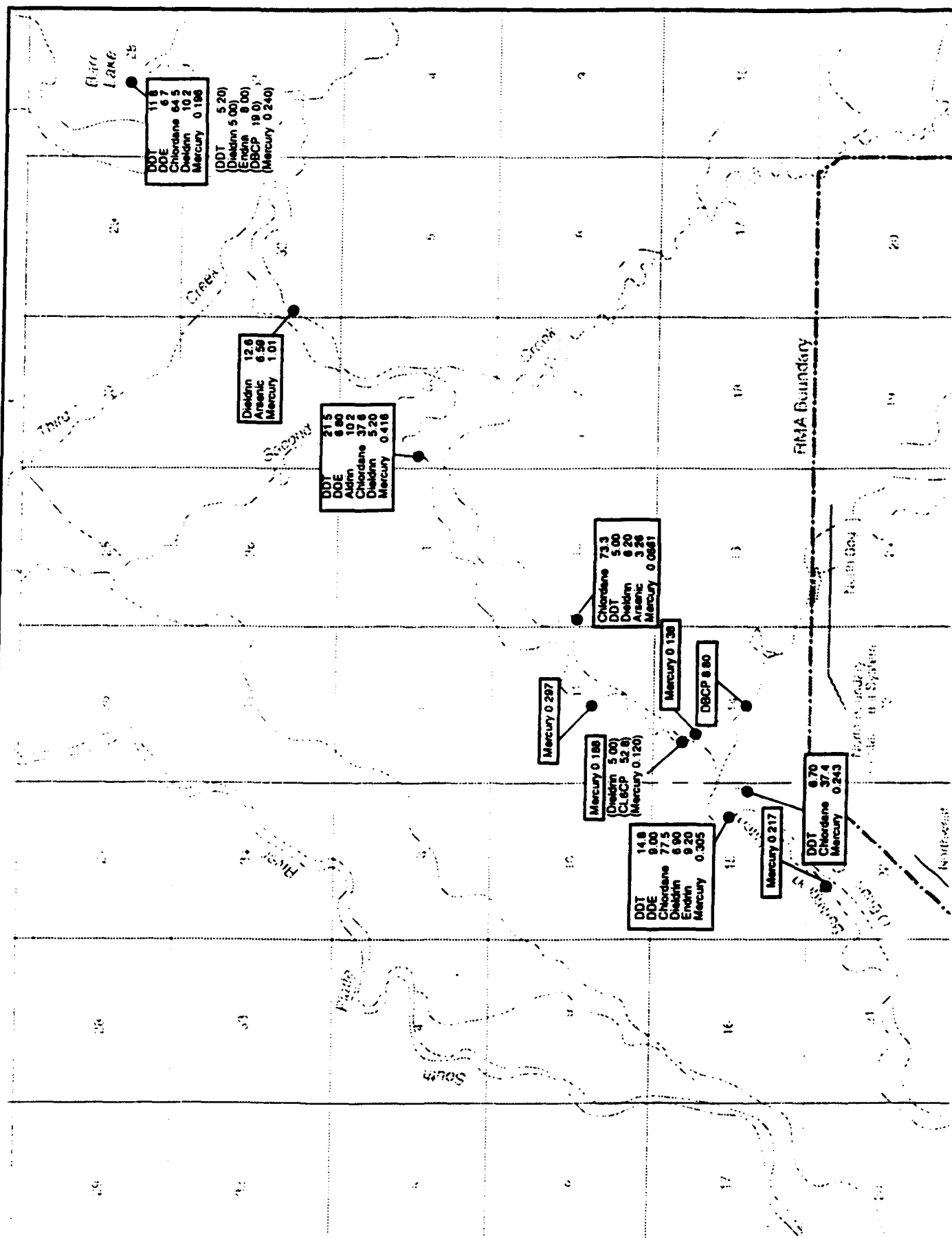
Figure 4.1
DISTRIBUTION OF ORGANIC COMPOUNDS, ARSENIC, AND MERCURY
DETECTED IN OFFPOST OPERABLE UNIT SURFACE WATER, NOVEMBER
1988







Prepared for:
**Program Manager for
 Rocky Mountain Arsenal**
 Commerce City, Colorado



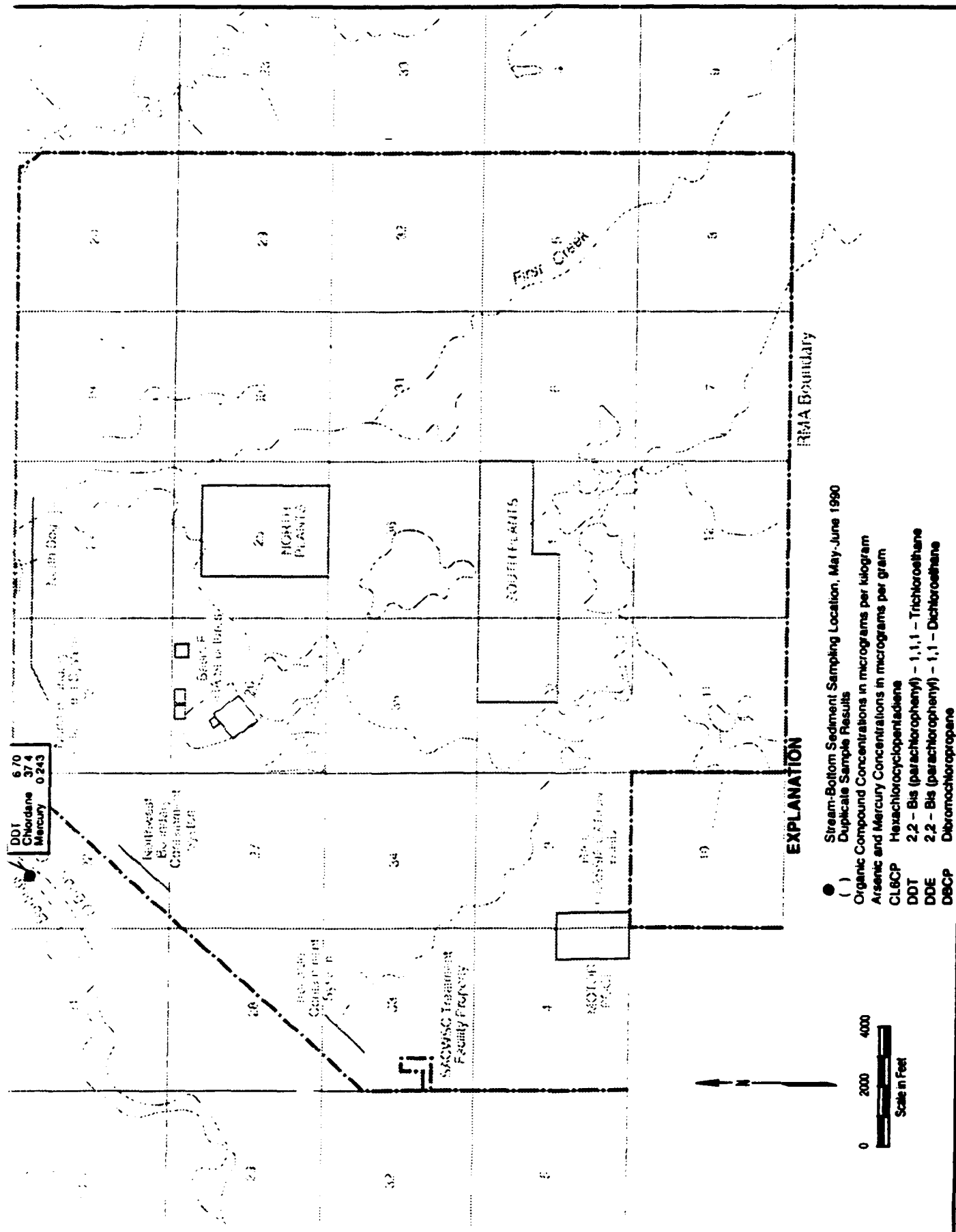


Figure 5.2
DISTRIBUTION OF ORGANIC COMPOUNDS, ARSENIC, AND MERCURY
DETECTED IN OFFPOST OPERABLE UNIT STREAM-BOTTOM SEDIMENT,
MAY-JUNE 1990

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

2

EXPLANATION

- o Surficial Soil Sampling Location, February 1989
- () Duplicate Sample
- * CDH Surficial Soil Sampling Location, February 1989; Data are Accurate to Two Significant Figures.

13 Section Number

CDH Colorado Department of Health

HLA Harding Lawson Associates

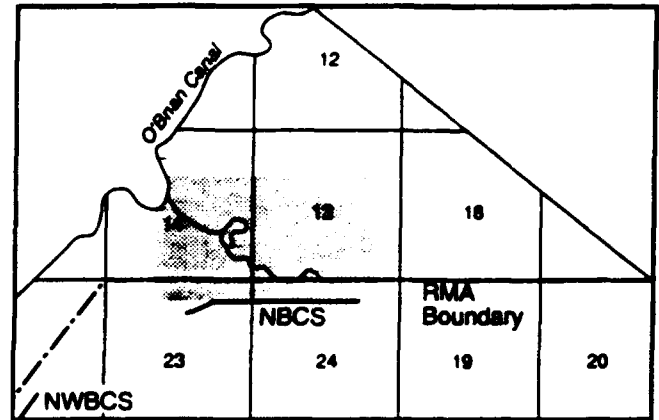
☆☆ Indicates CDH Results for Samples Collocated with HLA Samples

DDT 2,2 - Bis (parachlorophenyl) - 1,1,1 - Trichloroethane

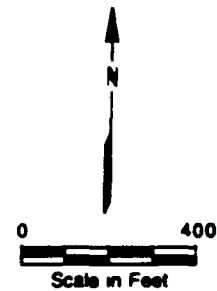
DDE 2,2 - Bis (parachlorophenyl) - 1,1 - Dichloroethane

Notes: Organochloride pesticide concentrations in micrograms per kilogram

Arsenic and Mercury concentrations in micrograms per gram



INDEX MAP



Prepared for:
Program Manager for
Rocky Mountain Arsenal

Commerce City, Colorado

Figure 6.1

DISTRIBUTION OF ORGANOCHLORINE
PESTICIDES, ARSENIC, AND MERCURY
DETECTED IN 96TH AVENUE RESIDENTIAL
AREA OFFPOST SURFICIAL SOIL, FEBRUARY
1989

Aldnn	7.00
Dieldnn	55.0
Endnn	10.0
DDT	5.00

Dieldnn	10
---------	----

Aldnn	26.0
Dieldnn	110
Endnn	19.0
Isodnn	3.00
DDT	7.00

Dieldnn	50
Arsenic	5

Aldnn	10.0
Chlordane	151
Dieldnn	120
Endnn	15.0
DDE	73.0
DDT	230
Mercury	0.127

**Dieldnn	40
DDT	120
Arsenic	7

Dieldnn	70
Arsenic	4

North Bog

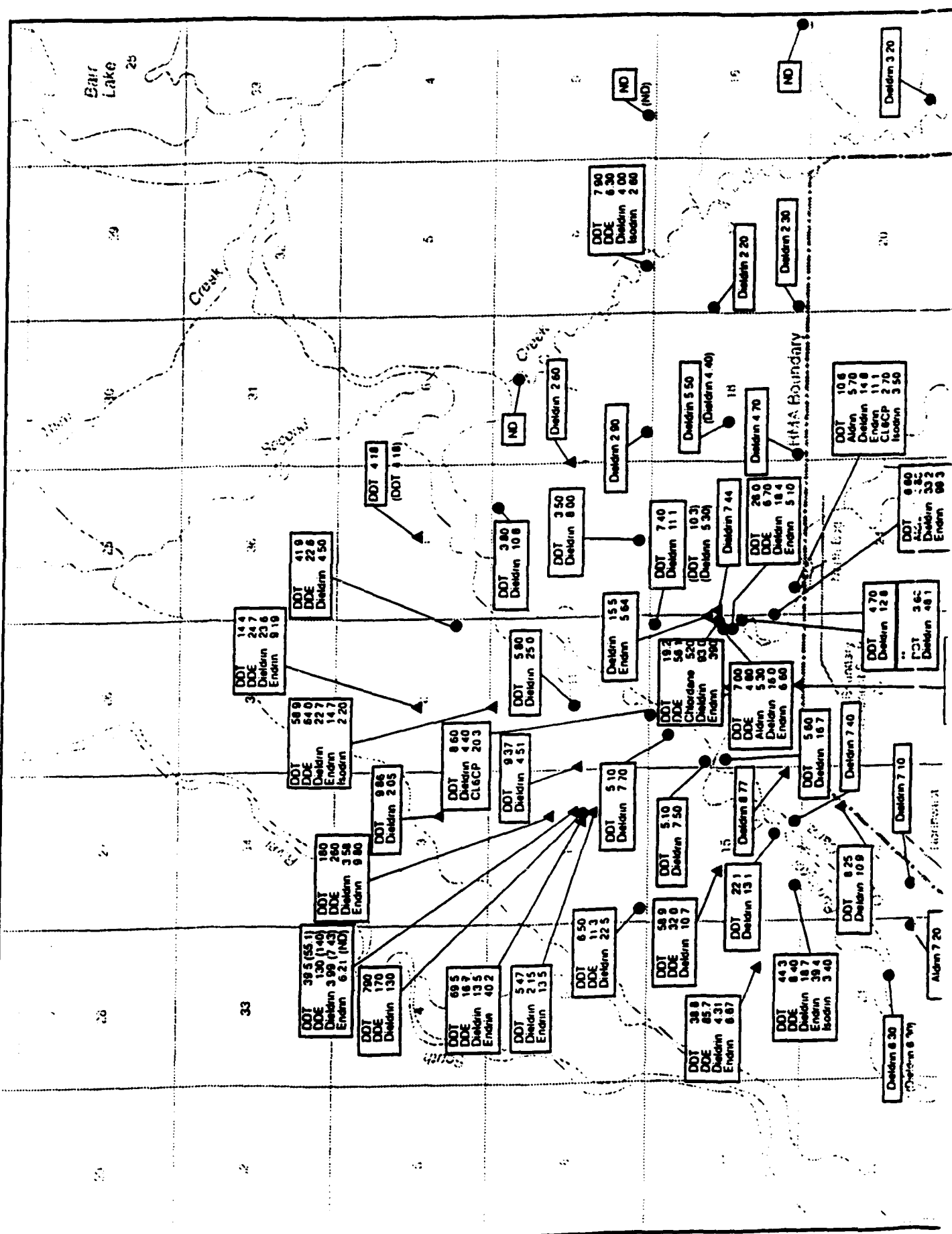
Aldnn	8.00
Chlordane	100
Dieldnn	89.0
Endnn	16.0
DDE	11.0
DDT	23.0
Arsenic	2.88

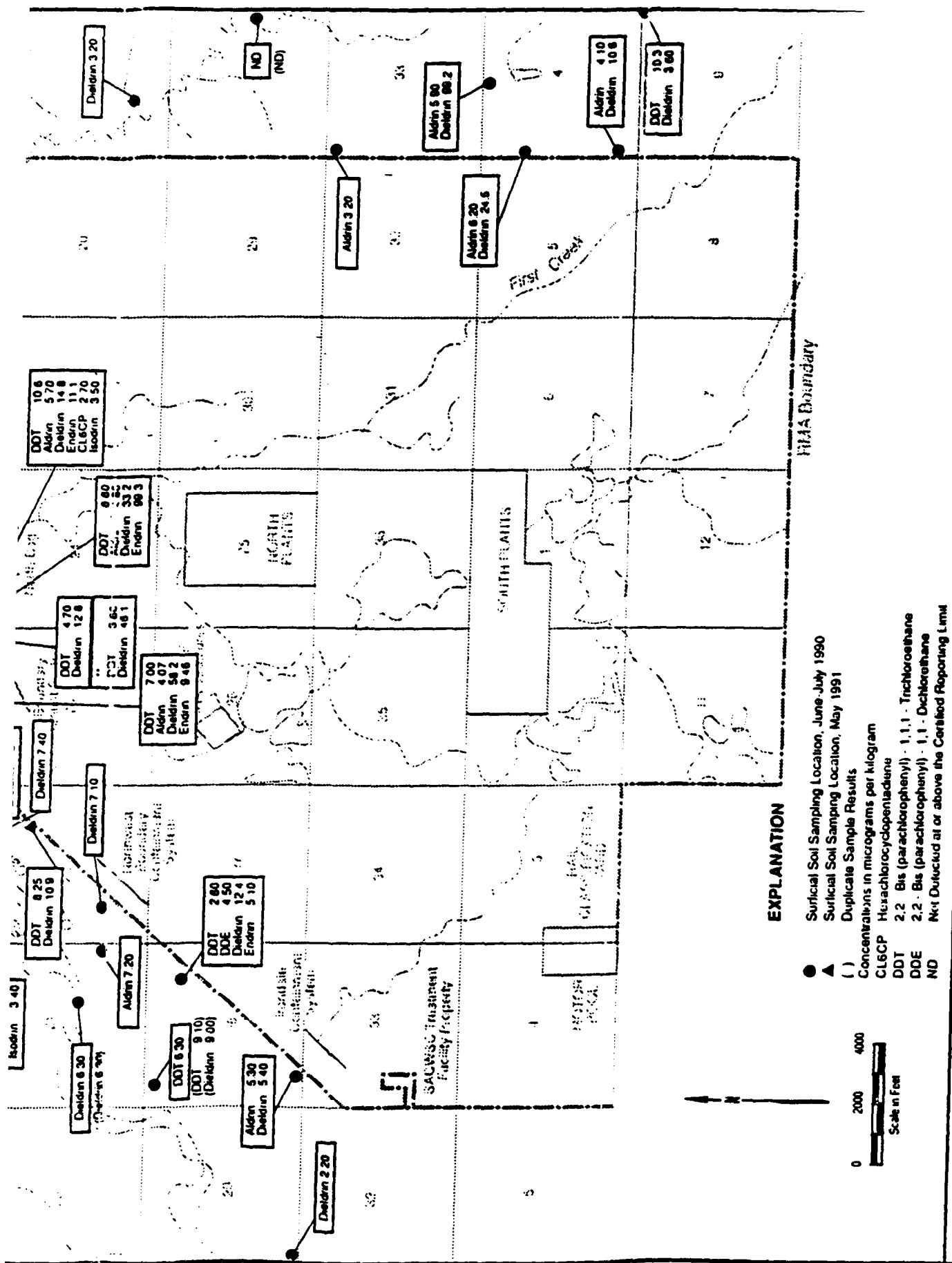
**Dieldnn	40
Chlordane	60
Arsenic	9

Aldnn	16.0
Dieldnn	130
DDE	36.0
DDT	53.0

**Dieldnn	90
Arsenic	7

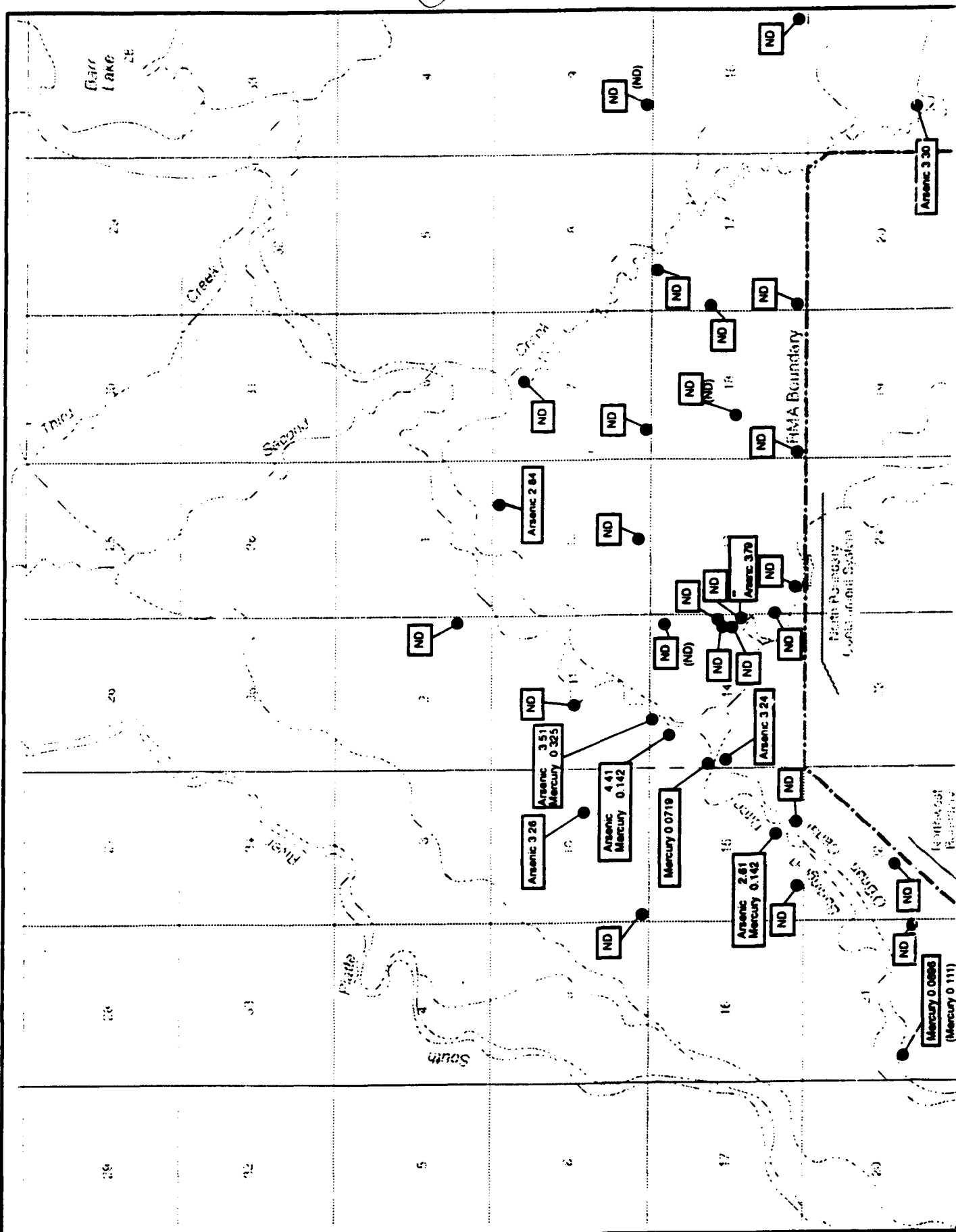
34.0
42.0
250
29.0
18.0
20.0
52.0
210
19.0
4.00
20.0

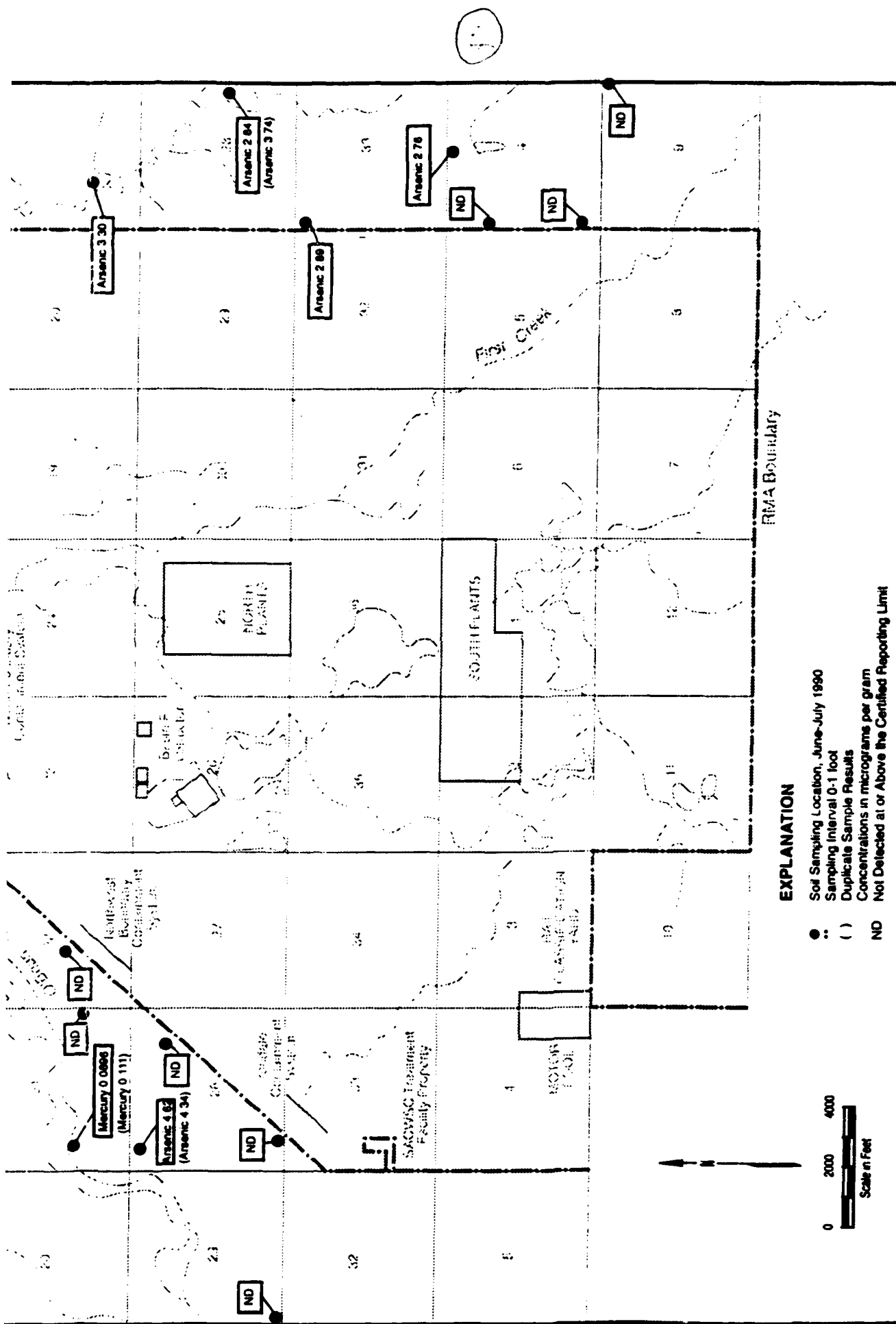




Prepared for:
**Program Manager for
Rocky Mountain Arsenal**
Commerce City, Colorado

Figure 6.2
**DISTRIBUTION OF ORGANOCHLORINE PESTICIDES DETECTED IN
OFFPOST SOIL, JUNE-JULY 1990 AND MAY 1991**





①

RMA1 1007aa

② Highway

14

First Creek

Peoria St.

¹ ND

² ND

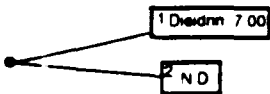
¹ ND

¹ Arsenic 3.59

96th Ave.

23

Rocky Mountain Arsenal



North Box

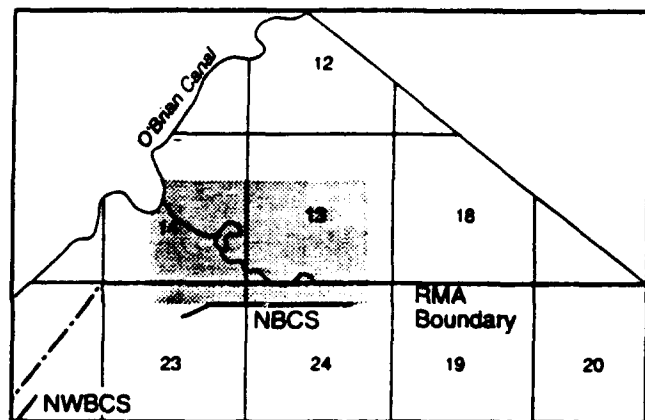
EXPLANATION

- Soil Sampling Location (0-1', 4-5'), February 1989
- ND Not detected at or above the certified reporting limit
- 13 Section Number

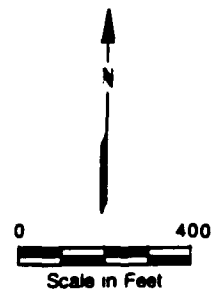
Notes: organochloride pesticide concentrations in micrograms per kilogram

Arsenic and Mercury concentrations in micrograms per gram

- 1 Sampling interval 0 - 1 foot
- 2 Sampling interval 4 - 5 feet



INDEX MAP



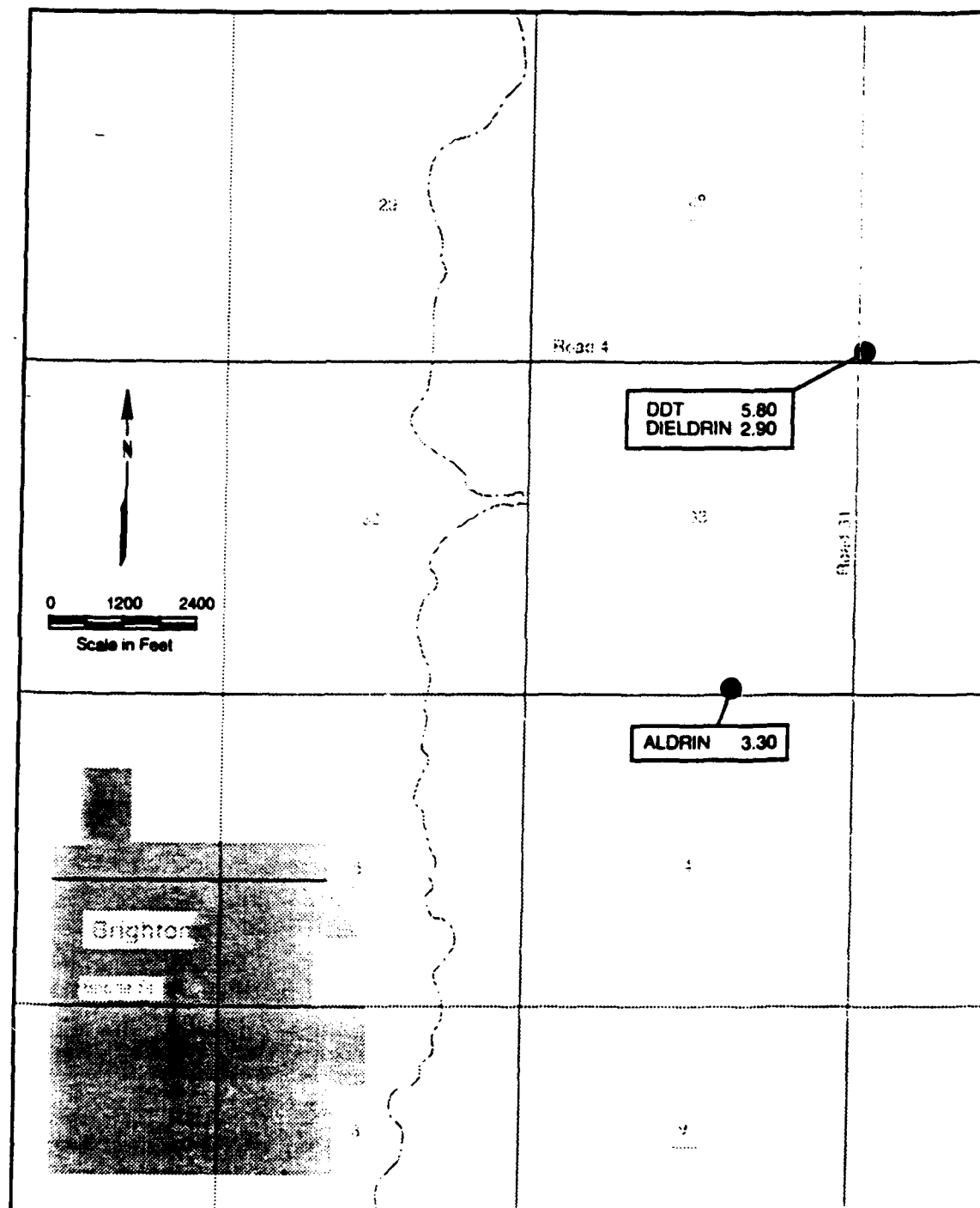
Prepared for:
Program Manager for
Rocky Mountain Arsenal

Commerce City, Colorado

Figure 6.4

DISTRIBUTION OF ORGANOCHLORINE
PESTICIDES, ARSENIC, AND MERCURY
DETECTED IN 96TH AVENUE RESIDENTIAL
AREA OFFPOST SUBSURFACE SOIL,
FEBRUARY 1989

①



EXPLANATION

● Background Surficial Soil Sampling Location, July 1990

() Sample is a Duplicate

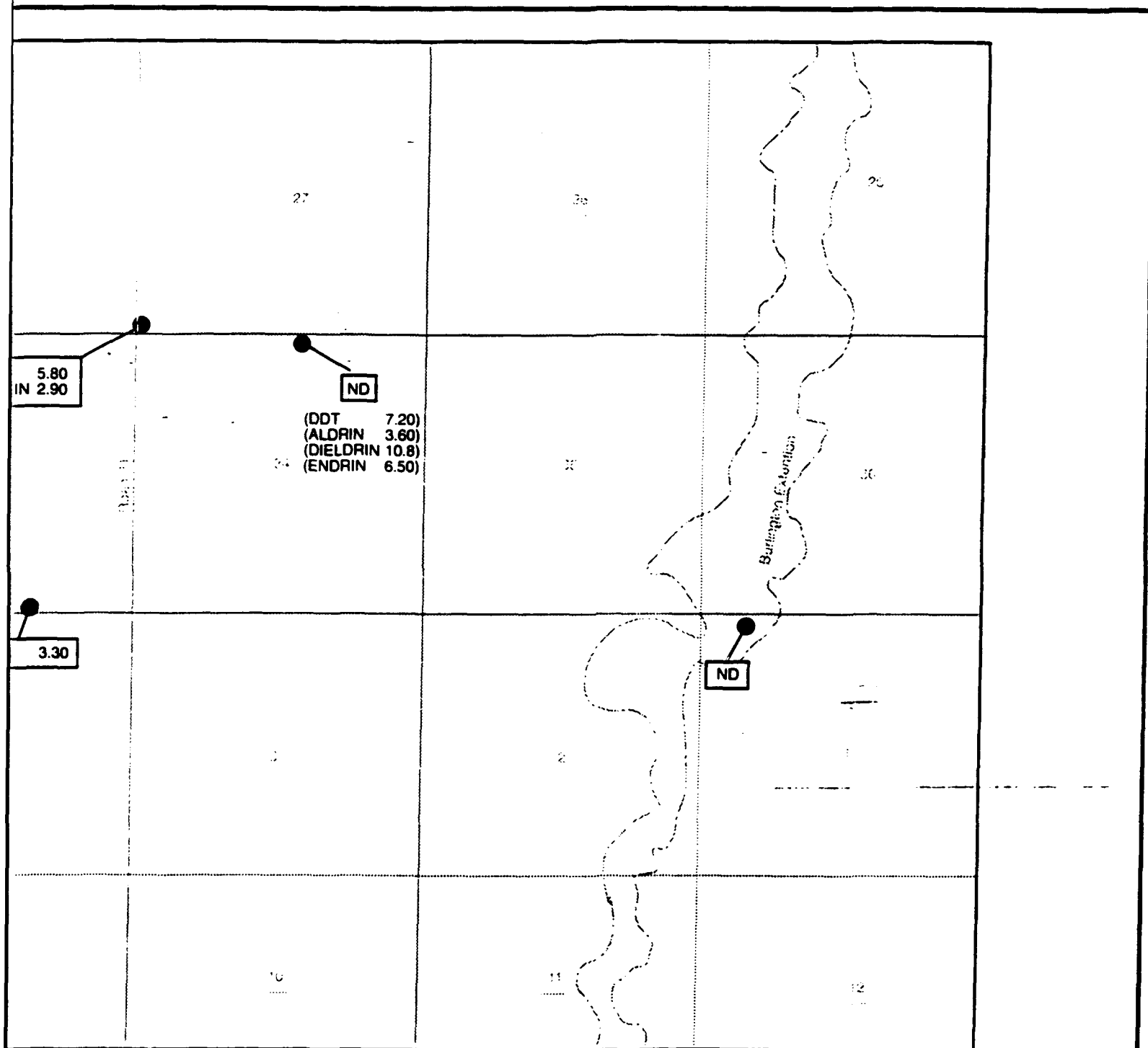
Concentration in micrograms per kilogram

ND Not Detected at or Above the Certified Reporting Limit

DDT 2,2 - Bis (parachlorophenyl) -1,1,1 - Trichloroethane

Prepared for:
Program Manager for
Rocky Mountain Arsenal
Commerce City, Colorado

2



for:
Manager for
Mountain Arsenal
City, Colorado

Figure 6.5

DISTRIBUTION OF ORGANOCHLORINE PESTICIDES, ARSENIC, AND
MERCURY DETECTED IN OFFPOST BACKGROUND SURFICIAL SOIL
NEAR BRIGHTON, CO

1

RMA1 10071

○ Dieldrin 0.0179
○ Dieldrin 0.023
● DDE 0.106
Dieldrin 0.23
○ ND

■ ND
■ ND
□ Dieldrin 0.053
□ Dieldrin 0.078
□ ND
▨ ND
▨ ND
▨ ND
▨ ND

North Bay

9
0

EXPLANATION

- Chicken Sampling Location
- ⊙ Chicken Egg
- ⊙ Chicken Liver
- Chicken Fat/Skin
- Chicken Muscle

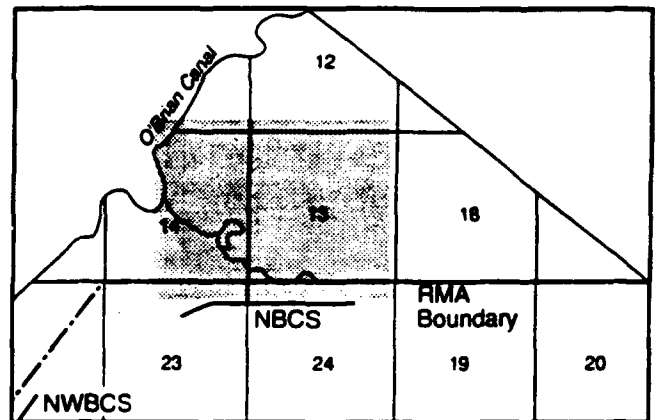
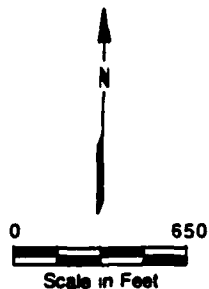
- Cow Sampling Location
- Cow Milk
- Cow Fat
- ▤ Cow Brain
- ▥ Cow Muscle
- ▧ Cow Liver
- ▨ Cow Kidney

Concentrations are in micrograms per gram

ODE 2,2-Bis(parachlorophenyl)-1,1-Dichloroethene

ND Compounds not detected at or above Certified Reporting Limit

13 Section Number



INDEX MAP

Prepared for:
Program Manager for
Rocky Mountain Arsenal

Commerce City, Colorado

Figure 7.1

DISTRIBUTION OF ORGANIC COMPOUNDS,
ARSENIC, AND MERCURY IN OFFPOST
OPERABLE UNIT AGRICULTURAL BIOTA

①

RMA1 1007G

+ Dieldrin 0.251

+ Mercury 0.0897
* Arsenic 0.573
* Arsenic 1.02

+ Mercury 0.155
Dieldrin 0.235

+ Mercury 0.052
Dieldrin 0.026

North Bog

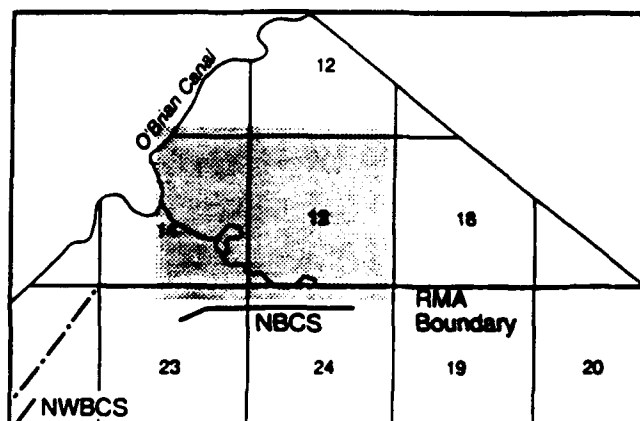
2

EXPLANATION

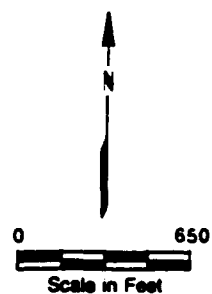
- X Aquatic Biota Sampling Location
- + Fish
- * Crayfish
- * Algae

Concentrations are in micrograms per gram

13 Section Number



INDEX MAP



**Prepared for:
Program Manager for
Rocky Mountain Arsenal**

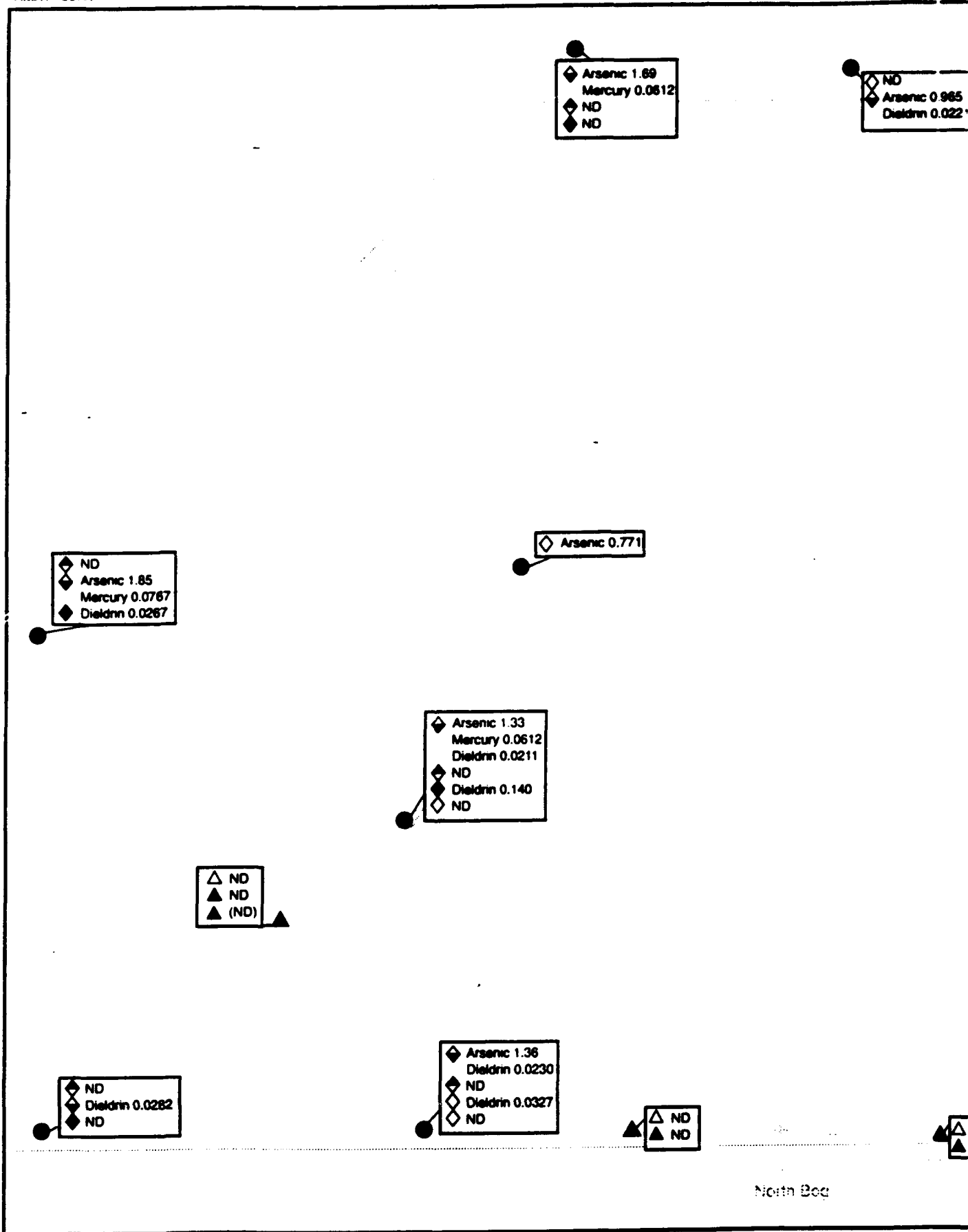
Commerce City, Colorado

Figure 7.2

**DISTRIBUTION OF ORGANIC COMPOUNDS,
ARSENIC, AND MERCURY IN OFFPOST
OPERABLE UNIT AQUATIC BIOTA**

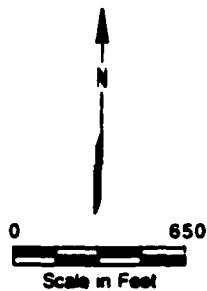
1

RMA1 1007H



2

ND
Arsenic 0.965
Dieldrin 0.0221



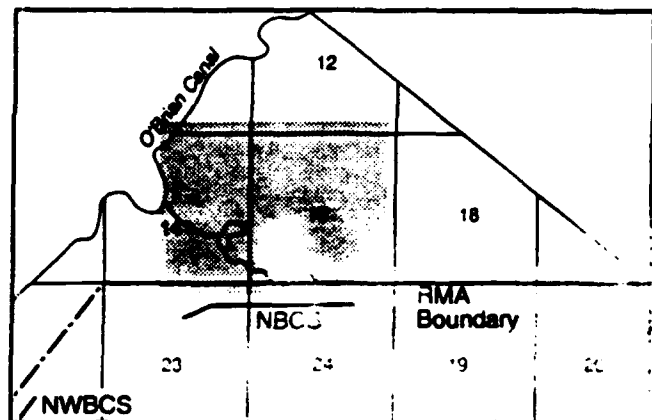
EXPLANATION

- Terrestrial Biota Sampling Location
- ◆ Field Mice
- ◆ Prairie Dogs
- ◆ Grasshoppers
- ◆ Earthworms
- ▲ Pheasant Sampling Locations
- △ Pheasant Liver
- ▲ Pheasant Flesh

Concentrations are in micrograms per gram

() Sample is a Duplicate

13 Section Number



Prepared for:
Program Manager for
Rocky Mountain Arsenal

Commerce City, Colorado

Figure 7.3

DISTRIBUTION OF ORGANIC COMPOUNDS,
ARSENIC, AND MERCURY IN OFFPOST
OPERABLE UNIT TERRESTRIAL BIOTA

ND
Dieldrin 0.571
ND

△ Dieldrin 0.380
ND