

INSTALLATION RESTORATION PROGRAM

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Site Investigation Report
Volume I

120th Fighter Interceptor Group
Montana Air National Guard
International Airport, Great Falls, Montana

February 1992

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Montana Air National Guard
International Airport, Great Falls, Montana
February 1992**

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Austin, Texas**

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CONTENTS

Volume I

List of Figures

List of Tables

Abbreviations

Executive Summary

	<u>Page</u>
Section 1: Introduction	1-1
1.1 Purpose of Report.....	1-1
1.2 Report Organization	1-1
1.3 Facility Background.....	1-2
1.3.1 Site Descriptions.....	1-2
Site 1: Current Fire Training Area.....	1-5
Site 2: Drainage Ditch Off Old Power Check Pad	1-5
Site 3: North Disposal and Fire Training Pit.....	1-5
Site 4: Former Fire Training Area 1.....	1-5
Site 5: Former Fire Training Area 2.....	1-6
Site 6: Aerospace Ground Equipment (AGE, Building 22) Area.....	1-6
Site 7: Dry Well Off Corrosion Control Building (Building 23).....	1-6
Site 8: Dry Well Off Composite Maintenance Building (Building 32).....	1-6
1.3.2 Facility History	1-6
1.4 Previous Program Activities.....	1-7
1.5 Regional Investigation Area	1-7
1.5.1 Environmental Setting.....	1-7
Cultural	1-7
Meteorology	1-8
Geography	1-8
1.5.2 Regional Geology and Hydrogeology	1-10
Geology.....	1-10

	Page
Hydrogeology.....	1-15
Section 2: Field Program.....	2-1
2.1 Summary.....	2-1
2.2 Geologic and Hydrogeologic Investigations.....	2-3
2.3 Field Screening Activities.....	2-3
2.3.1 Soil Gas Survey.....	2-3
2.3.2 Geophysics.....	2-5
2.3.3 Soil Sampling	2-5
2.3.4 Piezometer Construction	2-8
2.3.5 Piezometer Screening.....	2-11
2.4 Confirmation and Delineation Activities.....	2-11
2.4.1 Soil Borings	2-11
2.4.2 Monitoring Well Construction	2-11
2.4.3 Monitor Well Sampling.....	2-12
2.4.4 Specific Media Sampling.....	2-13
2.5 Background Sampling for Baseline Data.....	2-13
2.6 Handling of Investigation-Derived Materials	2-13
Section 3: Discussion of Results.....	3-1
3.1 Introduction	3-1
3.2 Geology and Hydrogeology.....	3-1
3.3 Background Sampling Results	3-2
3.4 Site 1 – Current Fire Training Area.....	3-7
3.4.1 Screening Activity Results	3-7
Soil Gas.....	3-7
Soil Borings	3-7
Piezometer Levels.....	3-12
Piezometer Screening.....	3-12
Monitoring Well Observations.....	3-12
3.4.2 Confirmation and Delineation Activities	3-12
Soil Sampling	3-12
Groundwater Sampling	3-18
Comparison of Screening Results with CLP Results	3-18
3.4.3 Geologic and Hydrogeologic Investigation Results.....	3-22
3.4.4 Conclusions	3-22
3.5 Site 2 - Drainage Ditch Off Old Power Check Pad.....	3-30
3.5.1 Screening Activity Results	3-30
Soil Gas.....	3-30

	Page
Soil Borings	3-30
Piezometer Levels	3-35
Piezometer Screening	3-35
Monitoring Well Observations	3-35
3.5.2 Confirmation and Delineation Activities	3-35
Soil Sampling	3-35
Sediment Sampling	3-35
Groundwater Sampling	3-39
Comparison of Screening Results to CLP Results	3-39
3.5.3 Geologic and Hydrogeologic Investigation Results	3-39
3.5.4 Conclusions	3-39
3.6 Site 3 – North Disposal and Fire Training Pit	3-41
3.6.1 Screening Activity Results	3-41
Soil Gas	3-41
Soil Borings	3-41
Piezometer Levels	3-41
Piezometer Screening	3-45
Monitoring Well Observations	3-45
3.6.2 Confirmation and Delineation Activities	3-45
Soil Sampling	3-45
Groundwater Sampling	3-45
Comparison of Screening Results with CLP Results	3-51
3.6.3 Geologic and Hydrogeologic Investigation Results	3-51
3.6.4 Conclusions	3-57
3.7 Site 4 – Former Fire Training Area 1	3-57
3.7.1 Screening Activity Results	3-57
Soil Gas	3-57
Soil Borings	3-57
Piezometer Levels	3-62
Piezometer Screening	3-62
Monitoring Well Observations	3-62
3.7.2 Confirmation and Delineation Activities	3-62
Soil Sampling	3-62
Groundwater Sampling	3-66
Comparison of Screening Results with CLP Results	3-66
3.7.3 Geologic and Hydrogeologic Investigation Results	3-66
3.7.4 Conclusions	3-75
3.8 Site 5 – Former Fire Training Area 2	3-75

	Page
3.8.1 Screening Activity Results	3-75
Soil Gas.....	3-75
Soil Borings	3-75
Piezometer Levels.....	3-75
Piezometer Screening.....	3-80
Monitoring Well Observations.....	3-80
3.8.2 Confirmation and Delineation Activities	3-80
Soil Sampling	3-80
Groundwater Sampling	3-80
Comparison of Screening Results with CLP Results	3-84
3.8.3 Geologic and Hydrogeologic Investigation Results.....	3-84
3.8.4 Conclusions	3-84
3.9 Site 6 - Aerospace Ground Equipment (AGE, Bldg. 22) Area	3-85
3.9.1 Screening Activity Results	3-85
Soil Gas.....	3-85
Geophysics.....	3-85
Soil Borings	3-85
Piezometer Levels.....	3-91
Piezometer Screening.....	3-91
Monitoring Well Observations.....	3-91
3.9.2 Confirmation and Delineation Activities	3-91
Soil Sampling	3-91
Sediment Sampling	3-96
Groundwater Sampling	3-96
Comparison of Screening Results with CLP Results	3-99
3.9.3 Geologic and Hydrogeologic Investigation Results.....	3-99
3.9.4 Conclusions	3-100
3.10 Site 7 - Dry Well Off Corrosion Control Building (Bldg. 23).....	100
3.10.1 Screening Activity Results	3-100
Soil Gas.....	3-100
Geophysics.....	3-100
Soil Borings	3-104
Piezometer Levels.....	3-104
Piezometer Screening.....	3-104
Monitoring Well Observations.....	3-104
3.10.2 Confirmation and Delineation Activities	3-104

	Page
Soil Sampling	3-104
Groundwater Sampling	3-110
Comparison of Screening Results with CLP Results	3-110
3.10.3 Geologic and Hydrogeologic Investigation	
Results.....	3-112
3.10.4 Conclusions	3-112
3.11 Site 8 – Dry Well Off Composite Maintenance	
Building (Bldg. 32)	3-113
3.11.1 Screening Activity Results	3-113
Soil Gas.....	3-113
Geophysics.....	3-113
Soil Borings	3-113
Piezometer Levels.....	3-113
Piezometer Screening.....	3-113
Monitoring Well Observations.....	3-120
3.11.2 Confirmation and Delineation Activities.....	3-120
Soil Sampling	3-120
Groundwater Sampling	3-120
Comparison of Screening Results with CLP Results	3-124
3.11.3 Geologic and Hydrogeologic Investigation	
Results.....	3-124
3.11.4 Conclusions	3-124
3.12 Investigation Derived Materials.....	3-125
Section 4: Preliminary Risk Evaluation.....	4-1
4.1 Introduction	4-1
4.2 Preliminary Human Health Evaluation	4-2
4.2.1 Selection of Chemicals of Concern	4-2
4.2.2 Exposure Assessment	4-3
4.2.2.1 Environmental Fate and Transport.....	4-3
4.2.2.2 Toxicity Profiles For the Chemicals of Concern	4-7
4.2.2.3 Mechanisms of Migration.....	4-21
4.2.2.4 Exposure Pathways.....	4-22
4.2.3 Toxicity Assessment.....	4-22
4.2.3.1 Health Criteria for Carcinogenic Effects.....	4-22
4.2.3.2 Health Criteria for Noncarcinogenic Effects.....	4-30
4.2.4 Risk Screening	4-31
4.2.4.1 Human Health Criteria	4-31

	Page
4.2.4.2 Qualitative Assessment of Site-Specific Risks	4-36
Site 1: Current Fire Training Area.....	4-37
Site 2: Drainage Ditch Off Old Power Check Pad	4-37
Site 3: North Disposal and Fire Training Pit.....	4-45
Site 4: Former Fire Training Area 1.....	4-49
Site 5: Former Fire Training Area 2.....	4-53
Site 6: Aerospace Ground Equipment Area	4-57
Site 7: Dry Well Off Corrosion Control Building	4-62
4.3 Preliminary Ecological Risk Evaluation	4-66
4.3.1 Selection of Chemicals of Concern	4-70
4.3.2 Environmental Receptors.....	4-70
4.3.3 Identification of Ecological Exposure Pathways.....	4-70
4.3.4 Environmental Risk Criteria.....	4-72
4.3.4.1 Terrestrial Wildlife.....	4-72
4.3.4.2 Terrestrial Vegetation	4-73
4.3.5 Ecological Hazard Evaluation	4-73
Site 1: Current Fire Training Area.....	4-73
Site 2: Drainage Ditch Off Old Power Check Pad	4-81
Site 3: North Disposal and Fire Training Pit.....	4-86
Site 4: Former Fire Training Area 1.....	4-86
Site 5: Former Fire Training Area 2.....	4-93
Site 6: Aerospace Ground Equipment Area	4-97
Site 7: Dry Well Off Corrosion Control Building	4-97
Site 8: Dry Well Off Composite Maintenance Building.....	4-105
4.4 Uncertainty	4-109
4.5 Human Health and Ecological Risk Evaluation	
Summary	4-111
4.5.1 Site 1 Preliminary Risk Evaluation Conclusions.....	4-111
4.5.2 Site 2 Preliminary Risk Evaluation Conclusions.....	4-112
4.5.3 Site 3 Preliminary Risk Evaluation Conclusions.....	4-112
4.5.4 Site 4 Preliminary Risk Evaluation Conclusions.....	4-113
4.5.5 Site 5 Preliminary Risk Evaluation Conclusions.....	4-113
4.5.6 Site 6 Preliminary Risk Evaluation Conclusions.....	4-113
4.5.7 Site 7 Preliminary Risk Evaluation Conclusions.....	4-113
4.5.8 Site 8 Preliminary Risk Evaluation Conclusions.....	4-114
Section 5: Immediate Response Actions Taken.....	5-1

Section 6: Summary and Conclusions

6.1 Summary	6-1
6.2 Conclusions.....	6-1
6.2.1 Data Gaps.....	6-1
6.2.2 Recommendations	6-2
Site 1 - Current Fire Training Area	6-2
Site 2 - Drainage Ditch Off Old Power Check Pad	6-3
Site 3 - North Disposal and Fire Training Pit.....	6-3
Site 4 - Fire Training Area 1	6-4
Site 5 - Fire Training Area 2	6-4
Site 6 - Aerospace Ground Equipment Area	6-4
Site 7 - Dry Well Off Corrosion Control Building.....	6-5
Site 8 - Dry Well Off Composite Maintenance Building	6-6
6.2.4 Decision Documents.....	6-6

References

Volume II

Appendix A: Technical Memoranda on Field Activities

Appendix B: Risk Assessment Criteria

Appendix C: Analytical Data

Appendix D: Geological Data

Appendix E: Quality Assurance

LIST OF FIGURES

1.1	Great Falls Regional Location Map	1-3
1.2	IRP Site Locations	1-4
1.5	Soils Map	1-12
1.6	Geologic Map	1-13
1.7	Geologic Cross Section	1-14
2.1	Typical Ground-Penetrating Radar Scan.....	2-6
2.2	Monitoring Well and Piezometer Locations	2-9
2.3	Locations of Sediment Samples, Site 2.....	2-14
2.4	Locations of Sediment Samples, Site 6.....	2-15
2.5	Locations of Background Monitoring Well and Soil Borings.....	2-16
3.1	Potentiometric Surface.....	3-3
3.2	Results of Soil Gas Survey, Site 1.....	3-9
3.3	Location of Soil Borings, Site 1.....	3-11
3.4	Selected Analytes Detected in Soil and Groundwater, Site 1.....	3-17
3.5	Monitoring Well and Piezometer Locations, Sites 1 and 2.....	3-25
3.6	Cross Section Orientation, Sites 1 and 2	3-26
3.7	Generalized Cross Section, Sites 1 and 2.....	3-27
3.8	Potentiometric Surface, Sites 1 and 2	3-28
3.9	Results of Soil Gas Survey, Site 2.....	3-31
3.10	Locations of Soil Borings, Site 2.....	3-33
3.11	Selected Analytes Detected in Soil and Groundwater, Site 2.....	3-37
3.12	Results of Soil Gas Survey, Site 3.....	3-42
3.13	Locations of Soil Borings, Site 3.....	3-44
3.14	Selected Analytes Detected in Soil and Groundwater, Site 3.....	3-49
3.15	Locations of Monitor Wells and Piezometers, Site 3	3-52
3.16	Cross Section Orientation, Site 3.....	3-53

Contents, continued

	Page
3.17 Generalized Cross Section, Site 3	3-54
3.18 Potentiometric Surface, Site 3.....	3-55
3.19 Results of Soil Gas Survey, Site 4.....	3-58
3.20 Locations of Soil Borings, Site 4.....	3-61
3.21 Selected Analytes Detected in Soil and Groundwater, Site 4.....	3-63
3.22 Monitoring Well and Piezometer Locations, Sites 4 through 8.....	3-70
3.23 Cross Section Orientation, Sites 4 through 8.....	3-71
3.24 Generalized Cross Section, Sites 4 through 8.....	3-72
3.25 Potentiometric Surface, Sites 4 through 8.....	3-73
3.26 Results of Soil Gas Survey, Site 5.....	3-76
3.27 Locations of Soil Borings, Site 5.....	3-78
3.28 Selected Analytes Detected in Soil and Groundwater, Site 5.....	3-82
3.29 Results of Soil Gas Survey, Site 6.....	3-86
3.30 GPR Survey, Site 6.....	3-88
3.31 Locations of Soil Borings, Site 6.....	3-89
3.32 Locations of Additional Soil Borings, Site 6, Aerospace Ground Equipment Area.....	3-90
3.33 Selected Analytes Detected in Soil and Groundwater, Site 6.....	3-95
3.34 Results of Soil Gas Survey, Site 7.....	3-101
3.35 GPR Survey, Site 7.....	3-103
3.36 GPR Record of Dry Well Location, Site 7	3-105
3.37 Locations of Soil Borings, Site 7.....	3-106
3.38 Selected Analytes Detected in Soil and Groundwater, Site 7.....	3-109
3.39 Results of Soil Gas Survey, Site 8.....	3-114
3.40 GPR Survey, Site 8.....	3-116
3.41 GPR Record of Dry Well Location, Site 8	3-117
3.42 Locations of Soil Borings, Site 8.....	3-118
3.43 Selected Analytes Detected in Soil and Groundwater, Site 8.....	3-123

LIST OF TABLES

3.1	Organic Constituents Detected in Soil Samples with Field GC Screen, Background	3-4
3.2	Chemical Constituents Detected in Soil, Background	3-7
3.3	Chemical Constituents Detected in Groundwater, Background	3-8
3.4	Organic Constituents Detected in Soil Gas Survey, Site 1	3-10
3.5	Organic Constituents Detected in Soil Sample with Field GC Screen, Site 1	3-13
3.6	Organic Constituents Detected in Piezometer Samples with Field GC Screen, Sites 1 and 2	3-14
3.7	Piezometer Construction Data	3-15
3.8	Chemical Constituents Detected in Soil, Site 1	3-16
3.9	Groundwater Field Measurements, Round 1 Sampling	3-19
3.10	Groundwater Field Measurements, Round 2 Sampling	3-20
3.11	Chemical Constituents Detected in Groundwater, Site 1	3-21
3.12	Bedrock Data for Sites 1 and 2	3-23
3.13	Monitoring Well Construction Data	3-24
3.14	Water Level Data for Sites 1 and 2	3-29
3.15	Organic Constituents Detected in Soil Gas Survey, Site 2	3-32
3.16	Organic Constituents Detected in Soil Samples with Field GC Screen, Site 2	3-35
3.17	Chemical Constituents Detected in Soil, Site 2	3-36
3.18	Chemical Constituents Detected in Sediment Samples, Site 2	3-39
3.19	Chemical Constituents Detected in Groundwater, Site 2	3-40
3.20	Organic Constituents Detected in Soil Gas Survey, Site 3	3-43
3.21	Organic Constituents Detected in Soil Samples with Field GC Screen, Site 3	3-46

3.22	Organic Constituents Detected in Piezometer Samples with Field GC Screen, Site 3.....	3-41
3.23	Chemical Constituents Detected in Soil, Site 3.....	3-48
3.24	Chemical Constituents Detected in Groundwater, Site 3	3-51
3.25	Water Level Data, Site 3.....	3-57
3.26	Organic Constituents Detected in Soil Gas Survey, Site 4	3-60
3.27	Organic Constituents Detected in Soil Samples with Field GC Screen, Site 4.....	3-62
3.28	Organic Constituents Detected in Piezometer Samples with Field GC Screen, Sites 4 through 8	3-64
3.29	Chemical Constituents Detected in Soil, Site 4.....	3-66
3.30	Chemical Constituents Detected in Groundwater, Site 4	3-67
3.31	Bedrock Data for Sites 4 through 8.....	3-69
3.32	Water Level Data for Sites 4 through 8.....	3-75
3.33	Organic Constituents Detected in Soil Gas Survey, Site 5	3-78
3.34	Organic Constituents Detected in Soil Samples with Field GC Screen, Site 5	3-80
3.35	Chemical Constituents Detected in Soil, Site 5.....	3-82
3.36	Chemical Constituents Detected in Groundwater, Site 5	3-84
3.37	Organic Constituents Detected in Soil Gas Survey, Site 6	3-88
3.38	Organic Constituents Detected in Soil Sample with Field GC Screen, Site 6.....	3-92
3.39	Chemical Constituents Detected in Soil, Site 6.....	3-94
3.40	Chemical Constituents Detected in Alternate Soil Borings, Site 6.....	3-95
3.41	Chemical Constituents Detected in Sediment Samples, Site 6.....	3-98
3.42	Chemical Constituents Detected in Groundwater, Site 6	3-99
3.43	Organic Constituents Detected in Soil Gas Survey, Site 7	3-103
3.44	Organic Constituents Detected in Soil Sample with Field GC Screen, Site 7	3-108
3.45	Chemical Constituents Detected in Soil, Site 7.....	3-109
3.46	Chemical Constituents Detected in Groundwater, Site 7	3-112
3.47	Organic Constituents Detected in Soil Gas Survey, Site 8	3-116

3.48	Organic Constituents Detected in Soil Sample with Field GC Screen, Site 8.....	3-120
3.49	Chemical Constituents Detected in Soil, Site 8.....	3-122
3.50	Chemical Constituents Detected in Groundwater, Site 8.....	3-123
4.1	Relevant Physical and Chemical Properties of Potential Chemicals of Concern	4-5
4.2	Matrix of Potential Exposure Pathways.....	4-23
4.3	Toxicity Values: Potential Carcinogenic Effects for Chemicals of Potential Concern	4-28
4.4	Toxicity Values: Potential Noncarcinogenic effects for Potential Chemicals of Concern.....	4-32
4.5	Potential Federal Applicable or Relevant and Appropriate Requirements for Chemicals of Potential Concern	4-35
4.6	Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 1	4-38
4.7	Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 1	4-39
4.8	Comparison of Surface Soil Contaminant Concentrations with Health Criteria for Site 1.....	4-40
4.9	Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 2	4-41
4.10	Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 2.....	4-42
4.11	Comparison of Surface Soil Contaminant Concentrations with Health Criteria for Site 2.....	4-43
4.12	Comparison of Sediment Contaminant Concentrations with Health Criteria for Site 2.....	4-44
4.13	Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 3	4-46
4.14	Comparison of Subsurface Contaminant Concentrations with Health Criteria for Site 3.....	4-47
4.15	Comparison of Surface Soil Concentrations with Health Criteria for Site 3	4-48
4.16	Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 4	4-50
4.17	Comparison of Subsurface Contaminant Concentrations with Health Criteria for Site 4.....	4-51

4.18	Comparison of Surface Soil Contaminant Concentrations with Health Criteria for Site 4.....	4-52
4.19	Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 5	4-54
4.20	Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 5	4-55
4.21	Comparison of Surface Soil Contaminant Concentrations with Health Criteria for Site 5.....	4-56
4.22	Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 6	4-58
4.23	Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 6	4-59
4.24	Comparison of Surface Soil Contaminant Concentrations with Health Criteria for Site 6.....	4-60
4.25	Comparison of Sediment Contaminant Concentrations with Health Criteria for Site 6.....	4-61
4.26	Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 7	4-63
4.27	Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 7	4-64
4.28	Comparison of Surface Soil Contaminant Concentrations with Health Criteria for Site 7.....	4-65
4.29	Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 8	4-67
4.30	Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 8	4-68
4.31	Comparison of Surface Soil Contaminant Concentrations with Health Criteria for Site 8.....	4-69
4.32	Guidelines for Evaluating the Toxicity of Chemicals of Potential Concern to Terrestrial Wildlife.....	4-74
4.33	Guidelines for Evaluating the Toxicity of Chemicals of Potential Concern to Terrestrial Vegetation.....	4-76
4.34	Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 1.....	4-78
4.35	Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 1.....	4-79
4.36	Comparison of Groundwater Contaminant Concentrations with Ecological Criteria for Site 1.....	4-80

4.37	Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 2.....	4-82
4.38	Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 2.....	4-83
4.39	Comparison of Groundwater Contaminant Concentrations with Ecological Criteria for Site 2.....	4-84
4.40	Comparison of Sediment Contaminant Concentrations with Ecological Criteria for Site 2.....	4-85
4.41	Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 3.....	4-87
4.42	Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 3.....	4-88
4.43	Comparison of Groundwater Contaminant Concentrations with Ecological Criteria for Site 3.....	4-89
4.44	Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 4.....	4-90
4.45	Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 4.....	4-91
4.46	Comparison of Groundwater Contaminant Concentrations with Ecological Criteria for Site 4.....	4-92
4.47	Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 5.....	4-94
4.48	Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 5.....	4-95
4.49	Comparison of Groundwater Contaminant Concentrations with Ecological Criteria for Site 5.....	4-96
4.50	Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 6.....	4-98
4.51	Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 6.....	4-99
4.52	Comparison of Groundwater Contaminant Concentrations with Ecological Criteria for Site 6.....	4-100
4.53	Comparison of Sediment Contaminant Concentrations with Ecological Criteria for Site 6.....	4-101
4.54	Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 7.....	4-102
4.55	Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 7.....	4-103

Contents, continued

	Page
4.56 Comparison of Groundwater Contaminant Concentrations with Ecological Criteria for Site 7.....	4-104
4.57 Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 8.....	4-106
4.58 Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 8.....	4-107
4.59 Comparison of Groundwater Contaminant Concentrations with Ecological Criteria for Site 8.....	4-108

ABBREVIATIONS

AGE	Aerospace ground equipment
ARARS	Applicable, relevant, and/or appropriate requirements
ATSDR	Agency for Toxic Substances and Disease Registry
bgl	Below ground level
BNA	Base neutral acid extractable semivolatile organic compounds
CAG	Carcinogen Assessment Group
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CLP	Contract laboratory program
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DQO	Data quality objective
EPA	U.S. Environmental Protection Agency
ES	Engineering-Science
FS	Feasibility study
FTA	Fire training area
GC	Gas chromatograph
HNU	Trace gas analyzer
HPLC	High performance liquid chromatography
HAZWRAP	Hazardous Waste Remedial Actions Program
IRP	Installation Restoration Program
MANG	Montana Air National Guard
MCL	Maximum contaminant level
NAAQS	National ambient air quality standards
NCP	National contingency plan
NGB	National Guard Bureau
NPL	National priority list
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear aromatic hydrocarbons
PCE	Perchloroethene
PRE	Preliminary risk evaluation
QA	Quality assurance
QC	Quality control
RfD	Reference dose
SAB	Science Advisory Board
SARA	Superfund Act Reauthorization Amendment
TCE	Trichloroethene
TCLP	Toxicity characteristic leaching procedure

TIC Tentatively identified compound
TPH Total petroleum hydrocarbons
USGS United States Geological Survey
UST Underground storage tank
VOC Volatile organic compound
WQC Water quality criteria

EXECUTIVE SUMMARY

A site investigation (SI) was conducted at the 120th Fighter Interceptor Group of the Montana Air National Guard, located at the Great Falls International Airport, Great Falls, Montana. The SI was performed under the National Guard Bureau's Installation Restoration Program. The objectives of the SI were to confirm the presence or absence of contaminants and to evaluate the potential for contaminant migration.

SI activities were conducted at eight sites at the base, originally identified in the preliminary assessment. The sites are identified as:

- Site 1, current fire training area¹
- Site 2, drainage ditch of old power check pad
- Site 3, north disposal and fire training pit
- Site 4, former fire training area 1
- Site 5, former fire training area 2
- Site 6, aerospace ground equipment (age) area (building 22)
- Site 7, dry well near corrosion control building (building 23)
- Site 8, dry well near composite maintenance building (building 32).

The locations of the eight potential hazardous waste sites are indicated on figure 1.2 and briefly described below, together with previous and current site uses and potential contaminants. Site locations, descriptions, and waste quantity estimates are taken from the preliminary assessment for the base (HMTC, 1988), from the site survey conducted at the time of the October 1989 kickoff meeting, and from observations during SI field work conducted July through October 1990. A more detailed discussion of each site is presented in section 3 of this report.

Site 1: Current fire training area. Site 1 was used as a fire training area (FTA) from 1968 until early in 1989. The site is located on the west side of the airport facility, west of the power check pad and the small arms range, and consists of one large and three small FTAs. The PA reported stained soil in all areas and cans, wood, metal, and tire debris in the smaller areas. The site was mostly clear of small debris during the SI, but a large cylindrical, metal object positioned in the center of the large FTA remained. This object

¹ The term "current" is used for consistency with the 1988 PA report and does not indicate ongoing fire training activities at this site.

aided in simulation of a burning aircraft during the fire training exercises. As much as 30,000 gallons of fuel and other flammable liquids may have seeped into the soil at this site.

Site 2: Drainage ditch off old power check pad. The old power check pad was used regularly when the 120th FIG flew the F-106 Delta Dart from 1972 to 1987, and has since been used less frequently. Petroleum, oil, and lubricant (POL) waste from overflow of an underground oil-water separator and storage tank (both still in place) have apparently contaminated a northwest-trending drainage ditch located between the old power check pad and the small arms range on the west side of the airport facility. Overflow from the tank drained through a 10-inch-diameter buried pipe (still in place) which discharges to the ditch about 250 feet away. The ditch also receives storm runoff from the power check pad. Waste quantities discharged at this site are unknown.

Site 3: North disposal and fire training pit. Three sources of waste released in or near a pit located at site 3 were identified during the PA: contaminated jet fuel from 1957 to 1960, waste fuels, oils, thinners, and solvents from FTA activities from 1966 to 1968, and unknown quantities of flammable liquids disposed of in the pit and surrounding areas over the life of the site. According to the PA, approximately 27,000 gallons of unburned fuel were released at the site. The location of the former FTA pit could not be definitively identified during SI field work, and no visual evidence of disposal of the above-described wastes was observed during the SI. Piles of asphalt-base material which covered a large portion of site 3 during the initial phases of SI field work were removed during the course of the field investigation, leaving a flat area scraped smooth by earth-moving equipment.

Site 4: Former fire training area 1. Former FTA 1 was used for one fire training exercise per month from 1959 to 1963, and an estimated 20,000 gallons of unburned fuel was deposited at the site. The site is located off the northwest side of the "hush house," and portions are now paved over.

Site 5: Former fire training area 2. Former FTA 2 was used for one fire training exercise per month from 1964 to 1966, and an estimated 6,500 gallons of unburned fuel was deposited at the site. The site is located off the northwest side of the "alert barns," approximately 400 feet northeast of former FTA 1. A portion of the site is now paved over.

Site 6: Aerospace ground equipment (age) area, building 22. Approximately 17,000 gallons of POL² waste, hydraulic fluid, and solvents was discharged to a 3-foot-diameter, brick-lined dry well located adjacent to the southwest side of building 22 from 1962 to 1978. This dry well was paved over in 1978. In addition, small amounts of waste oil were reportedly discharged to a ditch located southeast of building 22 during the same period. Discussions with base personnel during SI activities indicated that a small aboveground dump-

2 POL = petroleum, oil, and lubricants

ster which received wastes from area buildings may have been located in the area of this ditch.

Site 7: Dry well near corrosion control building (building 23). From 1955 to 1964, approximately 9,400 gallons of motor pool waste oils and fuels was disposed of, via an underground pipe, to a dry well located within 10 feet of the northwest wall of building 23. This well is currently covered by a lawn. A second dry well suspected to be located at the site off the east corner of the building was not found during the SI geophysical survey. Base personnel indicated at the time of the kickoff meeting that this second well may never have been installed.

Site 8: Dry well near composite maintenance building (building 32). From 1971 to 1977, small amounts of waste engine oil, hydraulic fluids, paint strippers and thinners, JP-4, and PD-680 may have been deposited in a dry well located between buildings 30 and 32. This dry well is currently paved over with asphalt.

Soil gas surveys were conducted at all sites to evaluate areas of potential soil contamination. The results were used to select locations for soil borings and to ensure that monitoring wells were located so that well construction would not result in drilling through contaminated soils. A geophysics survey was conducted using ground-penetrating radar at sites 6, 7, and 8 to locate the dry wells and any pertinent underground features such as storage tanks and utilities.

Soil borings were drilled to the soil-rock interface at all sites, and two soil samples from each soil boring were analyzed for selected chemical constituents.

Sediment samples were collected from drainage ditches at sites 2 and 6. These samples were analyzed for selected chemical constituents. Surface water samples were planned for these ditches. However, no water was present in these ditches during the field activities.

Piezometers were installed in the vicinity of all sites, and groundwater levels were measured to determine the direction of flow in the shallow aquifer. Water from these piezometers was screened for volatile constituents using field analytical instruments. One monitoring well was installed at each site, and groundwater samples were analyzed for selected chemical constituents.

The base is underlain by a thin soil cover, sandstone, and a shale unit which occurs at depths of at least 54 feet below ground surface. Groundwater occurs at the base of the sandstone unit, perched above the shale unit. The groundwater flow direction and gradient vary with topography, the dip of the sandstone-shale contact, and proximity to the edge of the bench on which the base is situated.

The soil samples at site 1 contained volatile and semivolatile organics, petroleum hydrocarbons, and metals. Contamination is limited to areas in and immediately adjacent to the burn areas. Groundwater samples at site 1 contained elevated concentrations of some metals. Concentrations of contaminants detected in soil and water were below the criteria established in the preliminary risk evaluation (PRE) for threat to human health and environment. However, no criteria exist

for total petroleum hydrocarbons (TPH), which were measured at high levels in soils at site 1.

The soil samples at site 2 contained low concentrations of petroleum hydrocarbons, cadmium, and zinc, none of which exceed the PRE criteria. Sediment samples contained bis(2-ethylhexyl)phthalate, benzo(b)fluoranthene, cadmium, and zinc. Only cadmium and zinc exceed PRE criteria. One groundwater sample contained low concentrations of TPH. This was not confirmed by a second round of samples.

The soil samples at site 3 contained low concentrations of acetone, toluene, and phthalates (common laboratory contaminants) and elevated concentrations of metals. None of the concentrations detected exceed PRE criteria. Groundwater samples at site 3 contained low concentrations of petroleum hydrocarbons. No constituents detected in groundwater samples from site 3 exceed PRE criteria.

The soil samples at sites 4 and 5 contained generally low concentrations of volatile and semivolatile organics, total petroleum hydrocarbons, and metals, none of which exceed the PRE criteria. Groundwater sample analyses indicate low concentrations of petroleum hydrocarbons and metals, none in excess of PRE criteria.

Analysis of soil samples at sites 6, 7, and 8 indicate fuel solvent constituents contamination which appears to be spread over the primary operations area of the base. High total petroleum hydrocarbon levels (for which no risk evaluation criteria exist) were detected in several soil samples. Metals concentrations in sediment samples from the drainage ditch at site 6 were above the PRE criteria. Analytical data from groundwater samples at sites 6, 7, and 8 indicate significant contamination exceeding the PRE criteria. The contaminants of concern are phthalates, benzene, and tetrachloroethene.

No immediate response actions were recommended as a result of this site investigation.

A focused feasibility study (FFS) for soils is recommended for site 1. This FFS should evaluate remediation of the site by either soil removal or in-situ treatment to reduce volatile and semivolatile organics and total petroleum hydrocarbon concentrations. Construction of additional monitoring wells at site 1 is recommended to confirm previous analytical results and to support a "no further action" decision document for groundwater.

Preparation of a "no further action" decision document is recommended for soils at site 2. Construction of additional monitoring wells at site 2 is recommended to confirm previous analytical results and to support a "no further action" decision document for groundwater.

Preparation of a "no further action" decision document for both groundwater and soils at site 3 is recommended.

Preparation of a "no further action" decision document for both soils at sites 4 and 5 is recommended. Construction of additional monitoring wells at site 4 and 5

is recommended to confirm previous analytical results and to support a "no further action" decision document for groundwater.

A remedial investigation is recommended for the primary operations area of the base, which includes sites 6,7, and 8. Contamination of this area, indicated in data gathered as part of this SI, may be from the dry wells at the three sites, from leaking underground storage tanks, or from both of these sources. This investigation should include development of additional subsurface hydrogeology, installation of additional monitoring wells, and sampling to better define the impact to groundwater, and collection and analysis of soil samples to further define the extent of contamination.

SECTION 1

INTRODUCTION

1.1 PURPOSE OF REPORT

Work on this report has been completed by Engineering-Science, Inc. (ES) under subcontract to the HAZWRAP Support Contractor Office. The HAZWRAP Support Contractor Office is operated by Martin Marietta Energy Systems, Inc. (Martin Marietta) for the U.S. Department of Energy (DOE). DOE is assisting the National Guard Bureau (NGB) by administering certain aspects of the NGB Installation Restoration Program (IRP).

This report is intended to describe the activities and present the data gathered during the site investigation (SI) at the 120th Fighter Interceptor Group (FIG), Montana Air National Guard, Great Falls International Airport, Great Falls, Montana. This SI was conducted according to the work plan developed by ES and approved by HAZWRAP on May 24, 1990, except as noted herein. SI activities at the Base officially began July 30, 1990 and were completed on October 29, 1990.

The preliminary assessment (PA) for the 120th FIG (HMTC, 1988) identified, through records search and interviews, eight sites at the base where waste management or spills may have resulted in environmental damage. The activities conducted at these eight sites as part of the SI included geophysical (at sites 6, 7, and 8 only) and soil gas surveys, soil borings to gather stratigraphic information and soil samples for analytical testing, construction of piezometers to determine groundwater flow direction, construction and sampling of groundwater monitoring wells, and sediment sampling for testing. This information will guide decision making regarding future activities at the eight sites. One of three options will be selected for each site based on the information contained herein. The options are 1) no further action, 2) remediation of the site, and 3) further investigation.

This report identifies the sites and reports fully on the investigation conducted as part of this SI. The methods of data collection and quality assurance procedures followed are fully described. Sites are characterized with respect to their setting and evident contamination, and general recommendations are made concerning any future investigations or actions considered necessary.

1.2 REPORT ORGANIZATION

The first section of this report (section 1) is an introduction to the SI conducted at the base and to the report itself, and describes previous IRP program activities at

the base, the sites investigated, and their environmental settings. Section 2 of the report describes in detail the field program carried out and identifies any deviations from the approved work plan. The results of this investigation are presented site by site in section 3. Section 4 is a preliminary risk evaluation which evaluates the potential risk to sensitive receptors (residences, water supplies, ecologically sensitive areas, etc.) based on the data available from this SI. Section 5 is titled "Immediate Response Actions Taken." However there have been no immediate response actions taken as a result of this SI. The details and conclusions presented in sections 2 through 5 are summarized in section 6 along with recommendations for future remedial activities at the base.

Following the main body of the report are a series of appendices. These appendices contain:

- Technical memoranda regarding field activities
- Risk assessment criteria
- A quality assurance report
- Logs of soil borings, wells and piezometers
- Additional activities.

The analytical data consist of several thousand pages of laboratory and quality assurance/quality control (QA/QC) data. Copies of these data are available upon request from the 120th FIG or the NGB.

1.3 FACILITY BACKGROUND

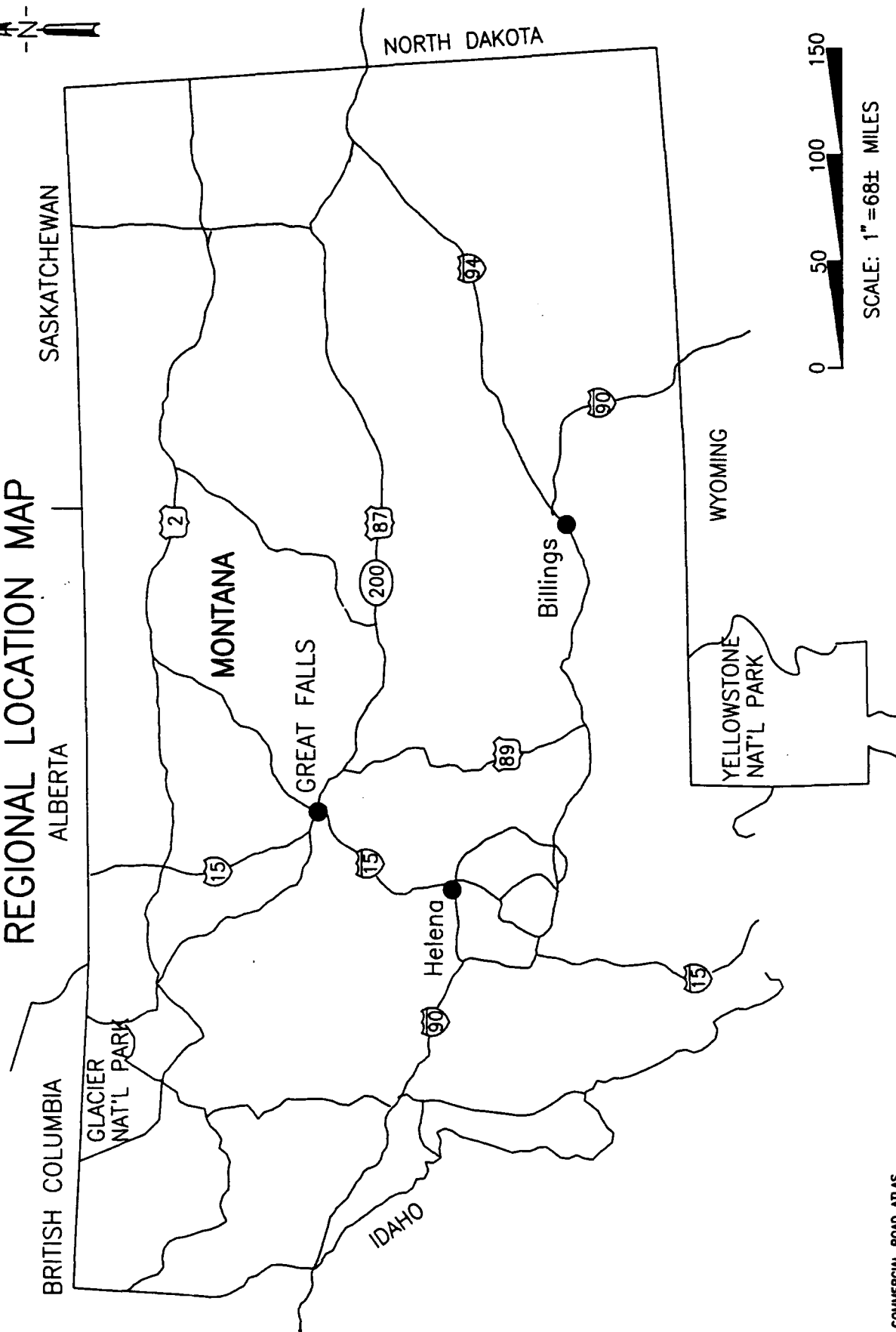
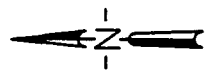
The 120th FIG is located at the Great Falls International Airport, Cascade County, Montana, approximately 3 miles southwest of Great Falls. Great Falls is located in central Montana, as shown on Figure 1.1. The base's facilities consist of over fifty buildings, occupying approximately 125 acres of land leased from the airport authority on the southeast corner of the 1,762-acre airport. Agricultural land borders the base on the west. The area immediately south of the base along Interstate 15 is designated for industrial and commercial uses. Part of the open area southwest of the airport is used for active outdoor recreation. Residential areas are located on and below the Sun River bench north and northeast of the base.

The 120th FIG's mission is to serve the U.S. Air Force and the Department of Defense (DOD) with a defense fighter group that can be mobilized in time of war or national emergency. In addition, the 120th FIG ensures air sovereignty in its assigned air defense sectors, and provides aircraft to intercept airborne objects posing a threat to the U.S. as part of the overall air defense system for the North American continent.

1.3.1 Site Descriptions

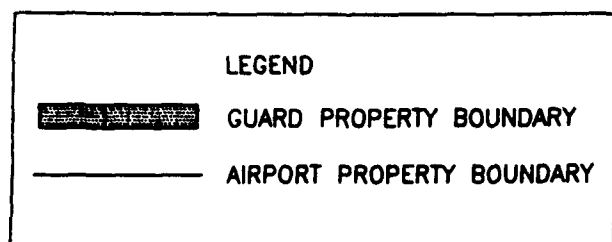
The locations of the eight potential hazardous waste sites are indicated on Figure 1.2 and briefly described below, together with previous and current site uses and potential contaminants. Site locations, descriptions, and waste quantity

FIGURE 1.1
GREAT FALLS
REGIONAL LOCATION MAP



SOURCE: COMMERCIAL ROAD ATLAS

1994 FIC International Airport, Great Falls, Montana



SITE 1
CURRENT FIRE TRAINING AREA

SITE 2
DRAINAGE DITCH
OFF OLD POWER
CHECKPAD

SMALL
ARMS
RANGE
301

POWER
CHECK
PAD

AIRPORT
BOUNDARY

AIRPORT BOUNDARY

AIRPORT BOUNDARY

SITE 4
FORMER
AREA 1

SITE 5
FORMER
AREA 2

SITE 8
DRY WELL
MAINTENAN

SUPPRESSOR
TAXIWAY

ALERT
TAXIWAY

AIRPORT BOUNDARY

BOUNDARY
BOUNDARY

AIRPORT
BOUNDARY

ING AREA

GE DITCH
POWER
AD

SMALL
ARMS
RANGE
301

POWER
CHECK
PAD

SITE 4
FORMER FIRE TRAINING
AREA 1

SITE 5
FORMER FIRE TRAINING
AREA 2

SITE 8
DRY WELL OFF COMPOSITE
MAINTENANCE BUILDING 32

SUPPRESSOR
TAXIWAY

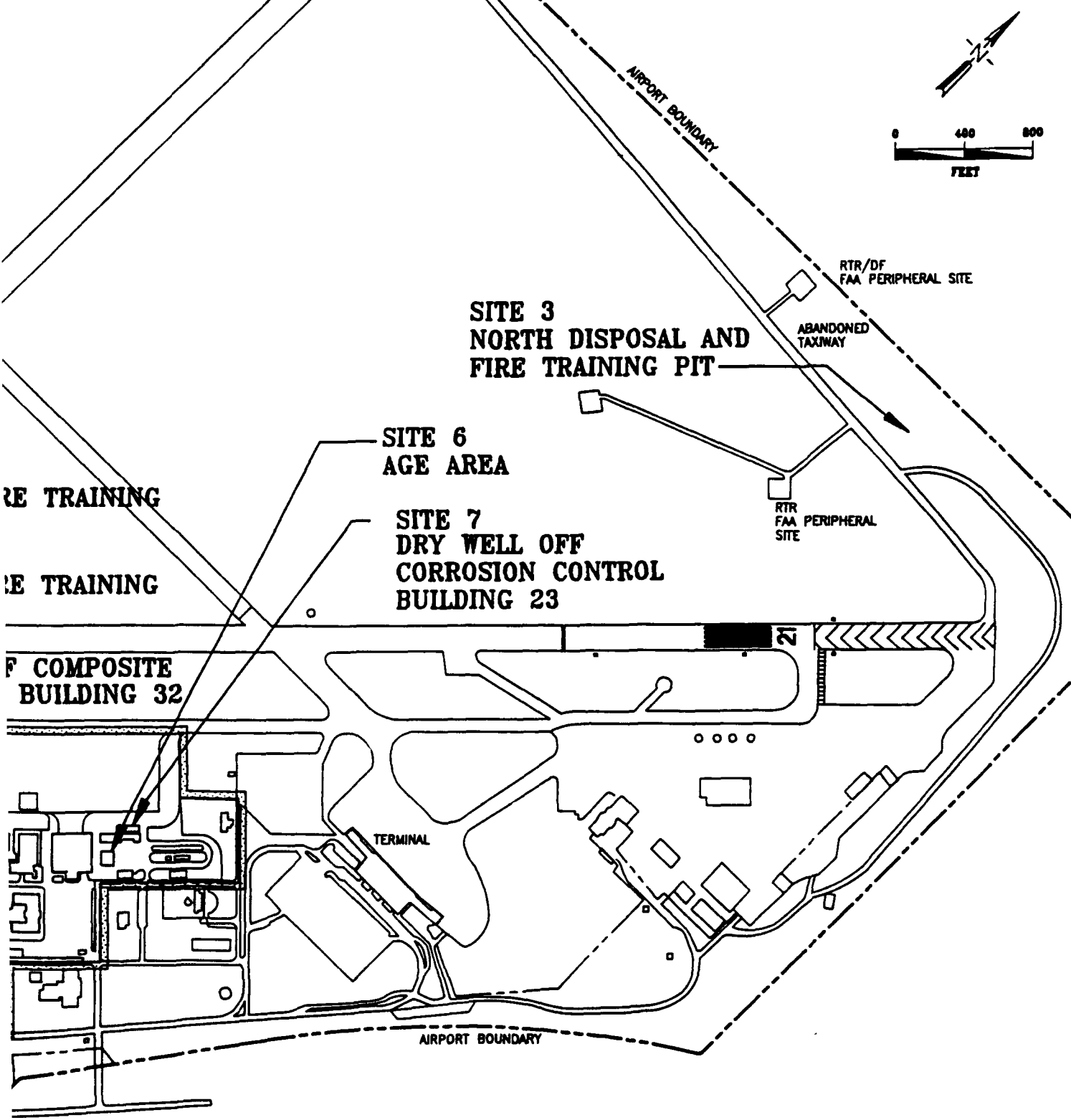
ALERT
TAXIWAY

SIT
AG

SE
DI
CO
BU

TERMIN

FIGURE 1.2
IRP SITE LOCATIONS
120th FIG, INTERNATIONAL AIRPORT
GREAT FALLS, MONTANA



estimates are taken from the PA for the base (HMTTC, 1988), from the site survey conducted at the time of the October 1989 kickoff meeting, and from observations during SI field work conducted July through October 1990. A more detailed discussion of each site is presented in section 3 of this report.

Site 1: Current Fire Training Area¹

Site 1 was used as a fire training area (FTA) from 1968 until early in 1989. The site is located on the west side of the airport facility, west of the power check pad and the small arms range, and consists of one large and three small FTAs. The PA reported stained soil in all areas and cans, wood, metal, and tire debris in the smaller areas. The site was mostly clear of small debris during the SI, but a large cylindrical, metal object positioned in the center of the large FTA remained. This object aided in simulation of a burning aircraft during the fire training exercises. As much as 30,000 gallons of fuel and other flammable liquids may have seeped into the soil at this site.

Site 2: Drainage Ditch Off Old Power Check Pad

The old power check pad was used regularly when the 120th FIG flew the F-106 Delta Dart from 1972 to 1987, and has since been used less frequently. Petroleum, oil, and lubricant (POL) waste from overflow of an underground oil-water separator and storage tank (both still in place) may have contaminated a northwest-trending drainage ditch located between the old power check pad and the small arms range on the west side of the airport facility. Overflow from the tank drained through a 10-inch-diameter buried pipe (still in place) which discharges to the ditch about 250 feet away. The ditch also receives storm runoff from the power check pad. Waste quantities discharged at this site are unknown.

Site 3: North Disposal and Fire Training Pit

Three sources of waste released in or near a pit located at site 3 were identified during the PA: contaminated jet fuel from 1957 to 1960, waste fuels, oils, thinners, and solvents from FTA activities from 1966 to 1968, and unknown quantities of flammable liquids disposed of in the pit and surrounding areas over the life of the site. According to the PA, approximately 27,000 gallons of unburned fuel were released at the site. The location of the former FTA pit could not be definitively identified during SI field work, and no visual evidence of disposal of the above-described wastes was observed during the SI. Piles of asphalt-base material which covered a large portion of site 3 during the initial phases of SI field work were removed during the course of the field investigation, leaving a flat area scraped smooth by earth-moving equipment.

Site 4: Former Fire Training Area 1

Former FTA 1 was used for one fire training exercise per month from 1959 to 1963, and an estimated 20,000 gallons of unburned fuel was deposited at the site.

¹ The term "current" is used for consistency with the 1988 PA report and does not indicate ongoing fire training activities at this site.

The site is located off the northwest side of the "hush house," and portions are now paved over.

Site 5: Former Fire Training Area 2

Former FTA 2 was used for one fire training exercise per month from 1964 to 1966, and an estimated 6,500 gallons of unburned fuel was deposited at the site. The site is located off the northwest side of the "alert barns," approximately 400 feet northeast of former FTA 1. A portion of the site is now paved over.

Site 6: Aerospace Ground Equipment (AGE, Building 22) Area

Approximately 17,000 gallons of POL waste, hydraulic fluid, and solvents were discharged to a 3-foot-diameter, brick-lined dry well located adjacent to the southwest side of building 22 from 1962 to 1978. This dry well was paved over in 1978. In addition, small amounts of waste oil were reportedly discharged to a ditch located southeast of building 22 during the same period. Discussions with base personnel during SI activities indicated that a small aboveground dumpster which received wastes from area buildings may have been located in the area of this ditch.

Site 7: Dry Well Off Corrosion Control Building (Building 23)

From 1955 to 1964, approximately 9,400 gallons of motor pool waste oils and fuels were disposed of, via an underground pipe, to a dry well located within 10 feet of the northwest wall of building 23. This well is currently covered by a lawn. A second dry well suspected to be located at the site off the east corner of the building was not found during the SI geophysical survey. Base personnel indicated at the time of the kickoff meeting that this second well may never have been installed.

Site 8: Dry Well Off Composite Maintenance Building (Building 32)

From 1971 to 1977, small amounts of waste engine oil, hydraulic fluids, paint strippers and thinners, JP-4, and PD-680 may have been deposited in a dry well located between buildings 30 and 32. This dry well is currently paved over with asphalt.

1.3.2 Facility History

The base was first used as a military installation before and during World War II, when the Army Air Corps 7th Ferry Group was headquartered at what was then called Gore Field. The 7th Ferry Group airlifted lend-lease equipment and supplies to the Soviet Union. The Air Force and the Air National Guard were formed after the war.

The present Montana Air National Guard began as the 186th Fighter Squadron on June 27, 1947, with Lt. Col. Willard S. Sperry as commander. The 186th was activated during the Korean police action and served at Moody Air Force Base (AFB), Georgia, and later at George AFB, California. Some 186th personnel served in Korea, Ohio, or at Malmstrom AFB, Montana, during this period. The unit was deactivated on December 31, 1952.

In 1953, the 186th became the first National Guard unit in the United States to fly the F-86A jet fighter. Six new buildings were constructed during the expansion

program of 1954. The 120th Fighter Interceptor Group came into existence on April 16, 1956. The runway was extended in 1960 to accommodate the F-89J aircraft. In 1984, the unit's mission was expanded when it was assigned the additional task of operating an alert detachment at Davis-Monthan AFB, Tucson, Arizona. Since July 1, 1987, the unit has flown the F-16 "Fighting Falcon."

1.4 PREVIOUS PROGRAM ACTIVITIES

The National Guard Bureau commissioned the study at the 120th FIG as part of the IRP because base operations had involved use and disposal of materials that were subsequently categorized as hazardous. The IRP was initiated at the base with a preliminary assessment conducted April 25 through 29, 1988, and reported August 1988 (HMTTC, 1988). Based on the results of the PA, the National Guard Bureau decided that environmental data must be collected to confirm and quantify any contamination that may have an adverse impact on public health or the environment.

A site investigation at the 120th FIG was planned. HAZWRAP was contracted by DOE on behalf of the NGB to perform the SI. HAZWRAP contracted ES to conduct the SI. A kickoff meeting was held at the site during October 1989, with NGB, 120th FIG, HAZWRAP, and ES personnel in attendance. Representatives from the EPA Helena office, the Montana Department of Health and Environmental Science, the Cascade County/Great Falls City Health Department were also present. Environmental information in addition to that published in the PA report (HMTTC, 1988) was collected by ES during and after the kickoff meeting, and decisions were made concerning the investigative approaches to be employed during the SI.

1.5 REGIONAL INVESTIGATION AREA

The environmental setting at the Great Falls International Airport is examined here to establish a reference for describing site-specific work performed at the site during this investigation.

1.5.1 Environmental Setting

Cultural

Great Falls is the dominant urban area in Cascade County, Montana, and is the trade center for twelve surrounding counties. The 1987 populations of Cascade County and Great Falls were 79,400 and 57,310, respectively. Agriculture, government, and service sectors make up the Cascade County economy. Government employment, including military, accounts for 26 percent of the Cascade County work force (Williams, 1986). The 120th FIG has an annual payroll of \$15.3 million, employing 1,004 part-time and 338 full-time members.

Cascade County has experienced declines in employment in recent years due to the closing of the Anaconda smelter and a Burlington Northern facility. Layoffs at a local brewery and reductions in government employment have resulted in additional declines (Williams, 1986).

The tourist industry is a growing segment of the Great Falls area economy. Proximity to Glacier National Park and other areas of outdoor recreation are being marketed in the area. Tourists are drawn to Great Falls to see the C.M. Russell Museum, Giant Springs Heritage State Park (one of the largest freshwater springs in the world), and historic landmarks of the Lewis and Clark Expedition.

Meteorology

The meteorological data presented in the PA were derived from local climatological data for the Great Falls area compiled by the National Oceanic and Atmospheric Administration (NOAA). The climate of the Great Falls area is semiarid. Mean annual precipitation is about 15 inches. About 70 percent of the annual total rainfall normally occurs between April and September. The mean annual temperature is about 45°F, with winters averaging 25°F and summers averaging 66°F.

Calculations performed by the method outlined in the *Federal Register* (47 FR 31224) indicate a net precipitation value of -19 inches per year in the area. The maximum rainfall intensity, based on a 1-year, 24-hour rainfall, is 1.25 inches (47 FR 31235).

Geography

Great Falls is located in central Montana, east of the Continental Divide, 91 miles northeast of Helena, and about 120 miles south of the Canadian border, as shown on Figure 1.1. The Missouri and Sun rivers flow through Great Falls. Major highways serving the city are Interstate 15, U.S. Highways 87 and 89, and Montana Highway 200.

The base lies on the northeastern edge of the Sun River bench, a topographic feature situated about 350 feet above the Sun and Missouri Rivers south and southwest of Great Falls. The elevation of the base is 3,674 feet above mean sea level. The Sun River bench is a relatively flat plateau that slopes down toward the northwest at approximately 50 feet per mile. The base is located in the Great Plains physiographic province, east of the boundary of the Northern Rocky Mountains province and the Great Plains province, as shown on Figure 1.3. The Great Plains are generally flat with areas of negative relief such as the Missouri River valley and areas of positive relief such as the Highwood Mountains.

The Missouri River originates on the eastern flank of the Continental Divide, flows northeasterly, and bisects and traverses Great Falls Township from the south to the northeast. The Sun River flows east from its headwaters near the Continental Divide and joins the Missouri River at Great Falls. The confluence of the two rivers is about 2 miles northeast of the base. The base obtains potable water from the City of Great Falls. The City of Great Falls water supply is obtained from the Missouri River. The base storm runoff drains into the Sun River via a network of swales, ditches, culverts, drop inlets, collector pipes, and trunk lines. Other runoff at the base flows into sanitary sewers and eventually reaches the city's waste treatment facility, which discharges to the Missouri River. Surface drainage on base property is depicted on Figure 1.4.

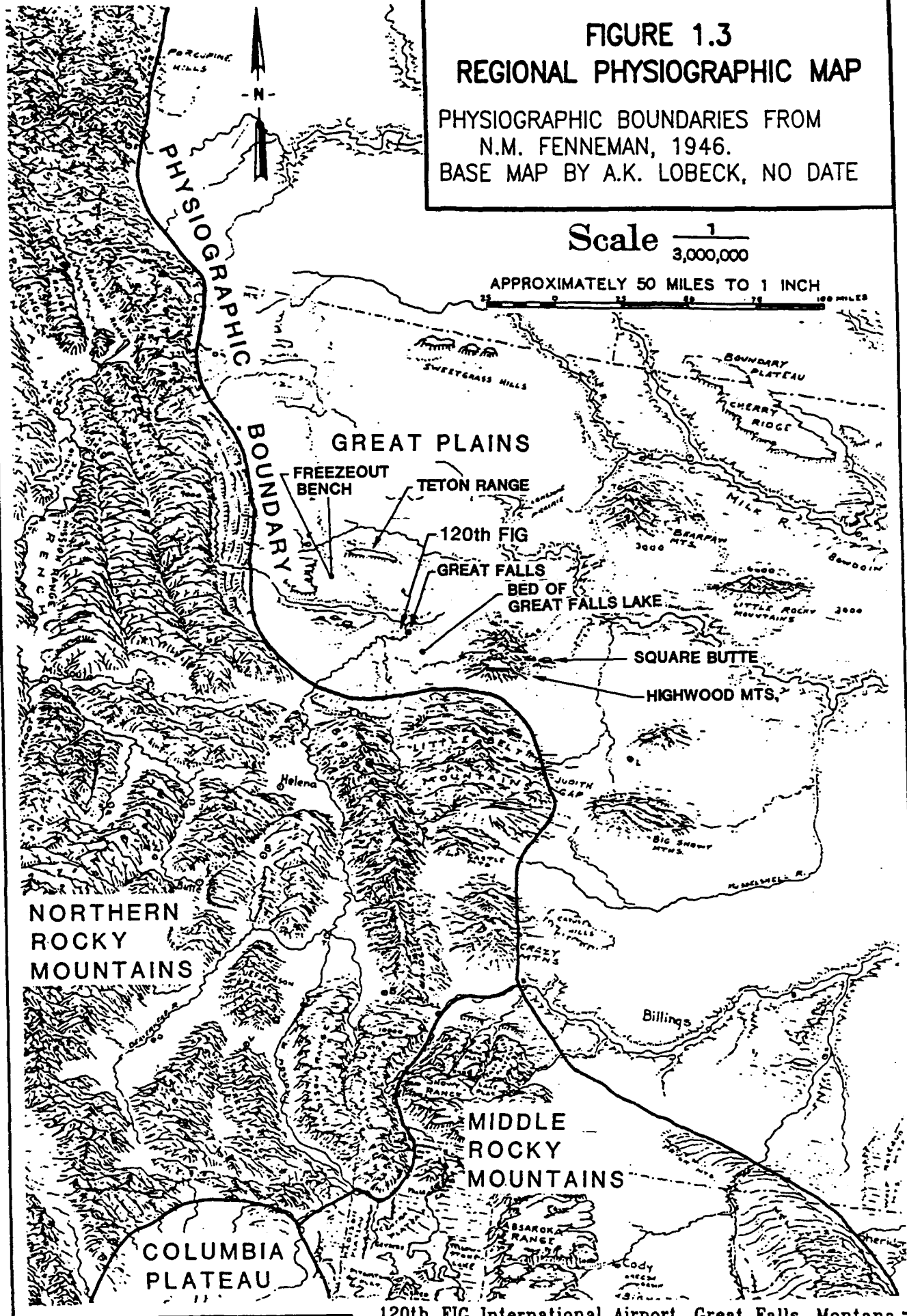
FIGURE 1.3 REGIONAL PHYSIOGRAPHIC MAP

PHYSIOGRAPHIC BOUNDARIES FROM
N.M. FENNEMAN, 1946.
BASE MAP BY A.K. LOBECK, NO DATE

Scale $\frac{1}{3,000,000}$

APPROXIMATELY 50 MILES TO 1 INCH

0 20 40 60 80 100 MILES



120th FIG International Airport, Great Falls, Montana

1.5.2 Regional Geology and Hydrogeology

Geology

The base is situated on sandy, silty loams and loamy sands of the Tally-Azaar-Litten Association (Soil Conservation Service, 1982). Of this group, about 45 percent is Tally soils, 20 percent Azaar soils, 15 percent Litten soils, and 20 percent minor soils, as shown on Figure 1.5. These soils typically have a low shrink-swell potential and a high infiltration rate, with estimated permeabilities ranging from 2 to 20 inches per hour (Soil Conservation Service, 1982). The low clay content of the soils results in a low available water capacity. In a typical soil profile, the surface layer is approximately 7 inches thick and consists of a dark grayish-brown fine sandy loam and an underlying material of light brown and grayish-brown fine sandy to silty clay loam. Total thickness of the soil ranges from 20 inches to greater than 40 inches (Soil Conservation Service, 1982).

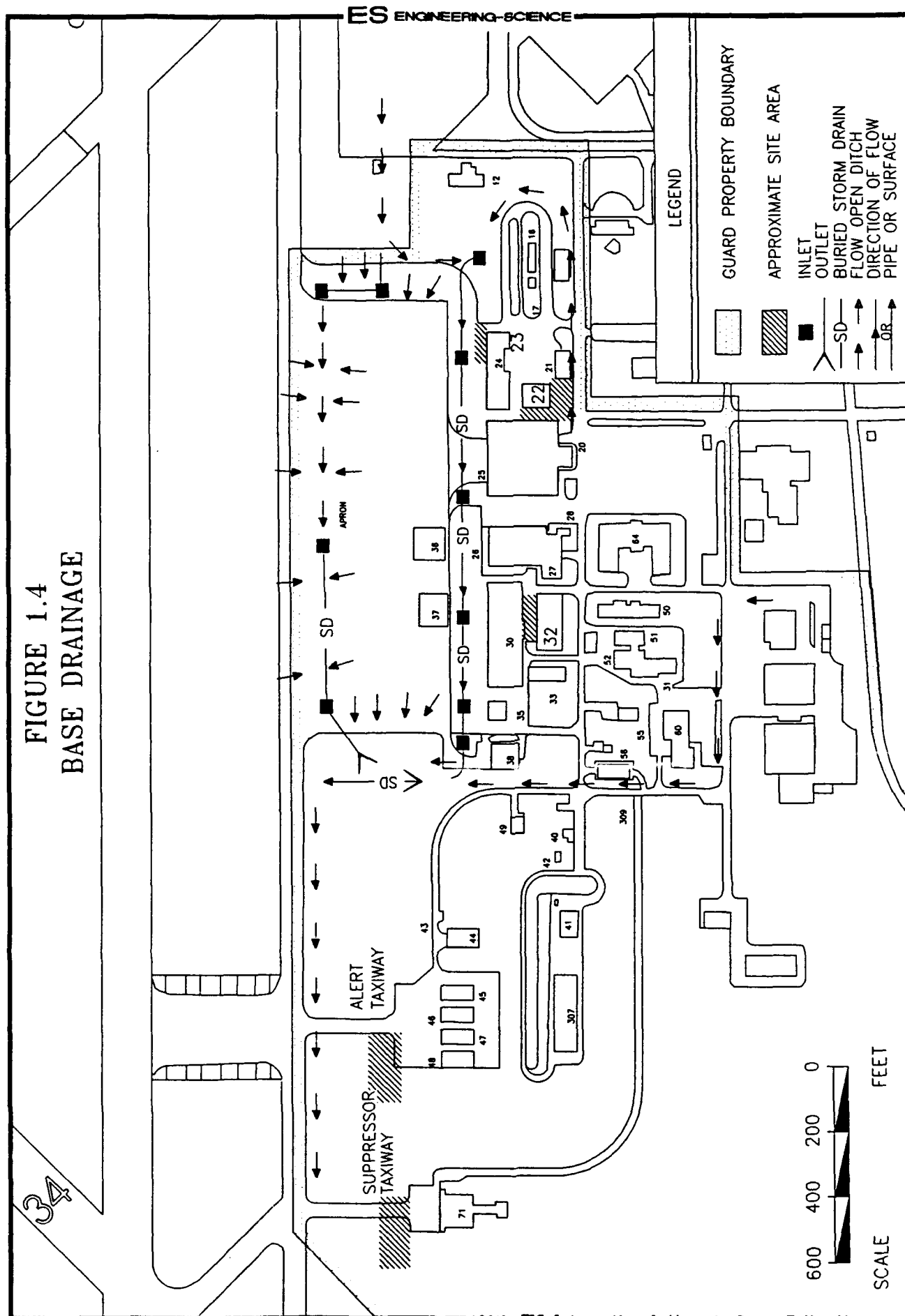
Geologic units exposed at the base and in surrounding areas are shown on Figure 1.6. The base is situated on the northeastern edge of the Sun River bench, a plateau of Cretaceous-aged rock which rises about 350 feet above Great Falls and slopes gently to the northwest. The cross section, Figure 1.7, shows the bench in relation to the valley floor and the relative positions of geologic units underlying the area. The location of the cross section is shown on Figure 1.6.

The rock units that underlie the base are, in descending order, the Taft Hill and Flood Members of the Blackleaf Formation, which belong to the Colorado Group, and the Kootenai Formation, all of which are of Cretaceous age; Morrison and Swift Formations of Jurassic age; and the Madison Group of Mississippian age.

Erosional remnants of the Taft Hill Member outcrop at and around the base, making up the majority of the unconsolidated to semiconsolidated material found in the upper 15 to 20 feet of material underlying the base. This member consists of marine strata of medium gray, soft, bentonitic clayey to silty shale and greenish-gray glauconitic sandstone, and also contains beds of nonglauconitic sandstone, siltstone, bentonite, and calcareous concretions (Lemke, 1977). At the type locality for this formation, which is west of the base, the member is apparently 240 feet thick with the beds thinning to the east (Fox, 1966).

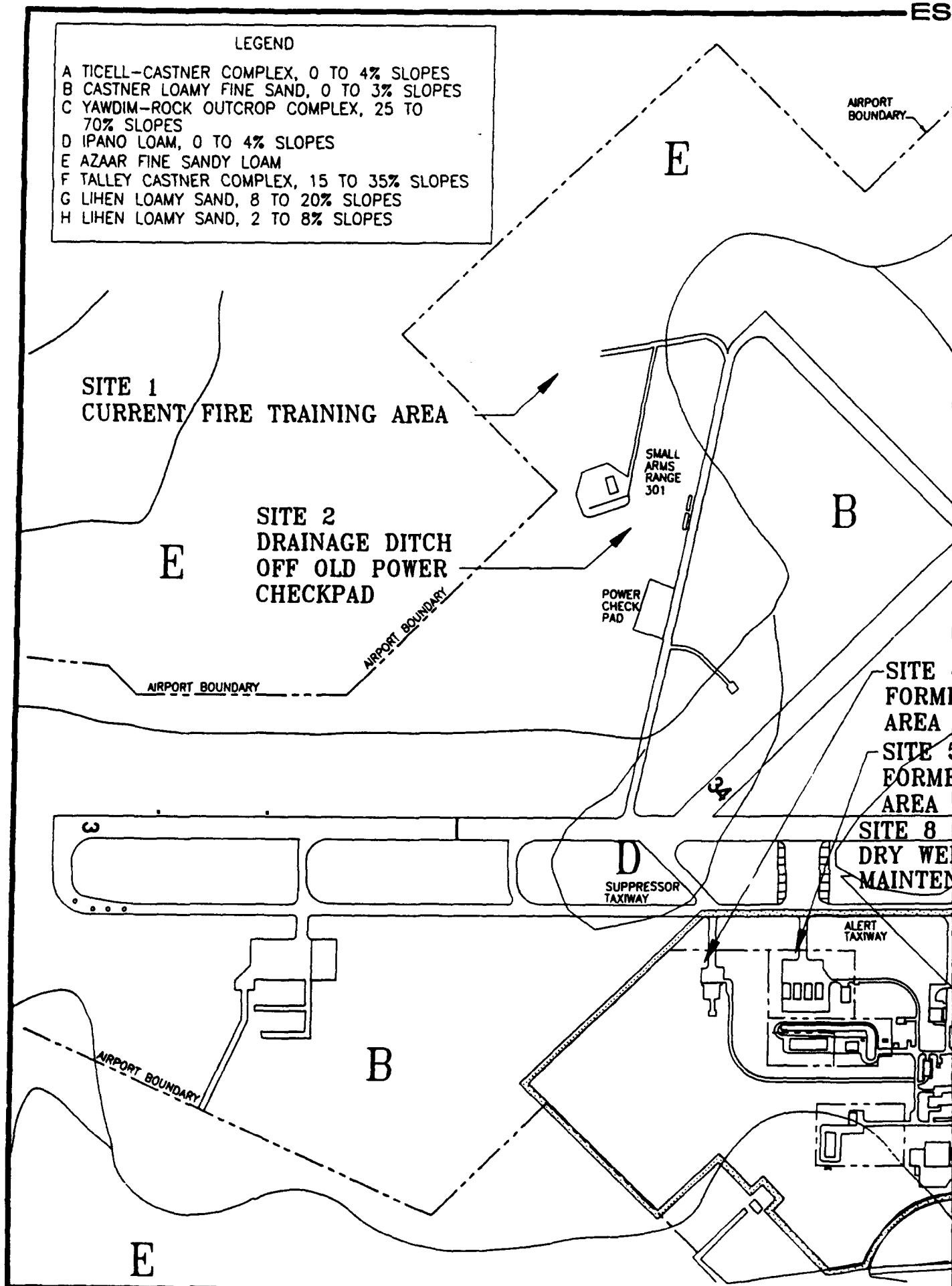
The Flood Member is the first competent rock encountered at the base. This member is composed of marine strata consisting of a lower unit of sandstone and siltstone, a middle unit of shale that is soft and dark gray, and an upper unit of cliff-forming sandstone. The upper unit accounts for 48 percent of the total thickness, with the shale accounting for 32 percent and the lower unit 16 percent (Wilke, 1983). At the type section for this formation, located 5 miles southwest of Great Falls, the member is 138 feet thick and ranges up to approximately 200 feet thick west of the base. Only the upper and middle units of the Flood Member were encountered during SI drilling activities. The upper sandstone forms the cliffs around the edge of the Sun River bench and consists of light gray, very fine to medium-grained quartz and chert sandstone. The sandstone weathers tan-brown to red-brown, and has either a clayey matrix or siliceous cement. The sandstone is characterized by massive beds showing vertical and horizontal joints, occasional

FIGURE 1.4
BASE DRAINAGE



LEGEND

- A TICELL-CASTNER COMPLEX, 0 TO 4% SLOPES
- B CASTNER LOAMY FINE SAND, 0 TO 3% SLOPES
- C YAWDIM-ROCK OUTCROP COMPLEX, 25 TO 70% SLOPES
- D IPANO LOAM, 0 TO 4% SLOPES
- E AZAAR FINE SANDY LOAM
- F TALLEY CASTNER COMPLEX, 15 TO 35% SLOPES
- G LIHEN LOAMY SAND, 8 TO 20% SLOPES
- H LIHEN LOAMY SAND, 2 TO 8% SLOPES



TO 4% SLOPES
0 TO 3% SLOPES
PLEX, 25 TO

ES

5 TO 35% SLOPES
% SLOPES
% SLOPES

AIRPORT
BOUNDARY

E

NING AREA

2
NAGE DITCH
OLD POWER
KPAD

AIRPORT BOUNDARY

SMALL
ARMS
RANGE
301

POWER
CHECK
PAD

B

D

A

SITE 4
FORMER FIRE TRAINING
AREA 1

A

SITE 5
FORMER FIRE TRAINING
AREA 2

SITE 8
DRY WELL OFF COMPOSITE
MAINTENANCE BUILDING 32

D
SUPPRESSOR
TAXIWAY

ALERT
TAXIWAY

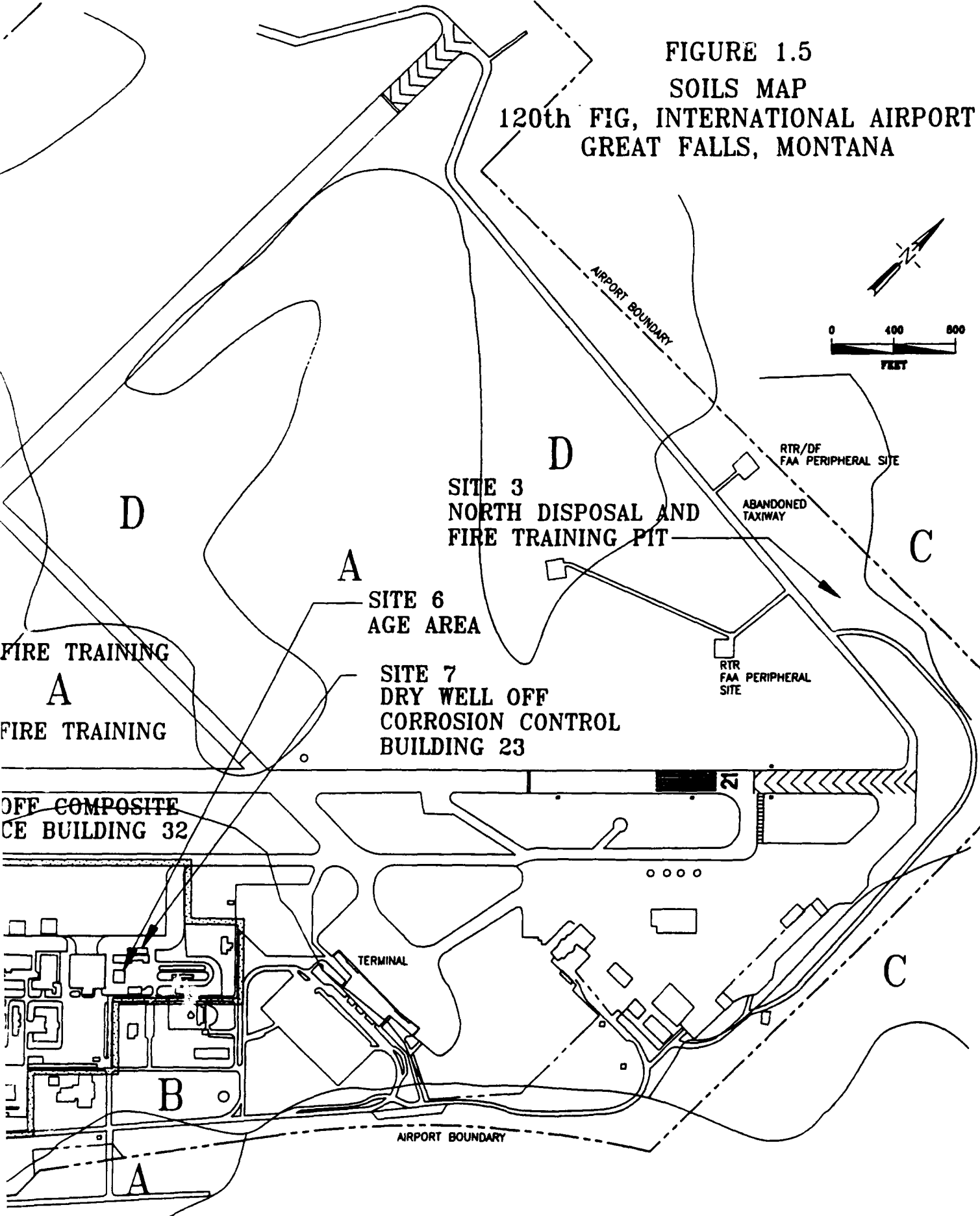
B

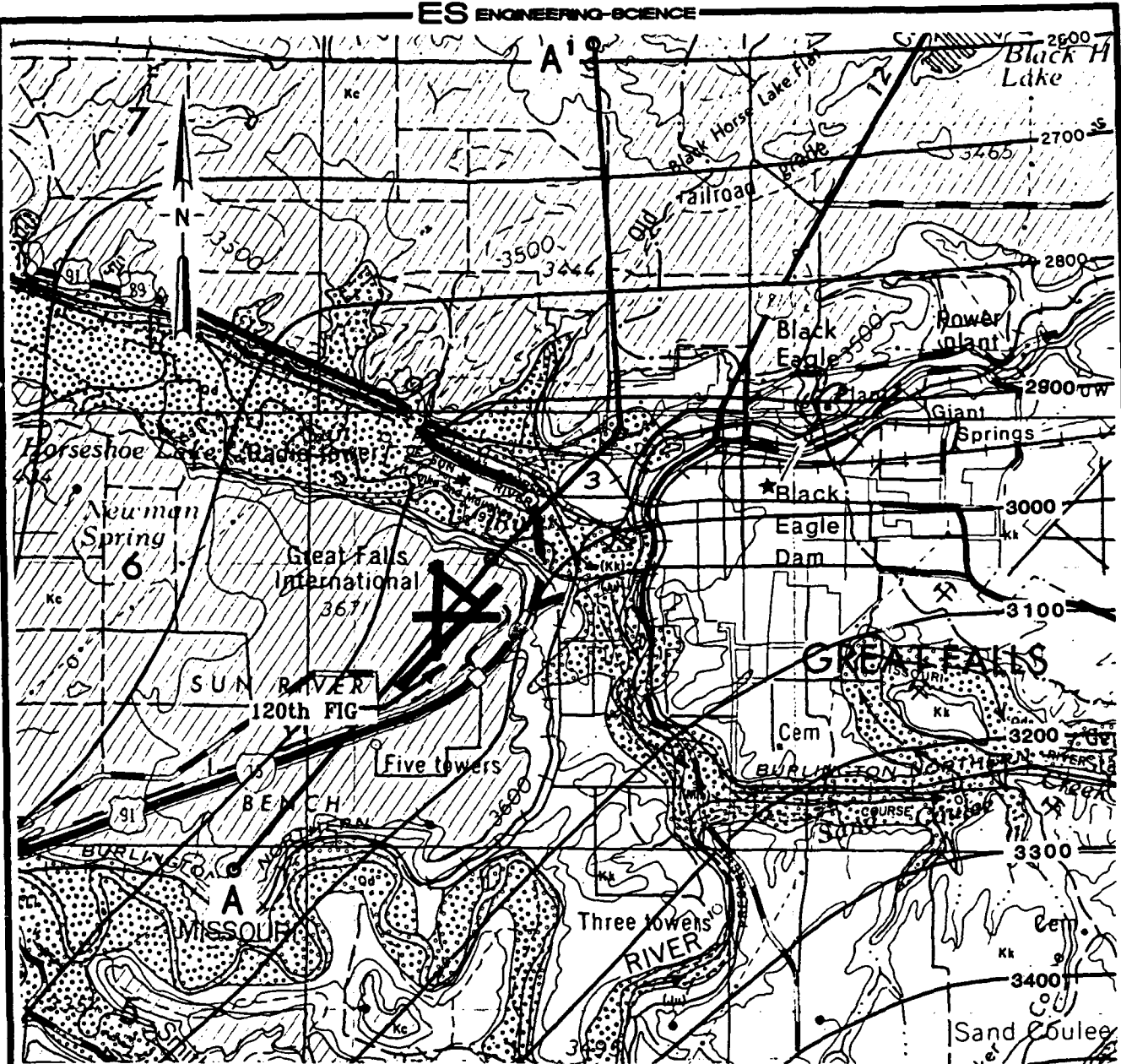
B

A

TERM

FIGURE 1.5
SOILS MAP
120th FIG, INTERNATIONAL AIRPORT
GREAT FALLS, MONTANA





DESCRIPTION OF MAP UNITS

-  QUATERNARY DEPOSITS
-  COLORADO GROUP
-  KOOTENAI FORMATION
-  MORRISON FORMATION
-  SWIFT FORMATION
-  MADISON GROUP

1 1/2 0 1 2 3 4 5 MILES

CONTOUR INTERVAL 200 FEET
WITH SUPPLEMENTARY CONTOURS AT 100-FOOT INTERVALS
DATUM IS SEA LEVEL

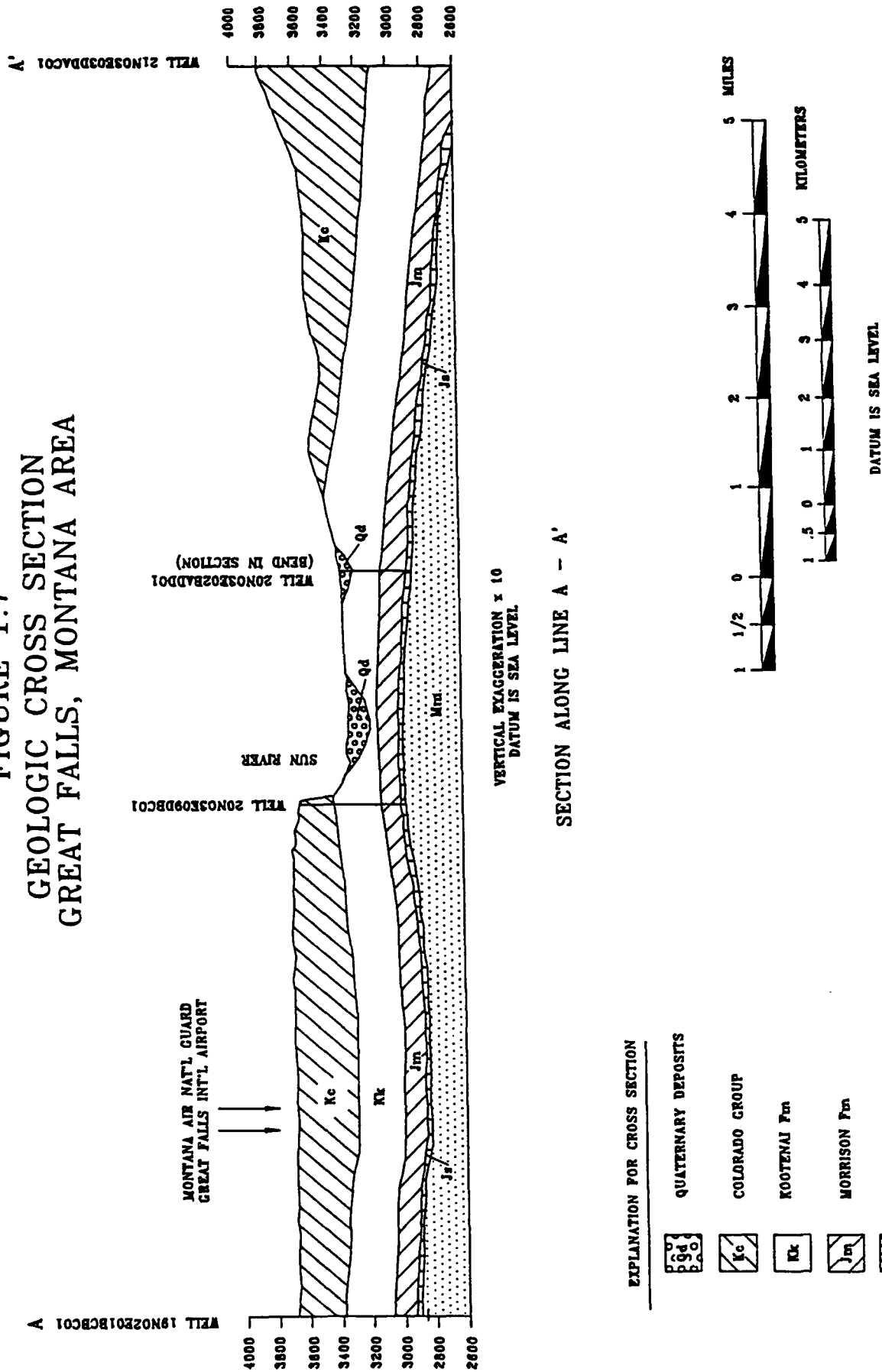
Elevation of the top
— 2800 — of the Madison group

A A'
LOCATION OF CROSS SECTION

SOURCE: APPRAISAL OF WATER IN BEDROCK AQUIFERS,
NORTHERN CASCADE COUNTY, MONTANA.
K.R. WILKE 1983 M.B.M.G. MEMOIR #54

FIGURE 1.6
GEOLOGIC MAP

FIGURE 1.7
GEOLOGIC CROSS SECTION
GREAT FALLS, MONTANA AREA



SOURCE: APPRAISAL OF WATER IN BEDROCK AQUIFERS, NORTHERN CASCADE COUNTY, MONTANA. K.R. WILKE 1983 M.B.M.C. MEMOIR 54

fossil wood, and widely scattered ferruginous calcareous dark brown to red concretions 1 to 4 inches in diameter (Fox, 1966).

The contact between the upper and middle units of the Flood is gradational. The middle unit consists of interbedded sandstones and shales that slump extensively. The sandstone is tan and fine to medium-grained and weathers to a light tan gray. Although some beds are argillaceous and friable, siliceous cement is common. The shale beds are dark gray and weather light gray, are both sandy and silty, and are generally calcareous. Also, an occasional laminate of coal was found along with some pyrite deposits.

The Kootenai Formation underlies the Flood Member and consists of 350 to 400 feet of nonmarine, interbedded, dark red, purple, or greenish-gray shales and siltstone with discontinuous light gray to buff sandstone beds and a few impure limestone lenses (Wilke, 1983). The formation is divided into three members: an upper, mostly mudstone and shale member, a lower sandstone and siltstone member, and a basal sandstone known as the Sunburst Sandstone.

The Morrison Formation lies unconformably under the Kootenai Formation and is about 100 to 180 feet thick. It is composed of varicolored, mainly greenish-gray, interbedded shale and siltstone with some discontinuous limestone and sandstone beds (Wilke, 1983).

The Swift Formation unconformably overlies the Madison Group. The formation is mostly fine-grained, light gray, cross-bedded quartz sandstone of marine origin and is cemented predominantly with calcite. In the Great Falls area, the formation is 5 to 20 feet thick and thickens to the east and southeast (Wilke, 1983).

The Madison Group is composed of massive to thin beds of gray, dense limestone with interbeds of shale and chert (Wilke, 1983). The top of this unit is approximately 800 to 900 feet below the top of the Sun River bench.

Hydrogeology

Groundwater at the base is present in each of the rock units described above. The shallowest groundwater encountered at the base occurs in the upper sandstone of the Flood Member. Regional groundwater flow in the area is to the west-northwest. Each of the aquifers is discussed below.

The Flood Sandstone on the Sun River bench is a perched aquifer (Wilke, 1983). North and west of the bench, hydrologic conditions change from perched to water table to confined. The relatively impermeable shale in the underlying Kootenai and the shales found in the middle of the Flood retard the vertical movement of water, producing the perched condition. The general groundwater flow in the Flood is to the north-northwest. However, due to seasonal fluctuations, surface topography, and variations in the underlying confining shales of the area, there may be localized areas where the groundwater flow direction are different. This is typical of groundwater in perched conditions and is evident at the base. Wells completed in the Flood are less than 100 feet deep and are important sources of water for domestic and stock uses on the bench. Water levels in the wells range from 20 to 100 feet below ground level. Reported well yields range from 6 to

40 gallons per minute (gpm) (Wilke, 1983). Well logs were obtained from the State of Montana and screened for active wells based on the regional gradient (north-northwest). Well logs were examined for the area between the base and the river. Well logs were not examined for wells across the river from the base. The logs indicate several active wells within a mile of the base to the north, northwest, and southeast. The Flood Member is recharged mainly from infiltration of precipitation on the bench. Groundwater movement is generally downdip, or to the northwest, except near outcrop boundaries. Therefore, local gradients at each site at the base are influenced by proximity to the cliffs and local topographic features. This conclusion is supported by the presence of springs along the cliffs that surround the bench. Limited water quality data are available for the Flood, but samples indicate that the water is of a sodium sulfate and sodium bicarbonate type, with dissolved solids concentrations ranging from 2,700 to 2,800 milligrams per liter (mg/L) (Wilke, 1983).

The basal sandstone and the discontinuous sandstones of the Kootenai Formation also form an important aquifer in the area. Water levels reflect water table conditions, although some water levels on the bench reflect perched conditions (Wilke, 1983). Like the Flood, the Kootenai is believed to become confined north and west of the bench. There are some wells in the vicinity of the base completed in the Kootenai. These wells are used for domestic purposes. Well yields are reported to range from >5 to 50 gpm, with water levels ranging from 24 to 115 feet below ground level (Wilke, 1983). The groundwater movement of the Kootenai is thought to be to the northwest following the regional dip, although local gradients may also be influenced as with the Flood Member. The water of the Kootenai characteristically contains magnesium, sodium, bicarbonate, and sulfate, with dissolved solids concentrations ranging from 558 to 1,550 mg/L (Wilke, 1983).

The water-bearing units of the Morrison Formation are relatively undefined, with sandstone beds of varying thicknesses and areal extents supplying water to wells. There are a few domestic wells in the vicinity of the site completed in the Morrison. Reported yields range from 4 to 72 gpm, with water levels ranging from 52 to 308 feet below ground surface. Limited water quality data are available for the Morrison and reflect no common chemical characteristics, with dissolved solids concentrations ranging from 908 to 1,480 mg/L (Wilke, 1983).

The upper limestone of the Madison and the Swift sandstone can be considered as a single aquifer. The Madison-Swift aquifer is generally confined except in the area around Great Falls, Montana, where water levels indicate water table conditions. Reported yields from wells in the aquifer range from 3 to 338 gpm, with water levels ranging from 7 to 340 feet below ground level. Groundwater movement is generally to the northwest. Water quality data reflect a calcium sulfate type water, with large concentrations of iron and fluoride and dissolved solids concentrations ranging from 520 to 1,570 mg/L. The Madison-Swift is recharged from infiltration of precipitation and runoff in outcrop areas and from leakage of overlying aquifers (Wilke, 1977).

The unconsolidated quaternary-deposits aquifer in the Great Falls area is generally less than 40 feet thick and contains alluvium of the Sun and Missouri rivers.

The unconsolidated deposits overlie, and are hydraulically connected to, parts of all the bedrock aquifers in the Great Falls area, with the exception of the Colorado Group on the Sun River bench (Wilke, 1977).

SECTION 2

FIELD PROGRAM

2.1 SUMMARY

This section describes the activities conducted for site investigations at the 120th Fighter Interceptor Group. The results of these investigations are presented and discussed in section 3.

Field investigations at each site were conducted as two tasks. The first task, referred to as field screening, consists of activities designed to gather preliminary information regarding the nature and extent of contamination at a site. These screening data were then used to develop the detailed plan for the second task: confirmation and delineation. Confirmation and delineation activities were designed to confirm the information gained during the field screening activities and to provide data of sufficient quality to support recommendations for additional activities or recommendations for no further action. Field activities at each site consisted of the following:

1. Soil gas survey - field screening to delineate the area most likely to contain residuals of wastes disposed of at the site.
2. Piezometer construction - field screening to determine the depth to groundwater and groundwater flow direction. This information is needed to determine the necessary depth and proper placement of monitoring wells.
3. Soil borings - to obtain soil samples at various depths for field screening with field analytical instruments and shipment to an environmental laboratory for confirmation analyses. Field instruments used were a portable HNU trace gas analyzer (for measuring volatile organics) and a portable gas chromatograph (GC).
4. Monitoring well construction - to obtain groundwater samples for shipment to an environmental laboratory for confirmation analyses.

In addition to the above activities, the following were conducted only at the specified sites:

1. Geophysical survey - field screening with ground-penetrating radar to locate dry wells at sites 6, 7, and 8.
2. Sediment sampling - to obtain sediment samples from drainage ditches at sites 2 and 6 suspected to have received waste.

In general, field activities were carried out as described in the work plan. Following is a list of exceptions to this work plan:

1. No mobile field laboratory was used during this investigation. Instead, a portable GC was used to screen soil samples for volatile organics only, which as shown by the correlation between screening data and CLP laboratory data (section 3), proved adequate for the screening task.
2. Piezometers were originally installed as temporary, as described in the work plan. However, during the course of the investigation, significant leaks from water lines in the area were discovered. Since these leaks may have impacted groundwater levels, it was decided to leave these piezometers in place to allow for future water level measurements. A bentonite slurry and a concrete pad were put in place, along with a locking protective casing. This "permanent" piezometer design does not conform to the design described in the approved work plan.
3. To address the water leak problems described in item 2 above, two additional piezometers were constructed in the active base area. These additional piezometers were needed to determine the impact of water leaks on local groundwater elevations and flow direction.
4. One additional monitoring well was installed at site 4. During construction of the planned well at this site, a shallow water-bearing zone was encountered at a depth of 6 to 11 feet. Since it could not be determined if the water encountered was from leaks in the base water system, and since this zone was producing a significant amount of water, it was decided to construct and sample a second monitoring well at this site to monitor this zone.
5. Some soil borings at site 3 were placed without adequate soil gas information. At the time of the soil gas survey at this site, a large pile of asphalt was located in the middle of the area suspected to have been used for fire training activities. A soil gas survey could not be conducted in this area, and the soil borings in this area were placed on a biased grid.
6. Off-scale readings for volatile organic compounds were observed during the soil gas survey at site 1 at all points on the edge of the larger stained area. (The specific organic compounds present were not identified due to the off-scale readings.) Therefore, no soil gas sample points were placed in the larger stained area. In addition, since both visual observation and soil gas results indicated gross soil contamination in the burn areas, no soil borings were placed directly in the main burn area, though one boring was placed in a smaller stained area. Instead, soil borings were placed in the surrounding area in an attempt to delineate the lateral extent of soil contamination. Soils at site 1 extend less than 5 feet prior to refusal at weathered sandstone, so delineation of the vertical extent of soil contamination in the soils was not done.

7. The geophysics survey indicated that there was no second dry well at site 7. Therefore, no soil gas survey was conducted, and no soil borings were placed in the area where the second dry well was thought to have been located.
8. Additional soil gas survey points and soil borings were placed immediately northwest of site 6, the site of a suspected leaking underground storage tank. The results of the additional soil gas survey were used in locating the additional soil borings. The information obtained during these additional activities is presented in appendix C to this report.

2.2 GEOLOGIC AND HYDROGEOLOGIC INVESTIGATIONS

No geologic or hydrogeologic investigations were carried out during field activities other than the site-specific activities described below.

2.3 FIELD SCREENING ACTIVITIES

2.3.1 Soil Gas Survey

The first screening tool used at the base to help characterize the site was the soil gas survey. This type of screening is very useful as a qualitative tool to determine the presence and extent of volatile organic contamination at a site. These preliminary data can then be used in effectively locating the soil borings, piezometers, and monitor wells.

The first step in the soil gas survey is to establish a grid system over each site. The typical grid spacing was 50 feet, but on smaller sites a 20- or 25-foot grid was used. The grid was laid out using an engineer's tape and compass, with the points marked with surveyor's flags. At least two points on or near the grid were later surveyed so that the grid could be tied in to the project base map. Final utility clearances were provided by the base prior to sampling.

At each site the first samples were collected to complete a profile at one point. The profile consisted of samples collected at three or four different depths at a single point. This point was selected, either by visual observations or from the geophysical survey, as being the point closest to the contaminant source. The samples were then analyzed, and the depth at which the highest volatile concentrations were found was used as the sampling depth for that site. This depth usually ranged from 2 to 5 feet.

It was not always possible to collect all the points at a site at the same depth. In some instances refusal was met at a point before the required sampling depth was reached. The actual depth of each point was recorded in the field notebooks.

The soil gas samples were collected from the unsaturated zone with either mechanically or manually driven $\frac{3}{4}$ -inch stainless steel probes. Soil gas enters the hollow probe through several narrow gauge slits and holes at the tip. After the probe was inserted, a stainless steel and Teflon® connector was attached to the end. The assembly was attached to a vacuum pump and purged with several volumes of soil gas. When the purging was complete the sampling assembly was connected to a Tedlar® air sampling bag, which was placed inside a vacuum chamber. The cham-

ber was then evacuated. The sampling bag would then inflate due to the pressure differential between the sampling assembly and the vacuum chamber.

After sampling, the Tedlar bags were labeled with the proper sample ID. The Tedlar bags were supplied by SKC, Inc., and were made of a special nonporous polymer for use in gas sampling. Each bag was equipped with a valve for connection to the sampling assembly. The bags were also equipped with a septum so that they could be sampled with a gas-tight syringe for injection into the gas chromatograph.

The sampling probes were cleaned before use with a laboratory detergent such as Alconox®. The probes were then rinsed with either distilled or ASTM type II water. Probe blanks were collected and analyzed daily to ensure the effectiveness of the decontamination procedure.

After collection, the samples were analyzed with a Photovac model 10S50 GC equipped with a 9-meter CpSil-5 capillary column and a 1-meter precolumn back-flush system. The detector was a 10.6-eV photoionization detector that is sensitive to a wide range of volatile organic compounds. The carrier gas used was high-purity zero-grade air. All samples were analyzed on the day of collection, usually within 8 hours.

Two identical GCs were used for this project. They were initially calibrated by injecting three different volumes of a known standard. The standard was a commercially available mixture of benzene, toluene, o-xylene, 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethene (1,2-DCE), and trichloroethene (TCE). The standard was certified by the manufacturer to contain 1 ppm of each of the constituents. The GC is sensitive to the mass of the constituents. Therefore, injecting different volumes of the same standard will produce a mass-based calibration curve. After the initial calibration, the instrument was calibrated daily with standard injections at only one volume. Each run of samples was bracketed by standard injections. Routine startup procedures used each morning included the running of instrument and syringe blanks to gauge instrument stability, flow balance, and column contamination.

Each sample chromatogram was compared with the standard chromatograms which bracketed the run. Compounds were identified by comparing the retention times in the sample with retention times in the standard. The concentrations in the samples were then calculated by the following equation:

$$C_{sa} = (V_{st}/V_{sa}) \times (A_{sa}/A_{st}) \times 1 \text{ ppm}$$

where:

C_{sa} = concentration in the sample, parts per million (ppm)

V_{st} = volume of standard injection, microliters (μL)

V_{sa} = volume of sample injection, μL

A_{sa} = Area of sample peak, volt seconds (Vs)

A_{st} = Area of standard peak, Vs

The calculations were repeated for each constituent found in the sample which corresponded to one of the constituents present in the standards. The results for each site were tabulated and plotted on a grid corresponding to the sampling grid. A summary of these results appears in the site-specific discussions.

2.3.2 Geophysics

Geophysical techniques were used to investigate the existence and locations of dry wells at sites 6, 7, and 8 and other underground features. Ground-penetrating radar (GPR) was the technique selected for the investigation due to its mobility and immediate response, allowing for interpretation without elaborate data reduction.

The GPR technique uses impulse radar technology to obtain a continuous, high-resolution profile of the subsurface. The pulse transmitted into the subsurface is produced by discharging a pulse of electromagnetic energy from a special antenna. The transmitted pulse travels through the subsurface until it reaches a soil interface or a buried object. Then, depending on the electrical characteristics at the interface or object, a portion of the transmitted pulse is reflected back to the surface, where it is picked up by a receiver section in the same antenna. The received signal is processed, and a real-time replica of the information is displayed by a graphic recorder. The resulting graph plots horizontal distance scanned against subsurface signal travel time in nanoseconds. Changes in apparent travel time with distance are interpreted as changes in soil interface depth or the existence of a buried object. Figure 2.1 shows the response of a GPR survey scan to a buried fuel storage tank at the base.

The instrument used was an SIR® System-3 equipped with a 500-megahertz antenna, manufactured by Geophysical Survey Systems, Inc. The instrument was set up and calibrated in accordance with the instructions of the manufacturer's operations manual (MN83-728 Rev (A)).

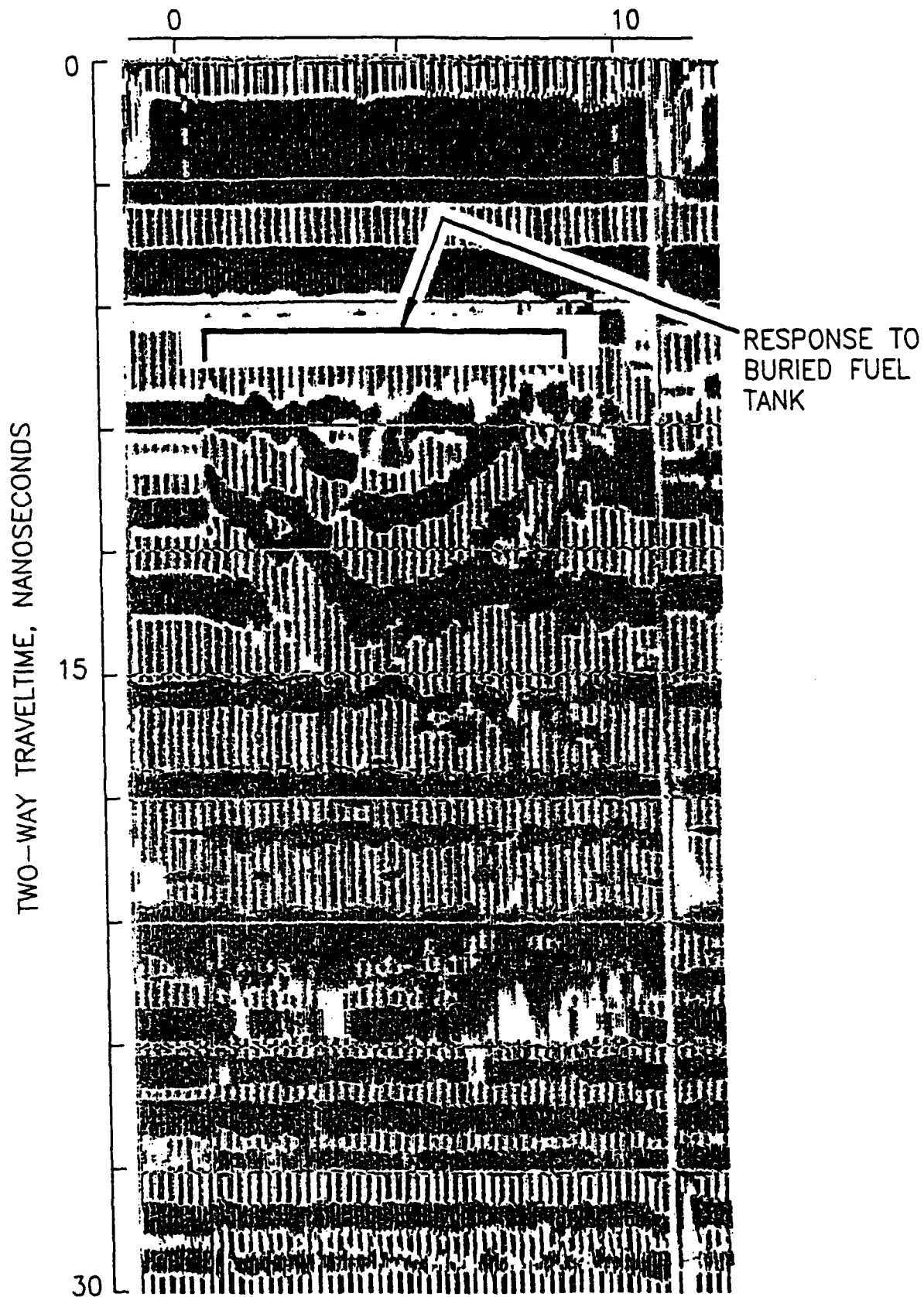
At most of the sites where geophysical surveys were conducted, a grid was established, tied to a site landmark or soil gas grid, and recorded in the field notebook. The survey was then conducted along or across the gridded area, and the lines of the grid were noted on the printed survey response. If the initial GPR scans indicated the existence of a buried object, additional scans were run at more tightly spaced intervals to determine the exact location of the object. This location was then marked on the ground surface and its grid coordinates recorded in the field notebook or on the GPR printout.

2.3.3 Soil Sampling

Soil borings were drilled and sampled in order to obtain subsurface soil samples for screening and confirmation chemical analysis from each of the sites identified as potential contaminant sources at the base. Additionally three background soil borings were drilled and sampled for analysis of the naturally occurring soil conditions. The borings were drilled and sampled to the top of the sandstone in order to evaluate the extent of contamination in the soil. The locations and number of soil borings were determined by analyzing data from the soil gas survey and placing boring

FIGURE 2.1 TYPICAL GROUND-PENETRATING RADAR SCAN

HORIZONTAL DISTANCE, FEET



locations in areas of high soil gas readings and near the perimeters of the potentially contaminated zones. The results of the screening activities are discussed in section 3 of this report.

The borings were drilled by hollow-stem auger method with 6-inch-inside-diameter augers. Since hollow-stem augers cannot drill into hard rock, the borings were terminated at the soil-rock contact approximately 3 to 8 feet below ground level. The average depth of a soil boring at the base was approximately 4 feet. Soil was sampled continuously through the augers using split-spoon samplers. Brass liners were placed inside the split-spoon sampling tubes in order to minimize the loss of volatile organic compounds during sample collection. Eight 3-inch-long brass liners were used in each 2-foot split-spoon sampler. The ends of each liner were wrapped in Teflon tape, and a plastic cap was placed over the tape. The liners were labeled 1 through 8, with liner 1 representing the top of the sampling tube and liner 8 representing the bottom of the tube nearest the cutting edge. Each sampling tube was labeled A, B, or C, depending on which depth interval the tube represented; i.e., sample tube "A" represented the depth interval from 0 to 2 feet and tube "B" represented the depth interval from 2 to 4 feet and so on.

Field sample screening was accomplished in two steps. Primary screening was performed on all eight sleeves from the sample tube in order to retain the best representative sample. Soil samples in the sleeves were scanned for volatile organic compounds (VOCs) using a photoionization meter (HNU) by separating all sleeves enough to insert the HNU probe between the liners. Samples exhibiting the highest total VOC concentrations were retained for secondary field screening.

If primary screening indicated the presence of organic vapors, a field headspace analysis was performed on sample liners indicating the concentration of VOCs. The field VOC headspace analysis was performed at the drill site immediately after sample retrieval. One brass liner was selected from each sampling tube for the VOC headspace analysis. A steel spike was driven halfway into the liner through the top of the plastic cap. The hole was then sealed with aluminum foil and, after 7 to 10 minutes, the aluminum foil was removed and the photoionization meter tip was quickly inserted through the hole in the plastic cap. The meter reading, in parts per million total VOC, was recorded in the field notebook. After the meter tip was removed, another layer of Teflon tape was placed over the plastic top, and the edges of the Teflon tape were sealed with silicone tape. The samples were transferred to the GC operator in a chilled ice chest for secondary screening.

Field headspace data were used as a guide in selecting samples from borings with potentially the highest concentrations. In addition, these data were used as indicators of expected concentrations in preparation for the field GC screening. Secondary field screening was performed with the portable GC. The GC used for this project was a Photovac model 10S50. The GC analyses were performed away from the drill site in a controlled environment. The GC protocol was very similar to that used for the soil gas survey described in section 2.3.1. The major differences are described below.

Soil samples were placed in 40 mL glass vials with septum lids. The vials were placed in a water bath and maintained at approximately 90°C for 1 hour. The headspace was then extracted from the vial with a gas-tight syringe and injected into the GC. The retention times of the samples were compared with retention times of the standards in order to identify the compounds present in the headspace.

Two standards were used. The first, a BTEX gas standard, contained benzene, toluene, ethyl benzene, o-xylene, m-xylene, and p-xylene. The concentration of each of these compounds was certified by the manufacturer (Scott Specialty Gases, Inc.) to be approximately 1 ppm. (The concentrations ranged from 1.07 to 1.26 ppm). The second standard used was TCE gas. This standard was certified by the manufacturer (Alphagaz) to be 10.4 ppm.

The concentration of the compounds in the headspace was not determined since this information would not have been useful in determining the concentrations in the soil samples.

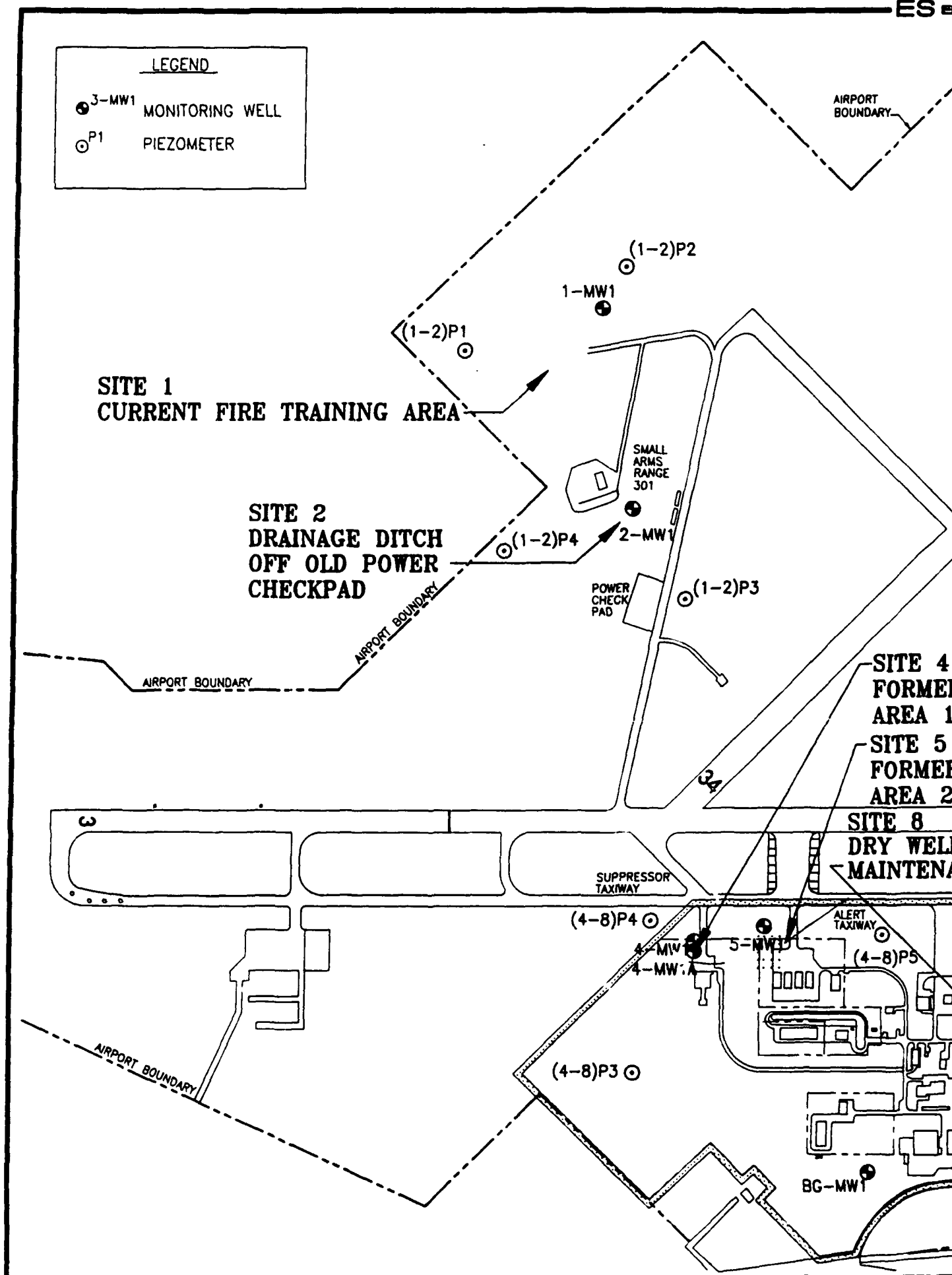
Samples selected for final CLP analysis were chosen using the results of the field GC analysis. Sample liners were retained in groups of three consecutive liners from each tube. One of the three consecutive liners was used for application of the field VOC headspace analysis and the field GC analysis. The three sleeves were sent to the CLP laboratory, with the sleeve used for field screening designated for use by the laboratory for metals analysis only.

Liners selected for screening were handled by sealing the ends of the sleeves with Teflon tape and placing a tight-fitting plastic cap over the tape. In all cases liners 1 and 8 were discarded since their sample integrity was most affected by sample collection. Selected liners were labeled with a nonvolatile marker and immediately placed in a chilled ice chest. Sample liners not retained for additional screening were emptied and used for soil description and other observations. The ES onsite geologist recorded all lithologies and other observations in the field notebook. Appendix C presents the soil boring lithologic logs for each boring. The soil in the liners not selected for analysis was discarded with the other soil cuttings at each site.

All equipment which was used in the borehole was decontaminated according to the guidelines defined in the quality assurance project plan (QAPP). All exploratory boreholes were abandoned in accordance with EPA, state (Montana), and local regulatory guidelines. Abandonment of the borings was performed by filling the borehole from the base of the borehole to land surface with a neat cement grout containing 3 to 5 percent bentonite powder by dry weight. Since the boreholes were shallow, grout was poured directly into the borehole until it was filled to the surface. The grout was then allowed to settle and set for at least 24 hours. If necessary, more grout was then added to the top.

2.3.4 Piezometer Construction

Piezometers were used to evaluate groundwater flow direction at the base and at remote locations. Thirteen piezometers were constructed at locations shown on Figure 2.2. Because of the distance between sites, the piezometers were evaluated



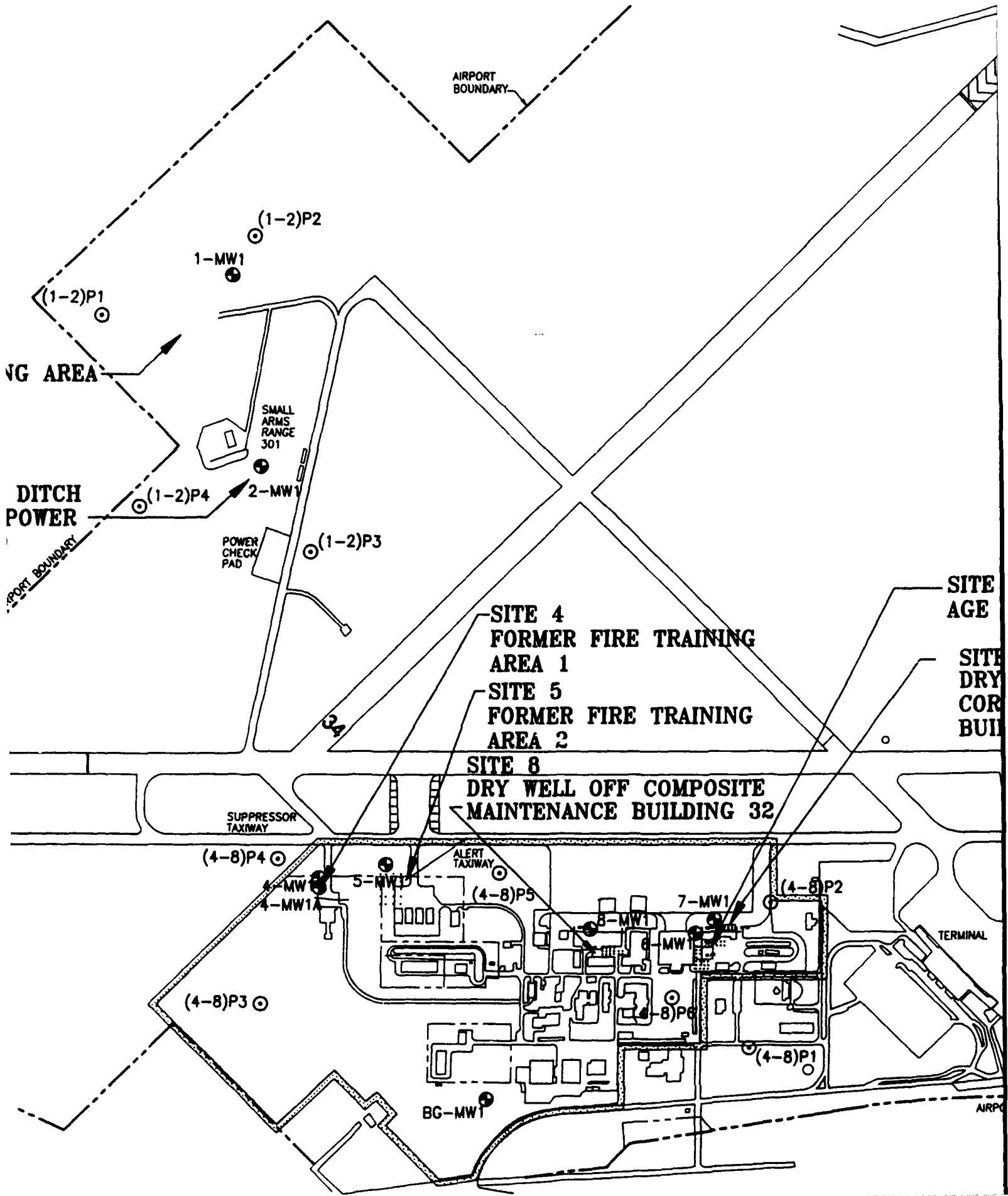
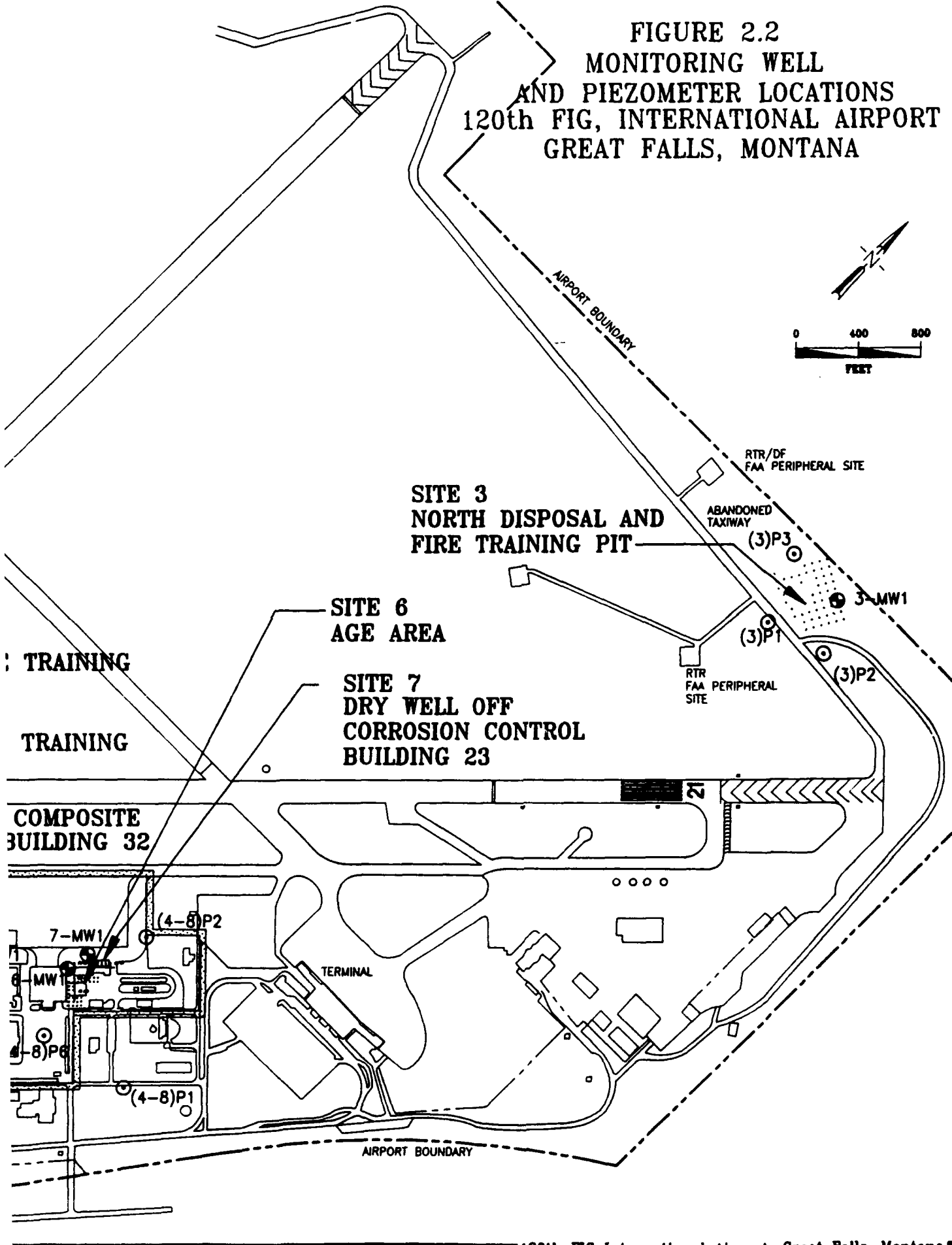


FIGURE 2.2
MONITORING WELL
AND PIEZOMETER LOCATIONS
120th FIG, INTERNATIONAL AIRPORT
GREAT FALLS, MONTANA



as three groups. The three piezometer groups are sites 1 and 2, on the west side of airport property; site 3, on the north edge of airport property; and sites 4 through 8, on the base. Water level measurements and surveyed piezometer elevations were used to calculate the groundwater elevation at each piezometer. Groundwater elevations were plotted and groundwater flow direction and gradient were interpreted from the plots.

Air rotary drilling methods were used to drill 6-inch-diameter boreholes for piezometer construction. The 2-inch-diameter piezometers consisted of a 5-foot-long PVC screened interval with 0.020-inch slots attached to a PVC riser of sufficient length to reach about 2 feet above ground surface. A shale packer composed of rubber and a steel clamp was used to create a seal above the water-producing zone in each piezometer. The shale packer was installed in each piezometer at the contact between unconsolidated material and the underlying competent rock, usually at a depth of 12 to 20 feet below ground surface. No filter pack was installed in the piezometer annulus opposite the position of the screened interval. Bentonite slurry was tremied into the piezometer annulus from the top of the shale packer to 2 to 3 feet below ground surface. Surface completion of the piezometers consisted of a 2-foot by 2-foot pad and a 6-inch-diameter locking steel protective casing. The top of the piezometer casing was covered with a slip cap. Elevations of piezometer casing tops and a pin set in the concrete pads were measured by a registered surveyor.

Following completion of piezometer construction, each piezometer was developed to remove mud and fines from the screen and adjoining formation. All of the piezometers were developed first by surging the piezometer with a bailer and finished by pumping with an electric submersible pump. The surging was performed by lowering a decontaminated bailer into the piezometer. The bailer was then manually lifted and lowered several times to help break loose mud or fines. When the piezometer was essentially clear of sediments, a submersible pump was placed in the piezometer to finish development.

The pumping was performed by placing the pump approximately 2-feet from the bottom of the piezometer. The pump was allowed to run until the water appeared to be clean or until the piezometer was pumped dry. Those piezometers which pumped dry were allowed to recover and then pumped dry again. This procedure was repeated as necessary until reasonable results were obtained. Water discharged from each piezometer was collected in 55-gallon drums and later transferred to a holding tank on the base.

The plan to abandon the piezometers at the end of the field investigation was reevaluated during the course of the investigation in response to field observations. Artificial groundwater recharge from a long-term water main leak on airport property, approximately 200 feet northwest of site 7, and an episode of leakage from the base fire hydrant system that coincided with the field investigation produced a dome of groundwater in the site 6 and 7 area.

2.3.5 Piezometer Screening

All of the original piezometers were screened for groundwater contaminants with the field GC in a manner similar to that described (section 2.3.3) for the field screening of the soil borings. The piezometers were developed by purging a minimum of three well volumes. Samples were collected from each piezometer with a Teflon bailer and placed directly into 40-mL vials with septum lids. The samples were placed in a water bath at approximately 90°C for 1 hour. The headspace was then injected into the GC. The sample retention times were compared with standard retention times to identify any constituents present in the water. No quantification of the constituents was made.

2.4 CONFIRMATION AND DELINEATION ACTIVITIES

2.4.1 Soil Borings

Soil samples were analyzed as part of the confirmation activities for the eight sites. Prescreened samples were sent to the selected analytical laboratory for confirmation of indicator parameters. Soil samples were prescreened to reduce the number of samples sent to the confirmation laboratory. A discussion of sample collection, screening, and handling is presented in section 2.3.3, "Soil Sampling." Boring identification, the sample depth interval, and the analyses performed on each sample are presented in appendix C, Table C-1. The results of the confirmation activities are discussed in section 3 of this report.

2.4.2 Monitoring Well Construction

Monitoring wells were constructed to obtain groundwater samples for evaluation of groundwater quality and to obtain water level data. One monitoring well was located downgradient of each site, after groundwater flow direction and gradient was determined using water levels measured in the piezometers. Water levels measured in monitoring wells were used in combination with piezometer data to further evaluate groundwater flow direction and gradient. The monitoring well and piezometer locations are shown on Figure 2.2.

Air rotary drilling methods were used to drill an 8-inch-diameter borehole through the unconsolidated material to bedrock, which varied in depth from 8 to 22 feet below ground level. The sampling team then took 15-foot continuous core samples to obtain accurate lithologic descriptions and to define the depth to water and the total depth of the well. The drilling method employed did not allow observation of saturated conditions in the core sample. Water levels were determined by removing the drill pipe from the borehole, waiting for a period of time, and then measuring the static water level in the hole. Monitoring wells for sites 4, 6, and 7 were constructed with 20 feet of 6-inch black steel surface casing placed within a 10-inch borehole. At site 5 MW1, 9 feet of surface casing was placed within a 10-inch borehole. The surface casing was used because of the presence of an observed shallow water-bearing zone. Selection of material lengths was based on site-specific groundwater conditions encountered. Grout was then used to secure the surface casing in the borehole and allowed to sit for 24 hours before continuing with monitoring well construction.

The screen used to construct the monitoring wells consisted of 2-inch-diameter schedule 40 PVC with 0.020-inch slots. The screen was capped at the bottom with a screw-on cone. All connections were flush jointed and threaded. The screened section was joined to a 2-inch-diameter, schedule 40 PVC, flush-threaded casing. Twenty feet of screen was placed in each monitoring well with the exception of MANG-4-MW1A, which received 5 feet of screen. To keep chemicals from entering the well with the installation of well casing and screen, no glues, solvents, or thread compounds were used during screen and casing installation. All screen and casing was decontaminated and wrapped in plastic prior to use. Stainless steel centering guides (centralizers) were used to center the casing and screen in the borehole. The purpose of the centering guide is to prevent the sand pack from bridging if the well screen and well casing should come in contact with the side of the borehole. For monitoring wells greater than 25 feet in depth, centering guides were placed near the bottom of the screen, at the top of the screen, and approximately at 15 to 25 feet of casing above the screen. After the PVC casing and screens and centralizers were placed, sand (8 to 20 mesh grain size) was placed between the screen and the boring wall. The sand extended to a minimum height of 3 feet above the top of the screen. Bentonite pellets were then poured through the open hole to a height of at least 2 feet above the sand. The bentonite was then hydrated with distilled water upon placement in the well. A 3 to 5 percent bentonite-grout mixture was placed from the top of the bentonite seal to about 2 feet below land surface using pressure grouting from a side-discharge tremie pipe. Grout was used for monitoring well construction at sites 1, 2, 3, and background. A bentonite slurry was used at sites 4, 5, 6, 7, and 8.

Following the completion of well construction, each monitor well was developed to remove mud and fines from the screen, filter pack, and adjoining formation by pumping with an electric submersible pump. The pump was placed approximately 2 feet from the bottom of the well and was allowed to run until the water appeared to be clean or until the well was pumped dry. Those wells which pumped dry (i.e., MANG-1-MW1) were allowed to recover and then pumped dry again. This procedure was repeated as necessary until analytical readings (described below) stabilized. Water discharged from each well was collected in 55-gallon drums and later transferred to a holding tank on the base.

Samples of the development water were collected during the later portion of development to measure pH, temperature, and conductivity. A pH/temperature meter and conductivity meter were used to take these readings. Before each day of sampling, the meters were calibrated following manufacturer's specifications and using standard solutions. Generally, the wells were pumped until the readings stabilized and the water produced was essentially free of turbidity.

2.4.3 Monitor Well Sampling

Following the development of the wells, each monitor well was sampled for chemical analysis. The wells were sampled a minimum of two days after development. The first round of groundwater samples was collected in October 1990. Each well was purged of any stagnant water in the well before sampling. A minimum of three well volumes was removed from each well. Prior to sampling, pH, tempera-

ture, and conductivity were measured. A pH/temperature meter and conductivity meter were used to take these readings. Before each day, the meters were calibrated following manufacturer's specifications and using standard solutions.

The samples were obtained with a decontaminated Teflon bailer. The samples were collected from the top of the water column by pouring the water from the bailer directly into the sample containers. A sample label was affixed to each bottle which identified the project name, sample location, date and time of sample collection, samplers' initials, analyses requested, and the method of preservation. The bottles were packaged in an ice chest with blue ice (to cool to 4°C) and sent to the laboratory via overnight delivery.

A second round of groundwater sampling was performed in February 1991. Monitor wells were purged and samples were collected using the same procedures described above.

2.4.4 Specific Media Sampling

To help in characterizing past site activities, sediment samples were collected in the disposal ditches at sites 2 and 6. Three samples were collected at both sites, and a duplicate was collected at site 6. The sampling locations for site 2 were chosen to collect samples upgradient of the outfall, at the outfall, and downgradient of the outfall. Figure 2.3 shows the locations for sediment samples at site 2. At site 6 there was no reported point of outfall, and due to the relative short length of the ditch (approximately 50 feet), samples were taken at three points. The three points correspond to the west end, the middle, and the east end of the ditch. Figure 2.4 shows the locations of the sediment samples at site 6.

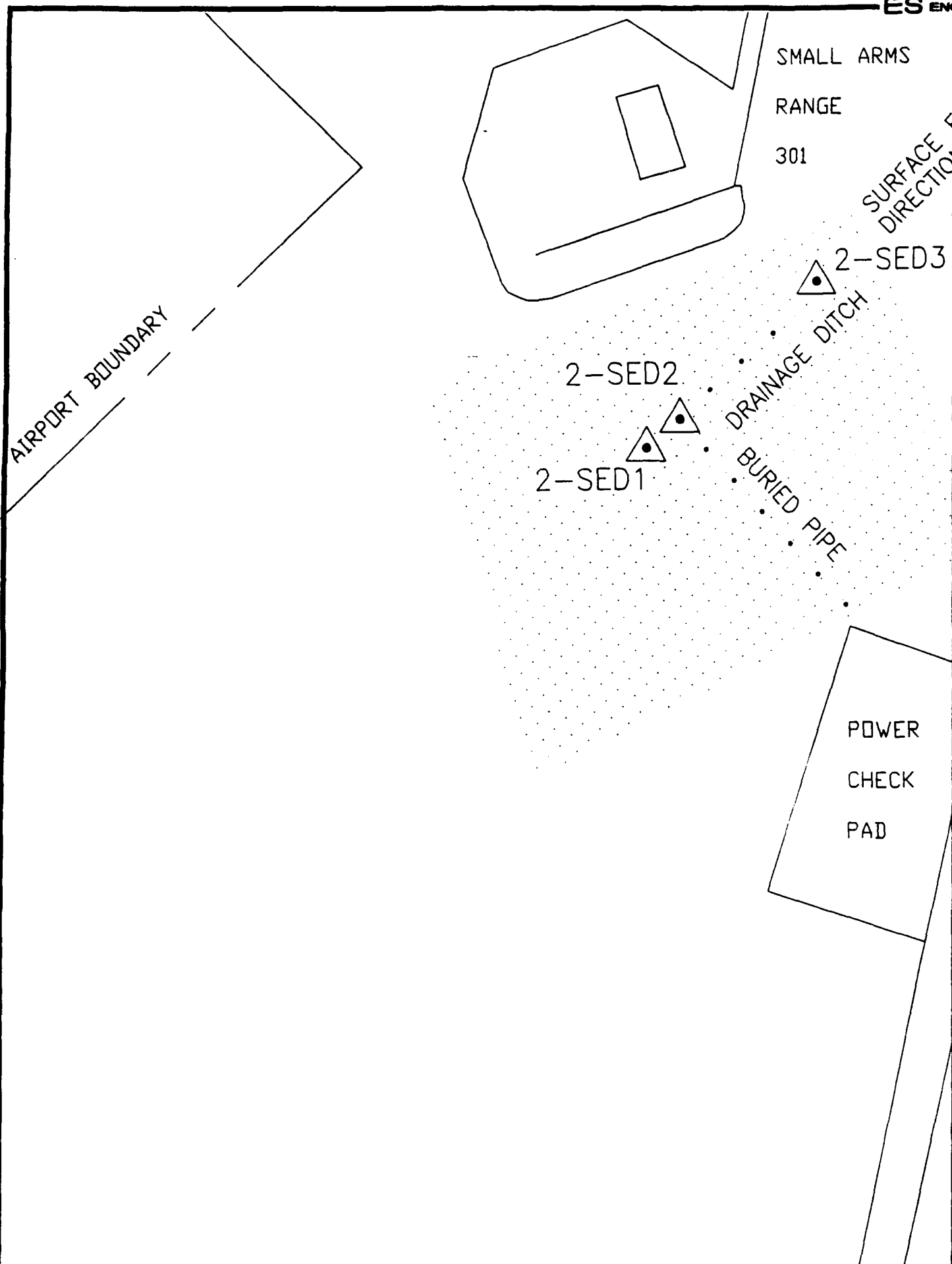
Samples were collected using a small stainless steel hand shovel and a stainless steel bowl. Before collection of each sample, all sampling equipment was decontaminated following work plan procedures. A sufficient amount of soil was placed in the bowl and mixed to make a composite sample. After mixing, the soil was put into the appropriate jars, sealed, labeled, and placed on ice for shipment. Since the samples for VOA analysis were composited, the VOA results were considered invalid. A full discussion of the VOA samples is in appendix E.

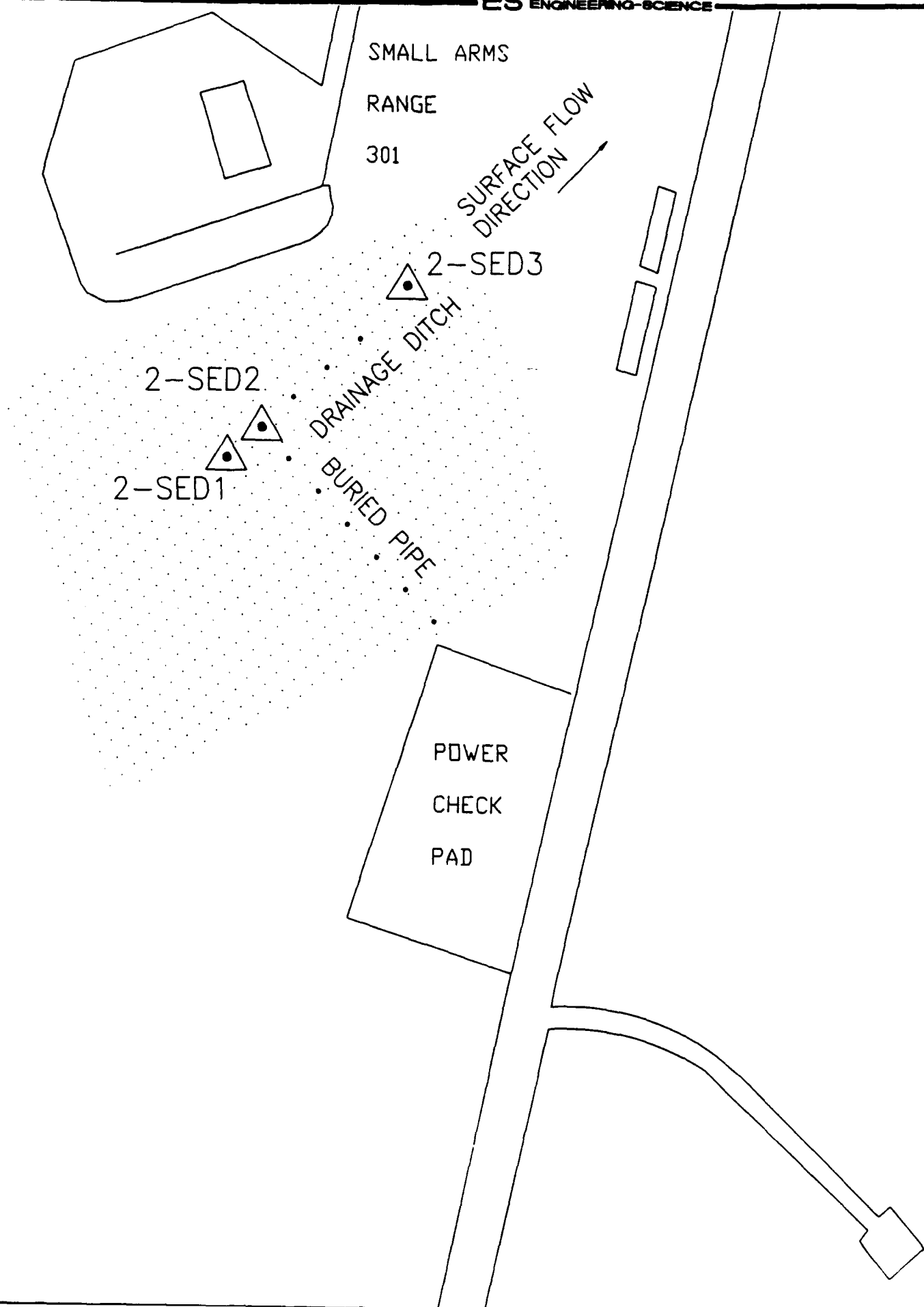
2.5 BACKGROUND SAMPLING FOR BASELINE DATA

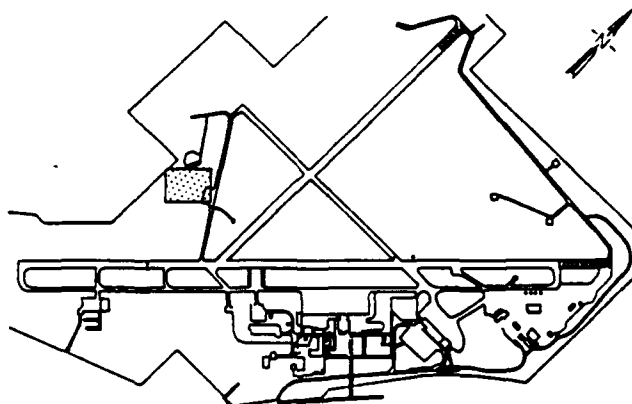
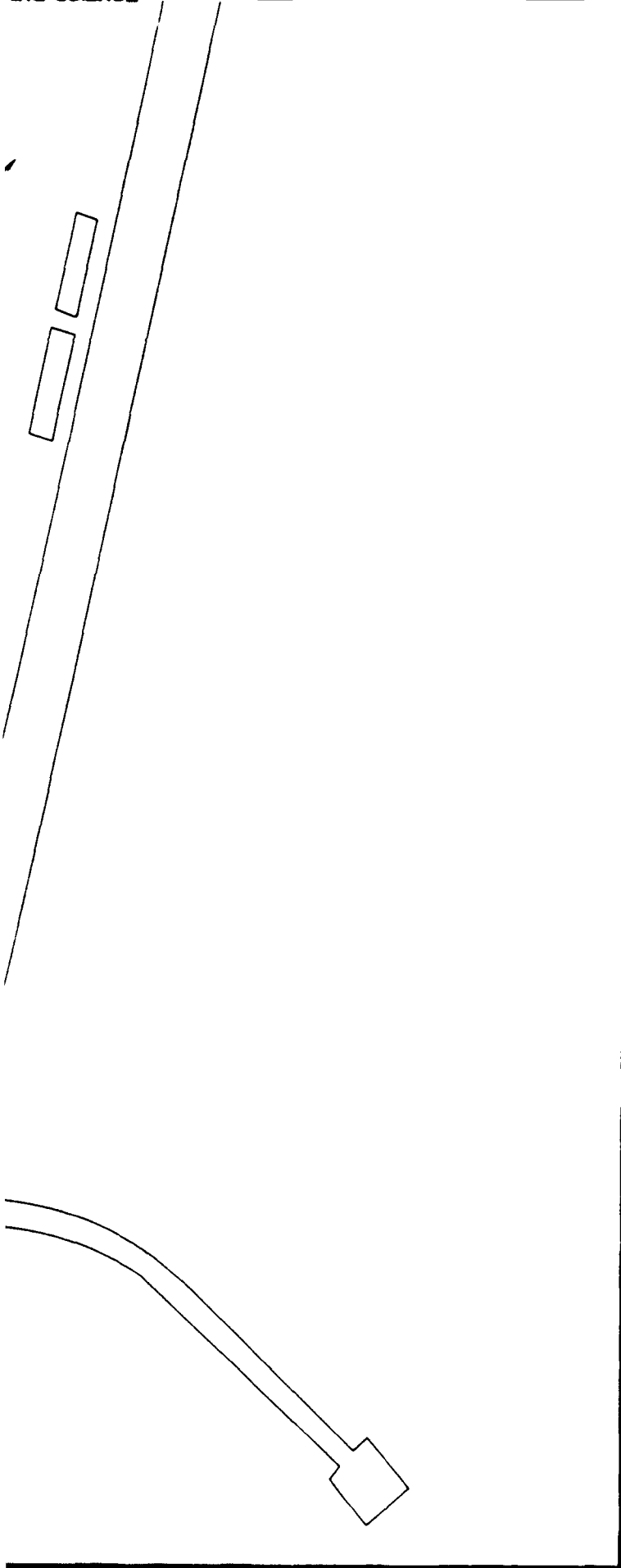
Three soil borings were drilled and one monitoring well was constructed for the purpose of collecting background samples and establishing a baseline for concentrations of target parameters in natural media. The background borings and monitoring well were located on the south side of the base, upgradient of past and present base operations and in areas where there was no apparent potential for contamination. Locations of background sampling points are shown on Figure 2.5. Results of background sample analyses are discussed in section 3.3.

2.6 HANDLING OF INVESTIGATION-DERIVED MATERIALS

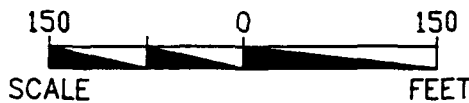
Solid materials generated from field operations consisted of drill cuttings, sample cores, well construction supply bags, and minor amounts of excess grout.







APPROXIMATE SITE LOCATION



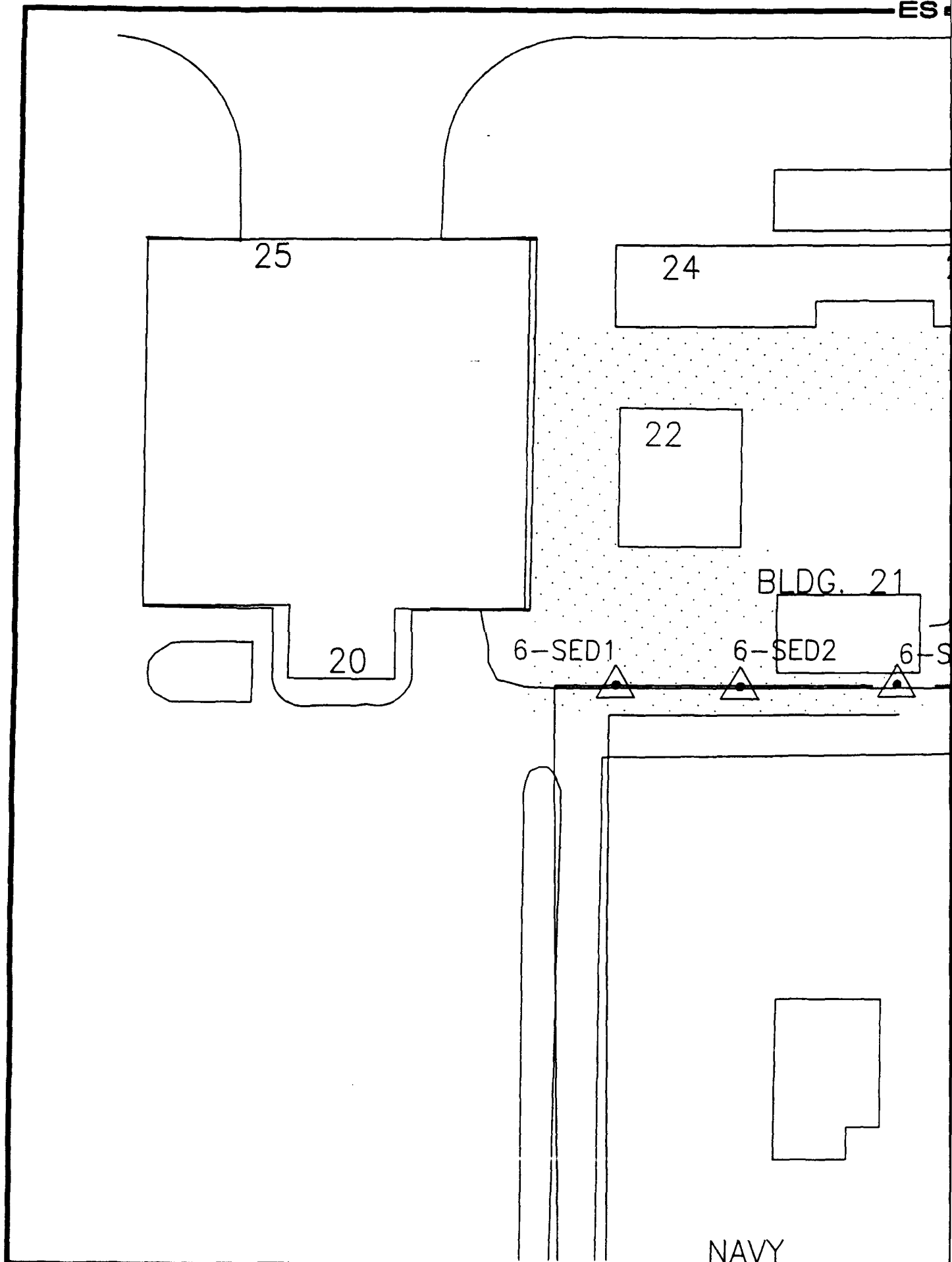
LEGEND

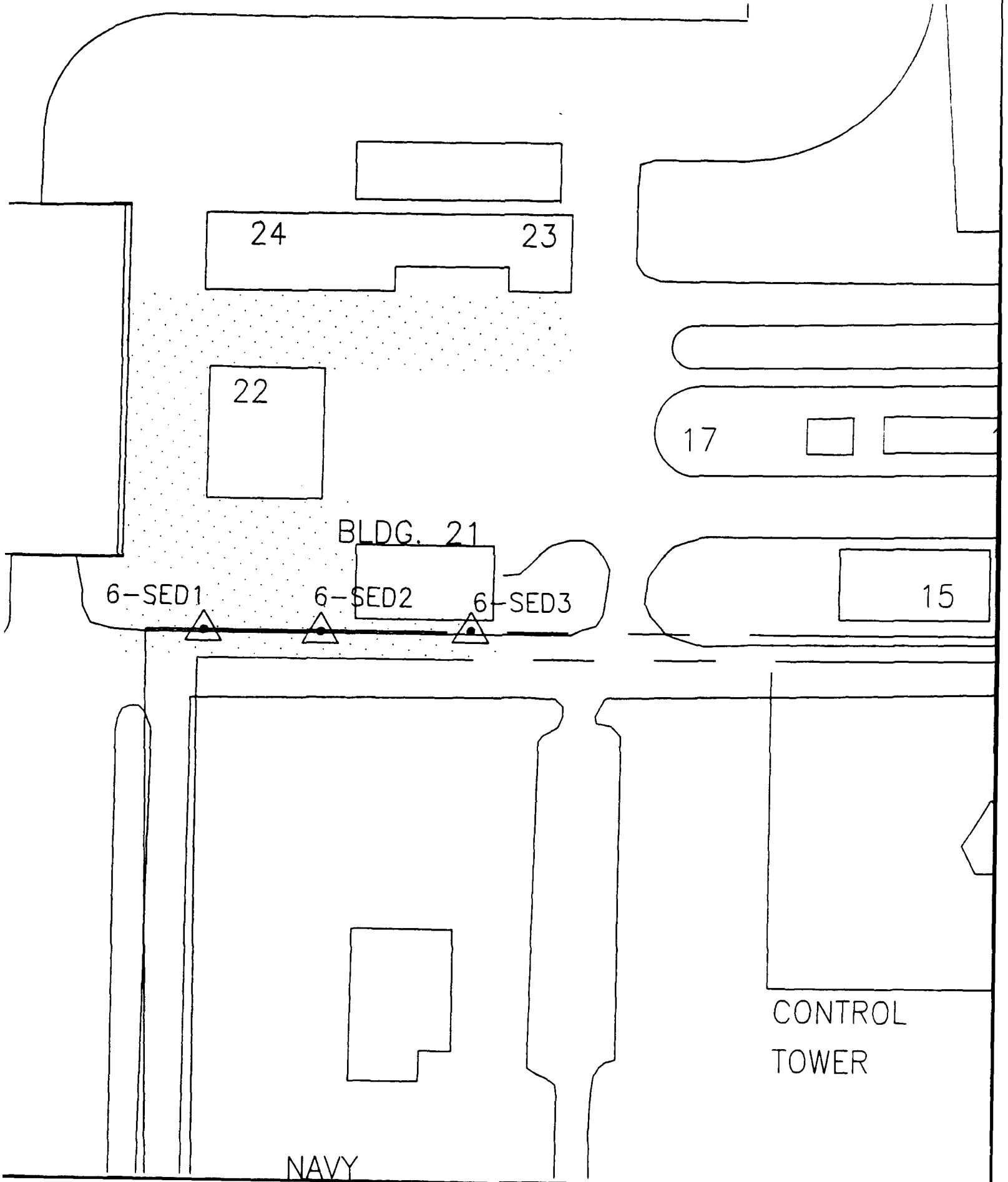
2-SED3
 SEDIMENT SAMPLE
 LOCATION AND
 NUMBER

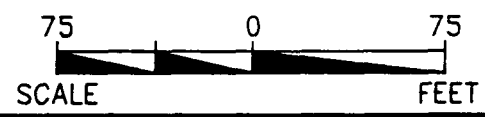
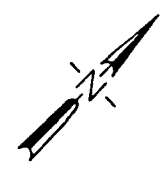
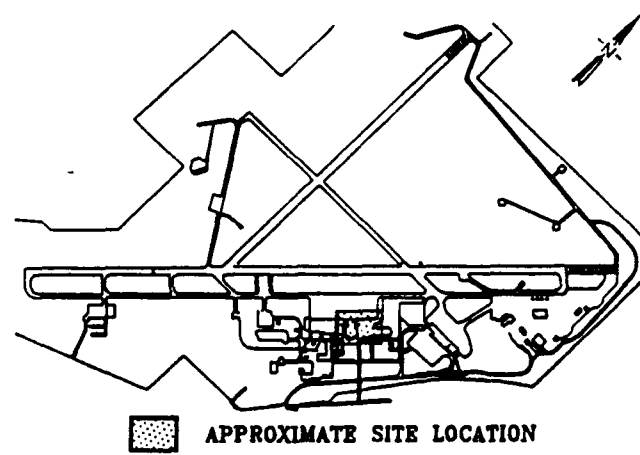
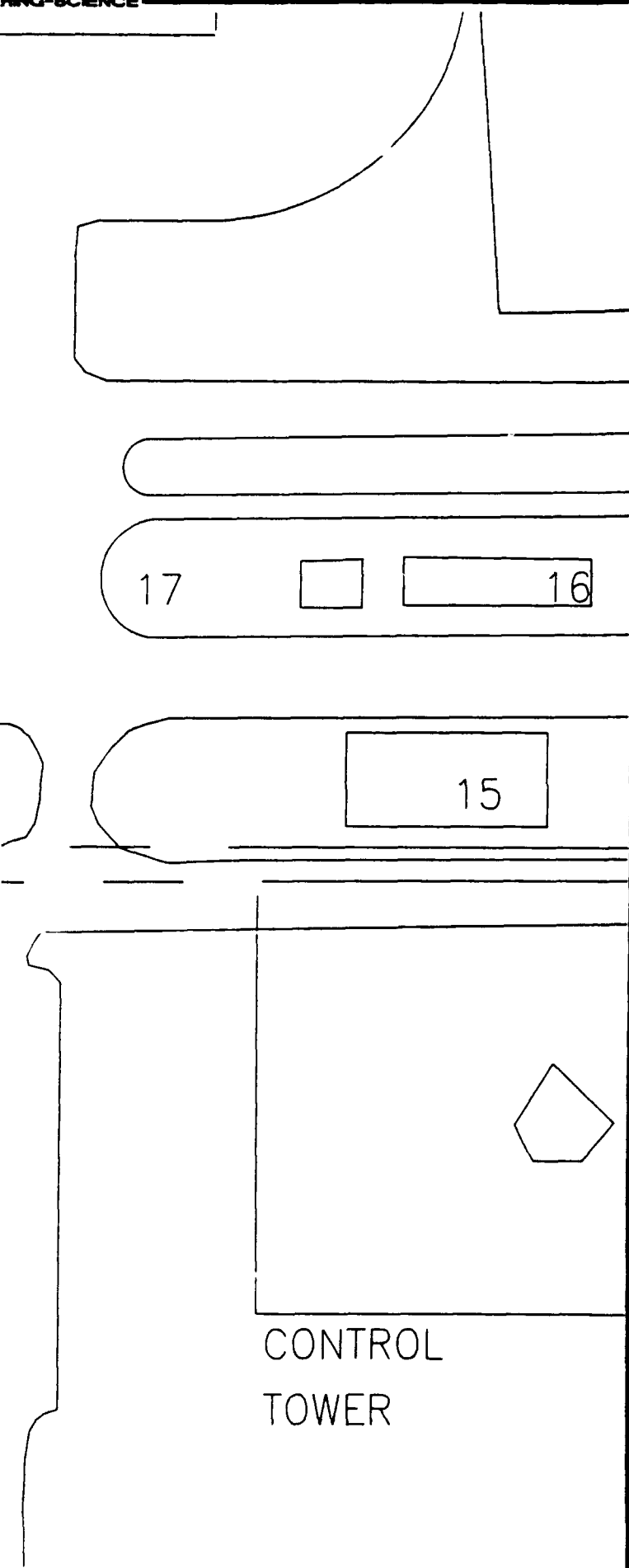
• SOV GRID POINT

 APPROXIMATE SITE
 LOCATION

FIGURE 2.3
 LOCATIONS OF
 SEDIMENT SAMPLES
 SITE 2
 DRAINAGE DITCH OFF
 OLD POWER CHECK PAD







LEGEND

6-SED2

- ▲ SEDIMENT SAMPLE LOCATION AND NUMBER
- APPROXIMATE SITE LOCATION

FIGURE 2.4
LOCATIONS OF
SEDIMENT SAMPLES
SITE 6
AEROSPACE GROUND
EQUIPMENT AREA

(4-8)P3

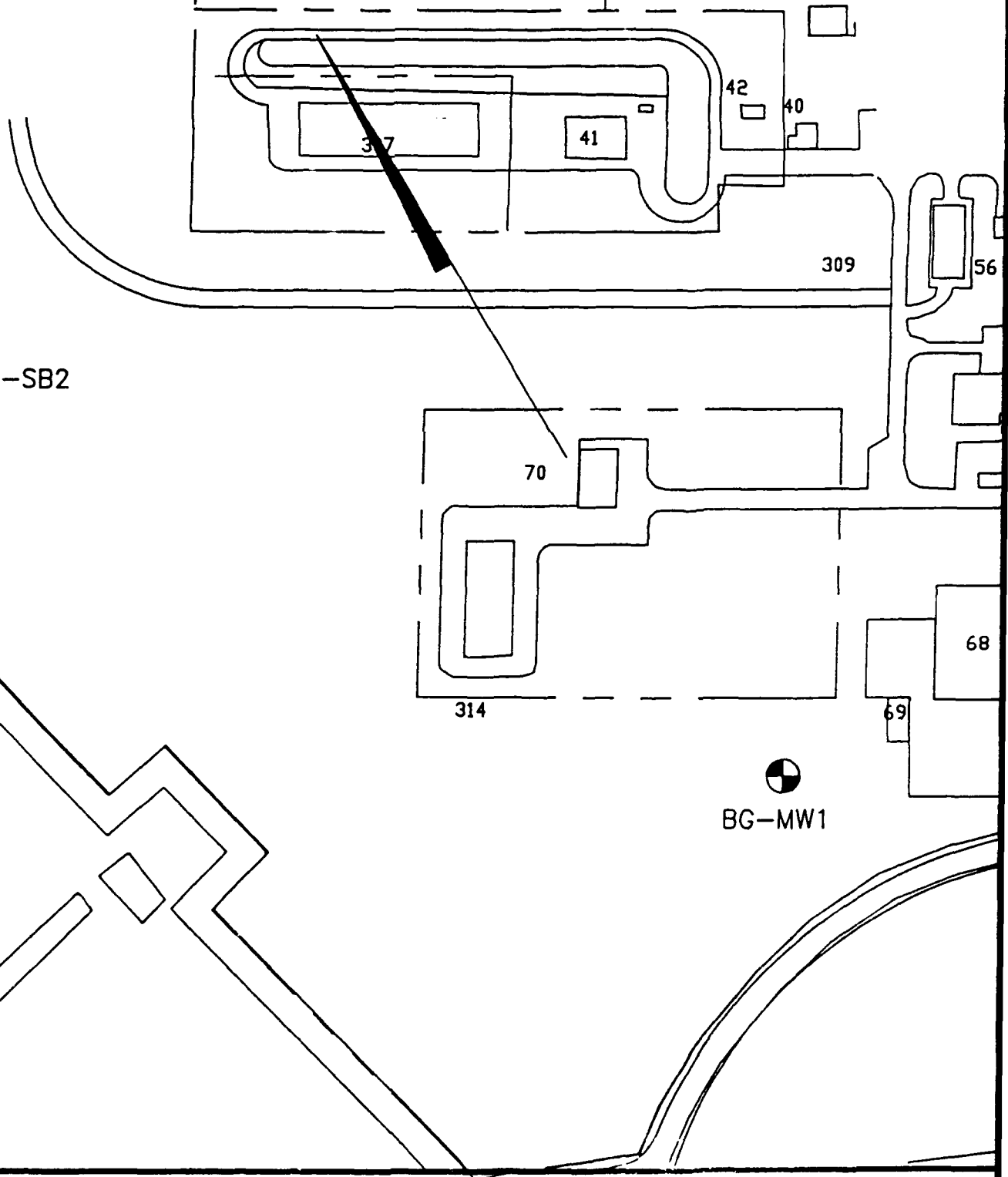
BG-SB3

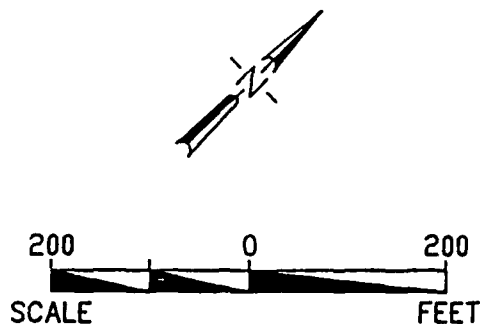
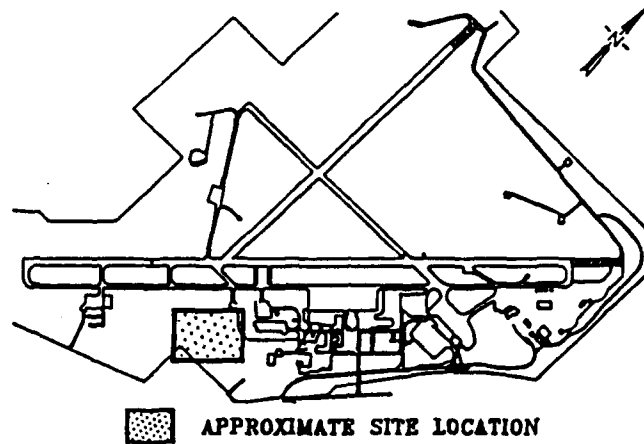
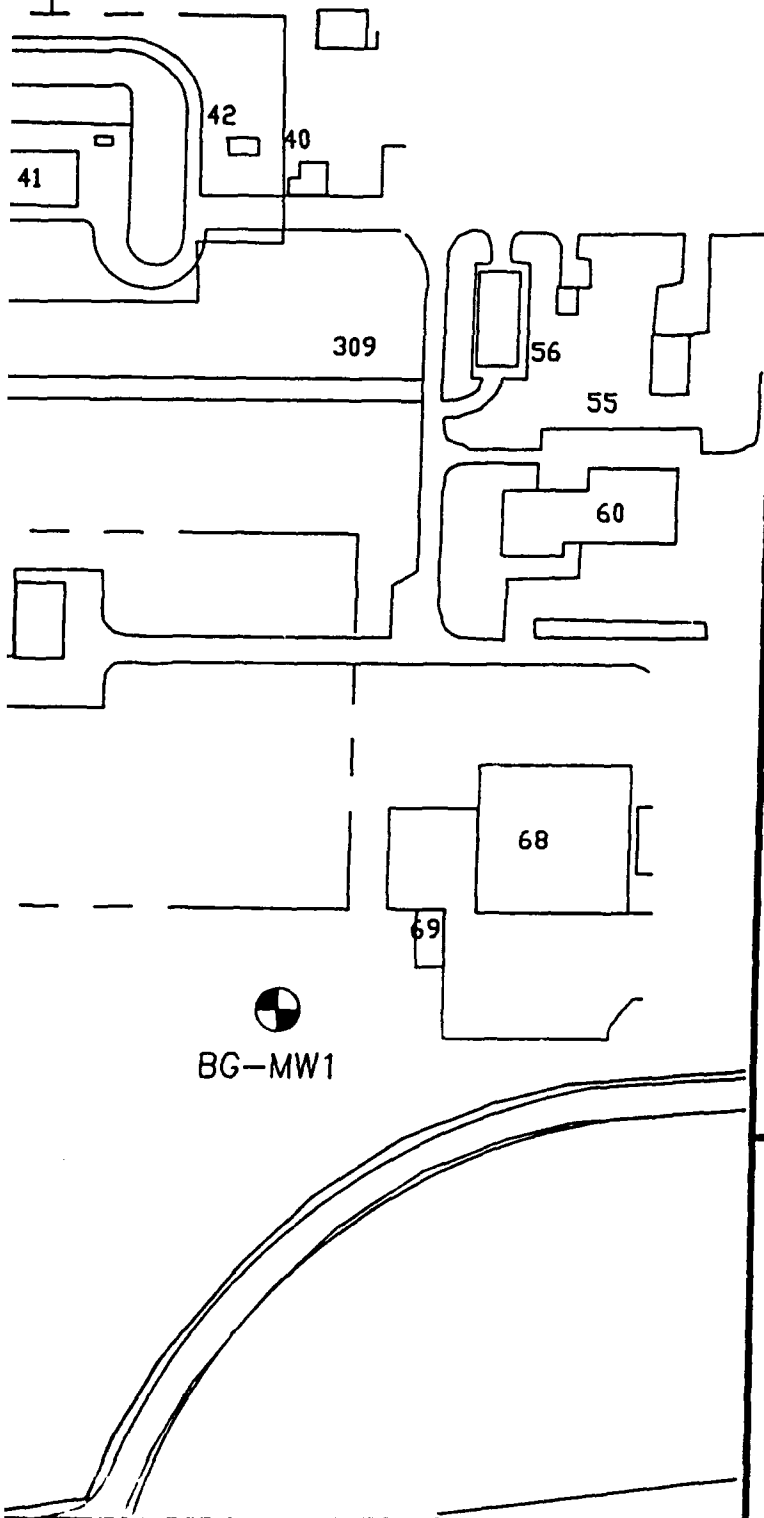
BG-SB2

BG-SB1

37

314





LEGEND

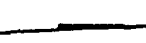
- 
(4-8)P3
PIEZOMETER
- 
MW1
MONITOR WELL
- 
SB1
SOIL BORING LOCATION
- 
GENERAL DIRECTION OF WATER FLOW

FIGURE 2.5
LOCATION OF BACKGROUND
MONITORING WELL
AND SOIL BORINGS

Materials such as cement bags were disposed of in base dumpsters. Excess grout was watered down and spread in untrafficked areas. Drill cuttings and sample cores were collected at each site in 55-gallon drums. Drums were labeled with the site number and transported from each site to a central location, the decontamination area southwest of the "hush house." A total of forty-two drums containing solids generated during this investigation were transported to this central location, where they were divided into three groups according to field observations and organic vapor measurements taken at the source site. Group 1 consisted of eight drums containing piezometer borehole core samples and cuttings. Group 2 consisted of twelve drums of monitoring well or soil boring cuttings collected at sites where no contamination was observed. Group 3 consisted of twenty-two drums of monitoring well and soil boring cuttings collected at sites where evidence of volatiles contamination was observed.

Representative samples were collected from each group of drums containing solid wastes. One sample was collected from group 1, two from group 2, and four from group 3. Each sample was collected with a hand auger from a single drum selected at random from the target group. Samples were placed in glass jars with Teflon-lined lids, labeled with appropriate information, and cooled on ice until they reached the laboratory. Samples were submitted to the laboratory for characterization. Soil samples were extracted using the TCLP² extraction. The extracts were analyzed by GC/MS for volatile and semivolatile organics. These extracts were also analyzed for metals. The purge water was analyzed for TPH, GC volatile organics, GC/MS semivolatile organics, and metals.

Water produced from monitoring wells and piezometers during development and purging was drummed at each site. The drums were transported to a central location, the decontamination area, where the contents of each drum were pumped into an 8-foot by 20-foot cylindrical steel holding tank. Water used to decontaminate drilling and sampling equipment was also pumped into the holding tank. Among the fluids pumped to the holding tank from the decontamination pit was greasy water resulting from drill rig maintenance. Contents of the holding tank were sampled at the end of field activities. Two samples of investigation-generated water were collected by lowering a clean bailer into the tank from the top. Samples were placed in appropriate containers, labeled, cooled on ice, and submitted to the laboratory for characterization.

² TCLP = Toxicity characteristic leaching procedure

SECTION 3

DISCUSSION OF RESULTS

3.1 INTRODUCTION

This section presents the results of the investigations at each site, discusses these results and any gaps in the data, and makes a preliminary evaluation of the significance of these results. The overall results and significance of the findings, along with the preliminary risk assessment in section 4, form the basis for the site recommendations presented in section 6. This information is presented site by site, with background sampling results discussed first.

Throughout this section the analytical results are compared to any applicable or relevant and appropriate requirements. These are generally site specific, but there are federal guidelines. A complete discussion of the ARAR's used in this project is in section 4.2. The ARARs are presented in the data tables for comparative purposes only.

3.2 GEOLOGY AND HYDROGEOLOGY

Investigation of eight sites at the 120th FIG resulted in data that is in general agreement with the regional geologic and hydrogeologic research presented in section 1.5.2. Drilling activities confirmed that the near surface geology consists of thin soils underlain by bedrock. The weathered materials that occur at and near the surface are made up of alternating layers of very weathered and broken sandstones, clays, and varying degrees of sandy and silty clays and clayey sands. These materials are the weathered remnants of the Taft Hill Member in some areas of the base (Lemke, 1977). The natural soils have a low shrink-swell potential and high permeabilities.

The bedrock consists of sandstones and shales of the Cretaceous-age Flood Member, which is a part of the Blackleaf Formation (Wilke, 1983). Sandstone encountered at depths of 2 to 10 feet below ground level are part of the upper unit of the Flood Member. The thickness of the sandstone generally ranges from 29.3 to 41.8 feet in the study area. Beneath the sandstone is the middle unit of the Flood Member, which consists of interbedded sandstones, shaley sandstones, and shales. The contact between the upper and middle units is gradational, therefore making it difficult to determine the exact depth to the contact.

Groundwater on the Sunset Bench commonly occurs above the sandstone-shale contact of the Flood Member. The shaley beds of the middle unit of the Flood

retard the vertical movement of water and cause perched water conditions in the area. Water perched at this contact discharges to a number of springs along the cliff face of the bench. The piezometers and wells constructed in the study area have water levels approximately 300 feet higher in altitude than other wells completed in the areas adjacent to the Sun River bench (Wilke, 1983). Typically, groundwater is slow to enter the wells because the clayey matrix of the sandstone results in reduced permeability. The groundwater also travels along paths of secondary permeability, such as horizontal and vertical fractures, cavities, and weathered bedding planes.

Sites investigated are located on the base as well as on airport property. Figure 1.2 shows the remote locations of sites 1, 2, and 3 in relation to the five sites on base. The direction of groundwater flow was found to mimic the topographic gradient and dip of beds within the Flood Member. Figure 3.1 is a potentiometric map of all of the sites based on water level measurements collected in Spring 1991. For this reason, geologic and hydrogeologic data for sites 1 and 2 and for site 3 were evaluated separately from data gathered at the five sites on base. Investigative results specific to each of these three areas are reported below in section 3.4.3 for sites 1 and 2, in section 3.6.3 for site 3, and in section 3.7.3 for site 4 through 8.

3.3 BACKGROUND SAMPLING RESULTS

Three background soil borings and one background monitoring well were drilled to determine background concentrations. Two soil samples were collected from each soil boring at depths of approximately 1 foot and 3 feet, and sent to the CLP³ laboratory. These soil samples were taken to provide representative background levels for subsurface soils. The locations of the borings and the well are shown on Figure 2.5.

The background samples were collected in an area which was reportedly never used for waste management activities. Additionally, the area was chosen where the groundwater was not downgradient of the eight sites under investigation. Gradients at each site were determined from piezometer data and were used to place the background monitor well.

Soil samples from all three background borings were screened with the field GC. The results are summarized in Table 3.1. Other than TCE, which was also present in the associated blanks, no organics were detected in any of the samples.

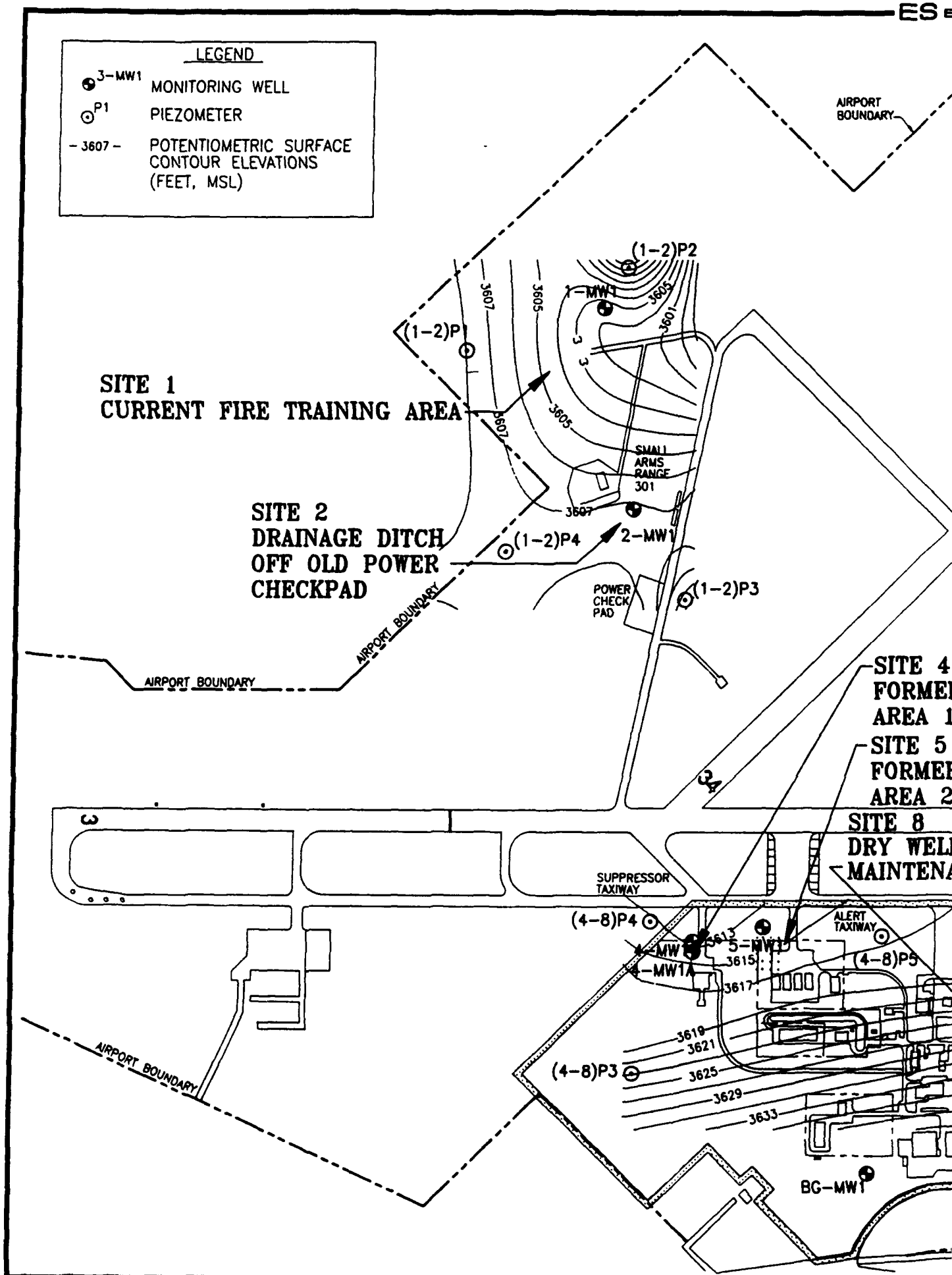
Six soil samples and two groundwater samples were collected from the background area for CLP analysis. The purpose of these samples was to establish baseline concentrations for comparison with concentrations at the sites under investigation.

Detection of some of the analytes shown in this section may not indicate that the contaminant is present at the site investigated. For instance, methylene chloride and acetone, laboratory solvents, are often detected due to contamination introduced to the sample in the laboratory. These solvents are extensively used as a

³ CLP = EPA Contract Laboratory Program

LEGEND

- 3-MW1 MONITORING WELL
- P1 PIEZOMETER
- 3607 - POTENTIOMETRIC SURFACE CONTOUR ELEVATIONS (FEET, MSL)



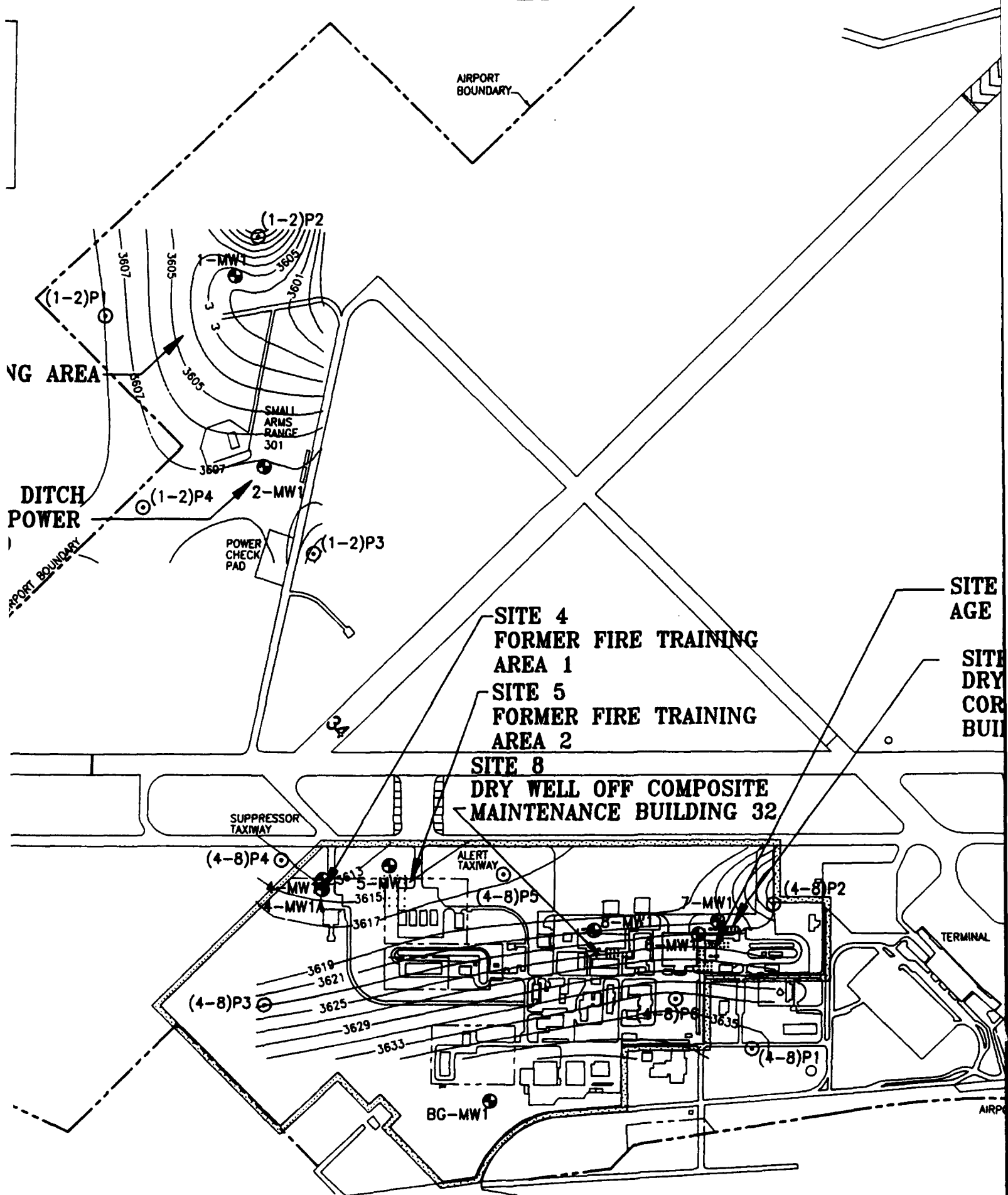


FIGURE 3.1
POTENTIOMETRIC SURFACE
120th FIG, INTERNATIONAL AIRPORT
GREAT FALLS, MONTANA

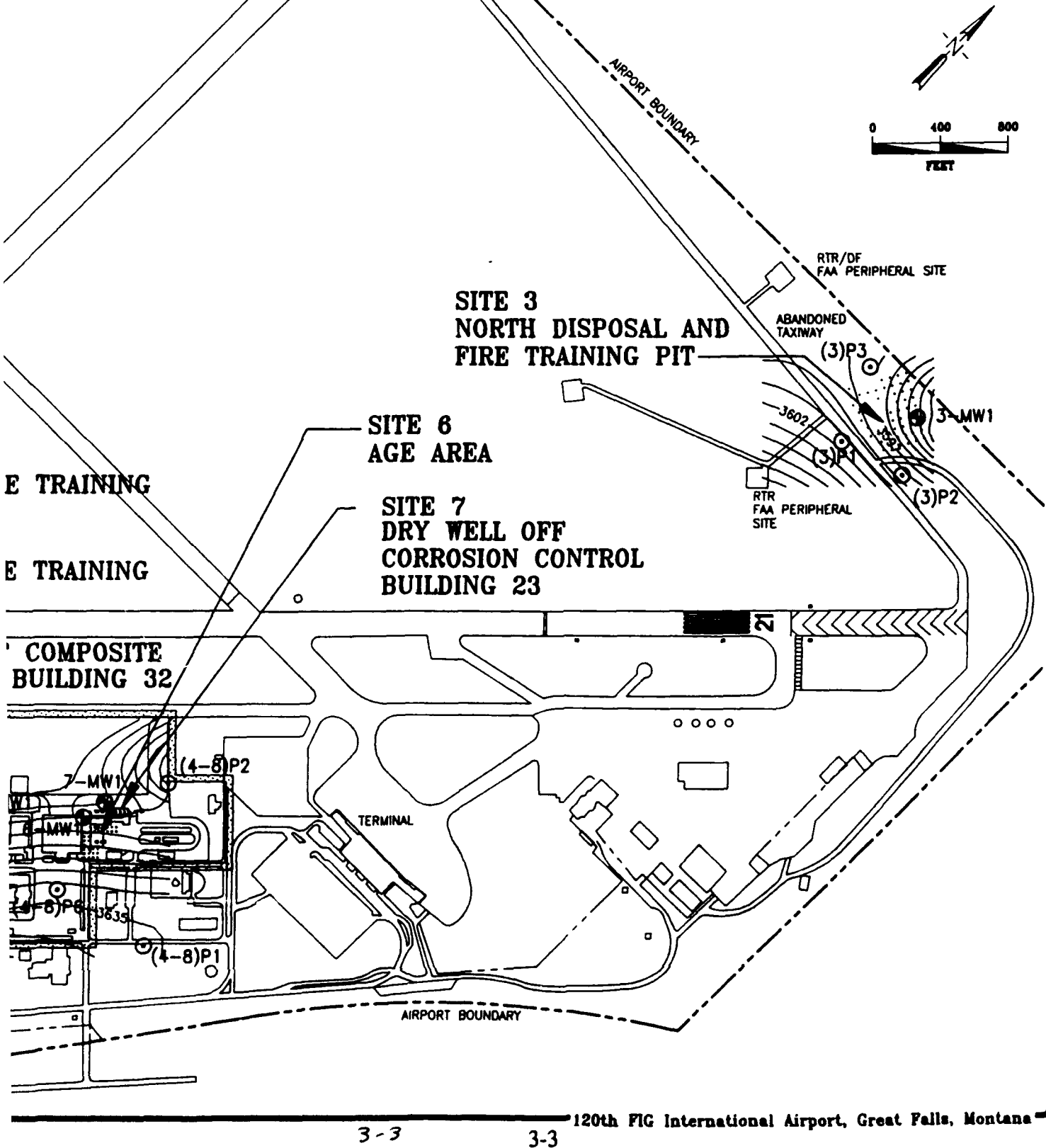


Table 3.1 Organic Constituents Detected in Soil Samples with Field GC Screen, Background

Soil Boring	Sleeve	CLP Sample ID	Constituents
1	A4	MANG-BG-SB1-1	TCE*
	B7	MANG-BG-SB1-3.5	TCE*
2	A3	MANG-BG-SB2-1	TCE*
	B6	MANG-BG-SB2-3	TCE*
3	A4	MANG-BG-SB3-1	TCE*
	B8	MANG-BG-SB3-3.5	TCE*

* This compound was also present in an associated blank.

laboratory extraction media or cleaning agents. Other contaminants that are introduced during sample collection and/or analysis are phthalates. Di-n-octylphthalate and bis(2-ethylhexyl)phthalate, which are commonly detected in sample and blanks, originate from plastic materials. PVC surgical gloves worn during sampling and analysis can be a source of phthalates. Other less common phthalate contaminants of this type are butyl benzyl phthalate and di-n-butyl phthalate.

According to the methodology presented in the HAZWRAP guidance document for evaluating organic laboratory analyses (DOE/HWP-65/R1), if the constituent is a common laboratory contaminant and is presented in a sample at a concentration less than 10 times the concentration of the constituent in any blank associated with the sampling program, the compound is not considered to be a positive result (e.g., the result is due to laboratory contamination).

The 10-times criterion is applied to common laboratory contaminants; however, for all other target compound list (TCL) compounds, the criterion is five times the concentration detected in any blank.

When detected, common laboratory contaminants such as methylene chloride and phthalates were often estimates (J qualifier), and/or detected in laboratory blanks (B qualifier). If a common laboratory contaminant is detected in a laboratory blank, its detection in the sample is not considered a positive result if the sample result is less than 10 times the blank result. Such sample results will not appear in the analyte summary tables or figure. The estimated (J qualifier) common laboratory contaminant values will be included in summary tables and figures. The estimated values are below the EPA contract required detection limit (CRDL) but above the method detection limit. Therefore, a J qualifier denotes a positive identification of a contaminant; however, a degree of uncertainty is attached to contaminant quantification.

The results of the CLP analyses on the background soil samples are summarized in Table 3.2. Only two organic compounds were detected, acetone (160 $\mu\text{g/kg}$) and toluene (10 $\mu\text{g/kg}$). These were found in only one boring each at low concentrations. Acetone is a common laboratory and sampling contaminant.

A number of metals were detected in the background samples. The metals detected, and the range of concentrations found are listed below. The average range of concentrations of these metals in soils in the United States (from Brown, K. et al, 1983) is also listed.

				<u>Average in the United States</u>	
Arsenic	4.3	-	9.6 mg/kg	1	- 50 mg/kg
Barium	101	-	971 mg/kg	100	- 3,000 mg/kg
Chromium	12.9	-	20.7 mg/kg	1	- 1,000 mg/kg
Copper	6.9	-	18.6 mg/kg	2	- 1,000 mg/kg
Lead	5.5	-	12.2 mg/kg	10	- 200 mg/kg
Nickel	6.4	-	14.8 mg/kg	5	- 500 mg/kg
Selenium	not detected	-	0.43 mg/kg	0.1	- 2 mg/kg
Zinc	30.4	-	54.7 mg/kg	10	- 300 mg/kg

Mercury and cadmium were not detected in any background samples. Average ranges in the United States for mercury and cadmium are 0.01 to 0.3 and 0.01 to 0.7, respectively.

Table 3.2 Chemical Constituents Detected in Soil, Background
(CLP Laboratory Analysis)

Chemical	MANG-BG SB1-1	MANG-BG SB1-3.5	MANG-BG SB2-1	MANG-BG SB2-3	MANG-BG SB3-1	MANG-BG SB3-3.5	Average	Standard Deviation	Average +/- Two Standard Deviations	Average +/- Three Standard Deviations
Volatile organics (µg/kg):										
Acetone	ND	ND	ND	ND	ND	160	27	65	ND - 157	ND - 222
Toluene	ND	ND	ND	ND	10	ND	2	4	ND - 9.0	ND - 15
BNA organics (µg/kg)	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA
Metals (mg/kg):										
Arsenic	5.2	9.6	6.1	4.3	4.3	6.1	5.9	2.0	1.9 - 9.9	ND - 11.9
Barium	219	971	101	206	171	919	431	400	ND - 1231	ND - 1631
Chromium	13.3	14.4	13.3	20.7	19.6	12.9	15.7	3.5	8.7 - 22.7	5.2 - 26.2
Copper	10.8 *	18.6 *	6.9 *	12.8 *	11.1 *	8.5 *	11.5	4.1	8.7 - 19.7	ND - 23.8
Lead	8.2	8.7	5.5 B	12.2	8.3	6	8.2	2.4	3.4 - 13	1.0 - 15.4
Nickel	10	14.4	6.4 B	14.8	10.5	7.4	10.6	3.5	3.6 - 17.6	0.1 - 21.1
Selenium	0.37 BW	ND	ND	0.32 BW	0.43 BW	0.42 BW	0.26	0.20	ND - 0.66	ND - 0.86
Zinc	34.3 *	54.7 *	33.3 *	48 *	47.4 *	30.4 *	41.4	9.9	21.6 - 61.3	11.7 - 71.2
Total petroleum hydrocarbons (mg/kg)	ND	ND	ND	ND	ND	ND	NA	NA	NA	NA

ND = not detected, NA = not applicable.
Data qualifiers follow the data. The qualifiers are:

Metals:

- B Reported value is less than reporting limit but greater than the instrument detection limit.
- * Duplicate analysis not within control limits set by Lab QA/QC.

W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.

3165BIAU2341873-2.WK1

The average concentrations and the standard deviations of the soils background results were calculated. These values, along with the ranges associated with the average and two and three standard deviations, are presented in Table 3.2. If the background concentrations follow a normal distribution, the average plus two standard deviations will include 95.4 percent of the values, and the average plus three standard deviations will include 99.7 percent of the values. For the purposes of this investigation, two standard deviations are used as the background range in soil for all parameters. Any organics detected in groundwater will be considered above background. Background levels for metals in groundwater will be less than or equal to the highest levels detected in the background samples.

The results of the groundwater analyses are shown in Table 3.3. No organic compounds were detected. There were four metals detected in the first round of sampling: arsenic (1.1 $\mu\text{g/L}$), barium (56 $\mu\text{g/L}$), lead (4.9 $\mu\text{g/L}$), and zinc (15 $\mu\text{g/L}$). In the second round, there were three metals detected: barium (62.2 $\mu\text{g/L}$), lead (4.3 $\mu\text{g/L}$), and zinc (9.8 $\mu\text{g/L}$). All of these metals were also present in a blank associated with the sampling and analysis program. The TPH concentration in the background well was 1 mg/L.

A field GC was used to further screen the soil samples collected from the background site. The results are shown in Table 3.1. No organics were detected in the field GC analysis, and very few organics in the CLP analysis. This shows a good correlation between the field GC and the CLP analysis.

3.4 SITE 1 - CURRENT FIRE TRAINING AREA

3.4.1 Screening Activity Results

Soil Gas

The results of the soil gas survey are shown in Figure 3.2 and Table 3.4. Samples were collected on a 300-by 600-foot grid with 50-foot spacing. The grid was set up to surround the fire training area, which was identified by the dark staining of the soil.

The soil gas survey indicated low concentrations of toluene and o-xylene throughout the grid. Several samples collected adjacent to the burn area had soil gas readings off scale.

Soil Borings

Description. A total of nine soil borings were drilled and sampled at site 1. Figure 3.3 shows the locations of the soil borings for site 1. All of the borings were drilled within the soil gas survey area except for boring SB7 which was drilled directly into a burn area, and SB9 which was drilled outside the soil gas grid to verify the areal extent of contamination. The deepest boring was 4 feet below ground level as this was the depth that refusal was met. This refusal was due to weathered sandstone, not the competent sandstone encountered at greater depths. No staining or other observations indicated contamination in the soil except for boring SB7. Black-stained soil extended to a depth of 1.5 feet below the surface in this area.

**Table 3.3 Chemical Constituents Detected in Groundwater, Background
(CLP Laboratory Analysis)**

Chemical	Round 1 MANG-BG MW1	Round 2 MANG-BG MW1
GC volatile organics ($\mu\text{g/L}$):	ND	ND
CLP semivolatile organics ($\mu\text{g/L}$):	ND	ND
Metals ($\mu\text{g/L}$):		
Arsenic	1.1 BJ	ND
Barium	56 BJ	62.2 B
Lead	4.9 J	4.3 JN
Zinc	15 B*J	9.8 JB
Total petroleum hydrocarbons (mg/L)	1	ND

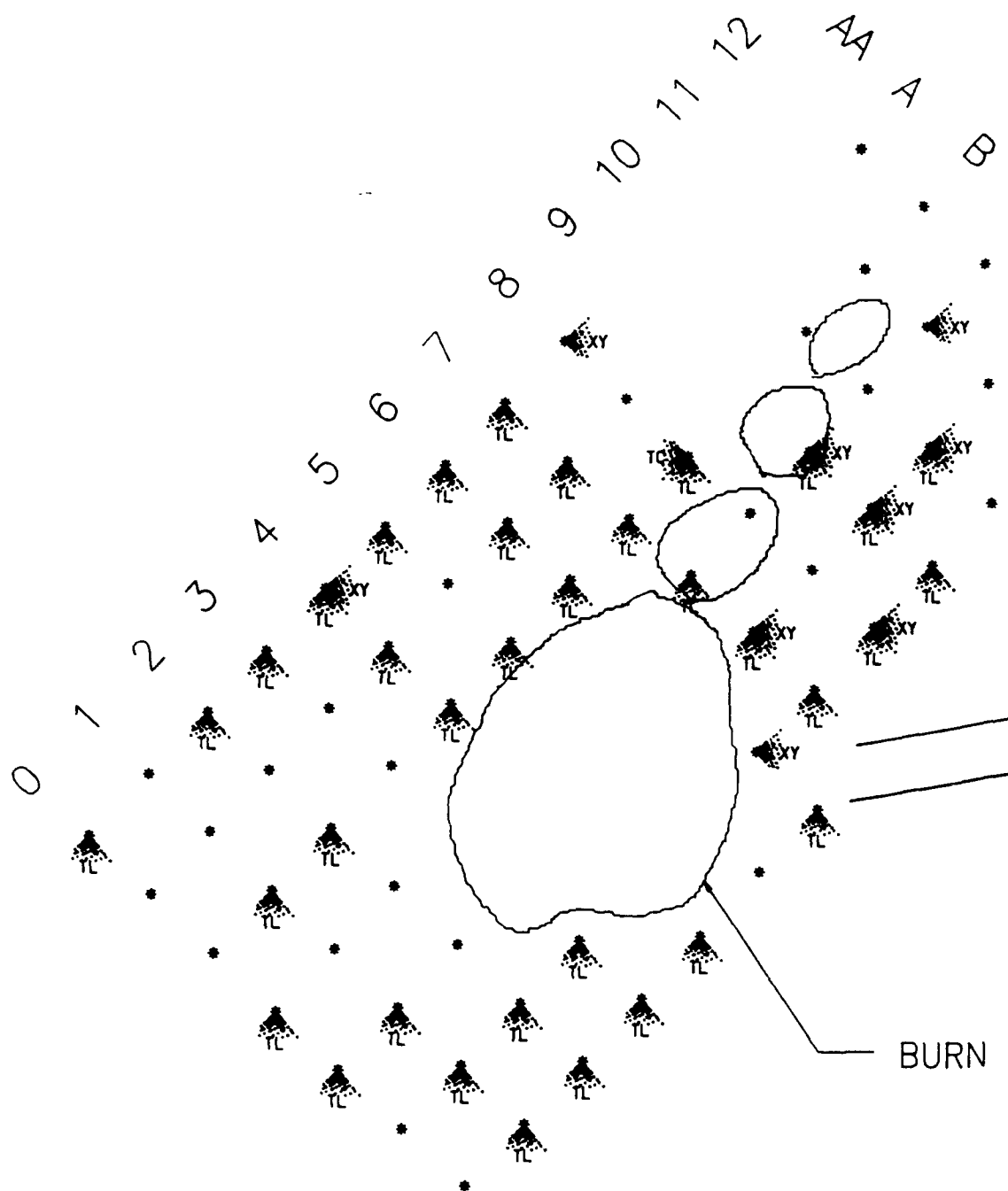
3105B\AU254BT3-3.WK1

ND = not detected.

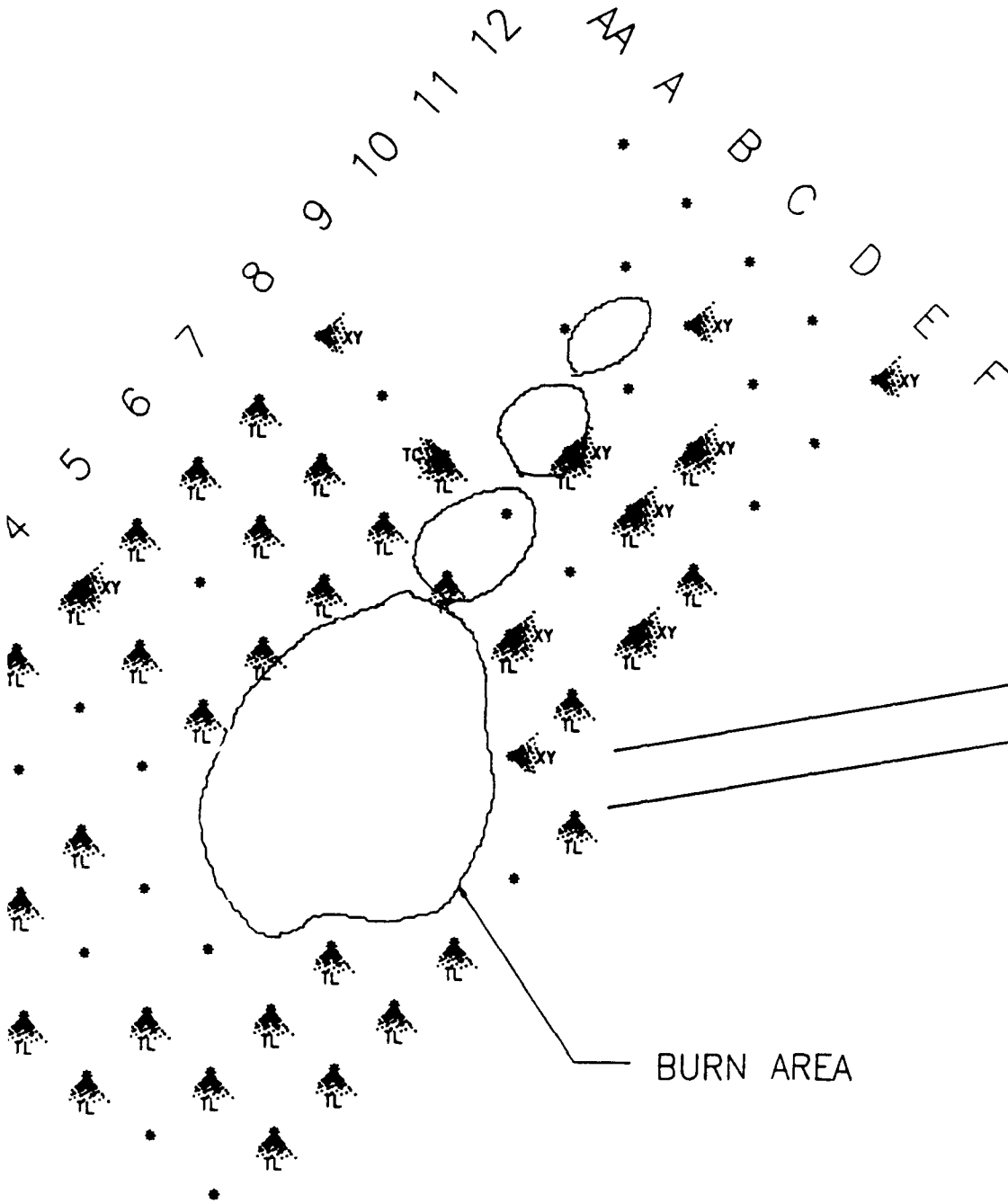
Data qualifiers follow the data. The qualifiers are:

Metals:

- B** Reported value is less than reporting limit but greater than the instrument detection limit.
- N** Spiked sample recovery not within control limits set by lab QA/QC.
- *** Duplicate analysis not within control limits set by lab QA/QC.
- J** The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

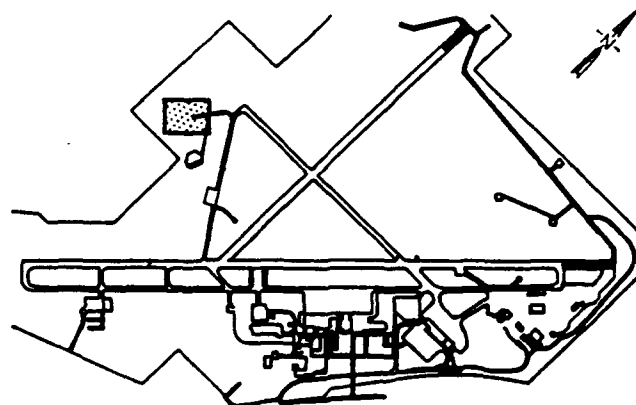


FIRE FIGHTING TRAINING AREA

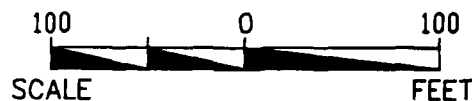
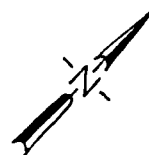


FIGHTING TRAINING AREA

D
FF
Y
F



APPROXIMATE SITE LOCATION



LEGEND

-  BENZENE DETECTED
-  TCE DETECTED
-  TOLUENE DETECTED
-  O-XYLENE DETECTED
- SOV GRID POINT

FIGURE 3.2
RESULTS OF SOIL
GAS SURVEY
SITE 1
CURRENT FIRE
TRAINING AREA

Table 3.4 Organic Constituents Detected in Soil Gas Survey
Site 1: Current Fire Training Area
(ppb by volume, GC)

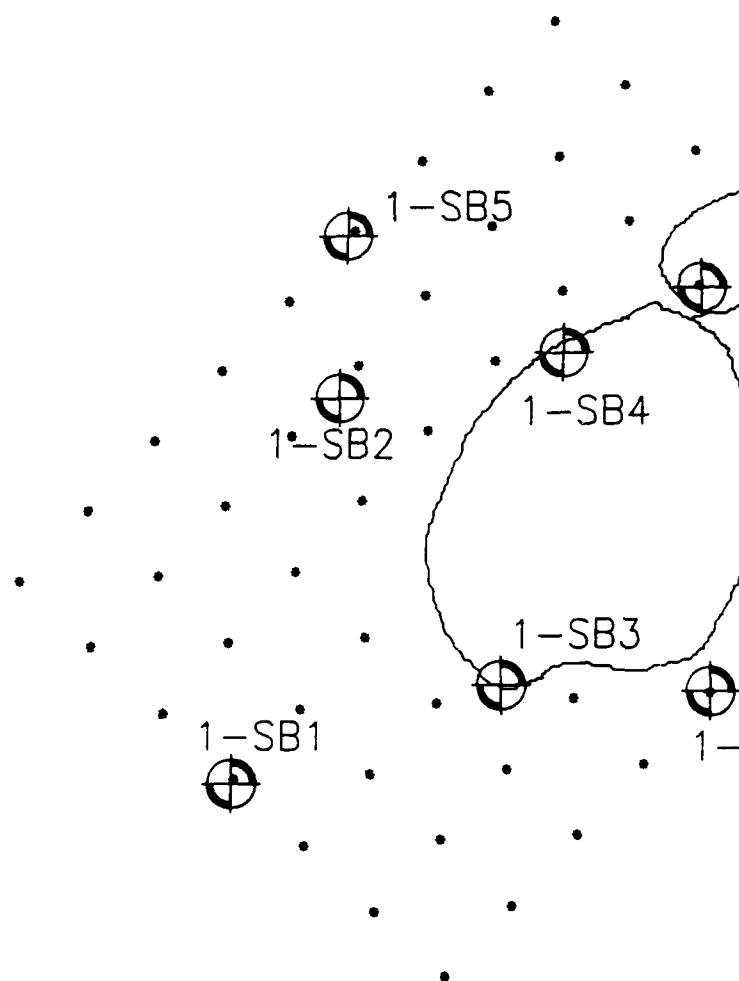
Sample ID	Grid Coordinates		TCE	Toluene	o-Xylene
F0	0	0	ND	ND	ND
F1	0	-50	ND	18	ND
F2	0	-100	ND	19	ND
F3	0	-150	ND	8	ND
F4	0	-200	ND	21	ND
F5	0	-250	ND	0	ND
F6	0	-300	ND	14	ND
E0	50	0	ND	ND	ND
E1	50	-50	ND	***	ND
E2	50	-100	ND	8	ND
E3	50	-150	ND	***	ND
E6	50	-300	ND	ND	150
E7	50	-350	ND	8	ND
E8	50	-400	ND	10	28
E9	50	-450	ND	8	ND
E10	50	-500	ND	ND	ND
E11	50	-550	ND	ND	ND
E12	50	-600	ND	ND	290
D0	100	0	ND	19	ND
D1	100	-50	ND	22	ND
D2	100	-100	ND	ND	ND
D7	100	-350	ND	8	300
D8	100	-400	ND	ND	ND
D9	100	-450	ND	9	52
D10	100	-500	ND	33	97
D11	100	-550	ND	ND	ND
D12	100	-600	ND	ND	ND
C0	150	0	ND	8	ND
C1	150	-50	ND	ND	ND
C2	150	-100	ND	ND	ND
C7	150	-350	ND	***	ND
C8	150	-400	ND	ND	ND
C9	150	-450	ND	14	240
C10	150	-500	ND	ND	ND

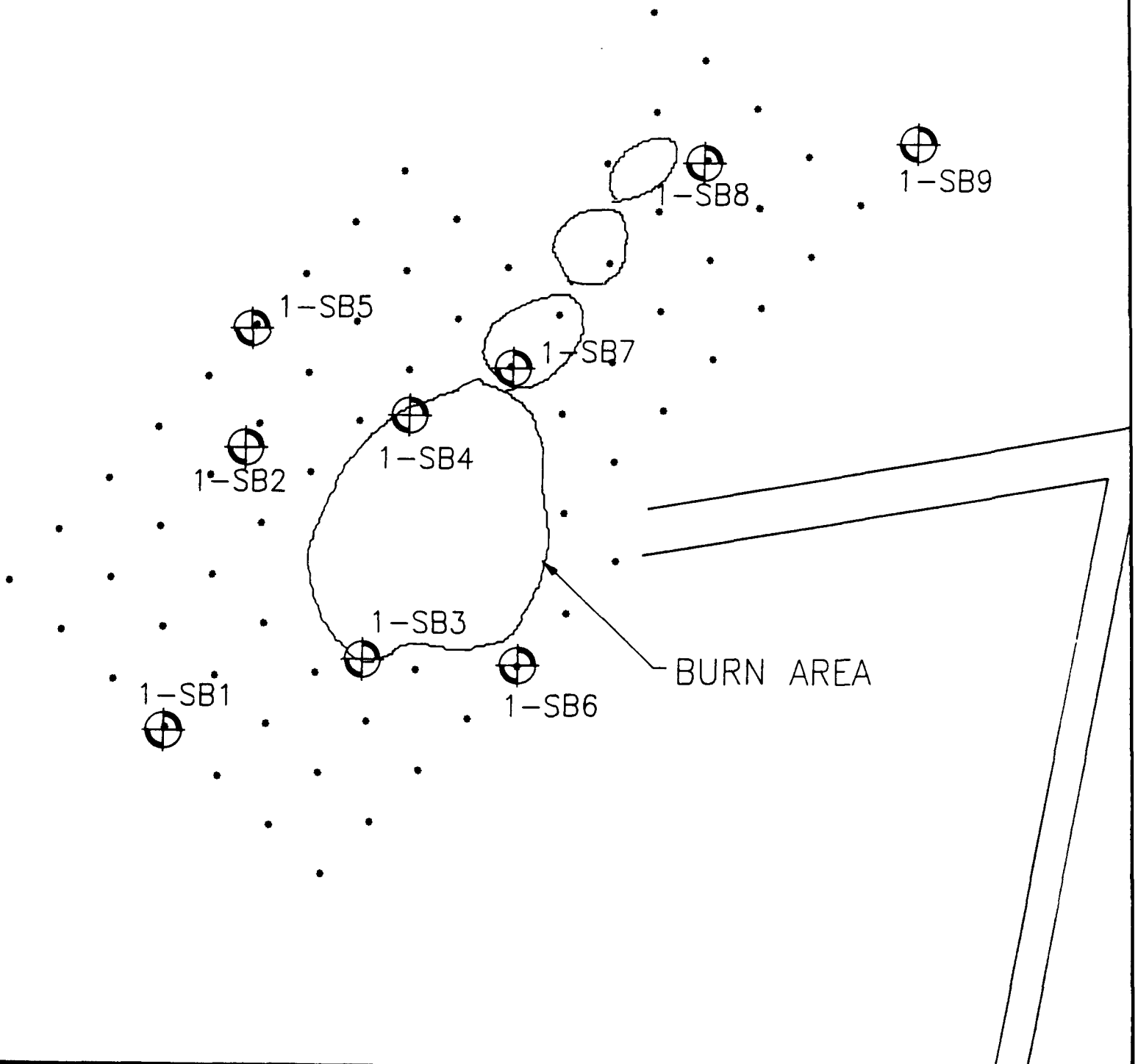
Sample ID	Grid Coordinates		TCE	Toluene	o-Xylene
C11	150	-550	ND	ND	1,680
C12	150	-600	ND	ND	ND
B0	200	0	ND	ND	ND
B1	200	-50	ND	18	ND
B2	200	-100	ND	23	ND
B3	200	-150	ND	ND	ND
B4	200	-200	ND	8	ND
B5	200	-250	ND	8	ND
B6	200	-300	ND	12	ND
B7	200	-350	ND	8	ND
B8	200	-400	9	16	ND
B10	200	-500	ND	ND	ND
B11	200	-550	ND	ND	ND
B12	200	-600	ND	ND	ND
A0	250	0	ND	ND	ND
A1	250	-50	ND	ND	ND
A2	250	-100	ND	ND	ND
A3	250	-150	ND	ND	ND
A4	250	-200	ND	11	ND
A5	250	-250	ND	ND	ND
A6	250	-300	ND	12	ND
A7	250	-350	ND	12	ND
A8	250	-400	ND	ND	ND
A12	250	-600	ND	ND	ND
AA0	300	0	ND	8	ND
AA1	300	-50	ND	ND	ND
AA2	300	-100	ND	49	ND
AA3	300	-150	ND	12	ND
AA4	300	-200	ND	24	340
AA5	300	-250	ND	17	ND
AA6	300	-300	ND	19	ND
AA7	300	-350	ND	8	ND
AA8	300	-400	ND	ND	190

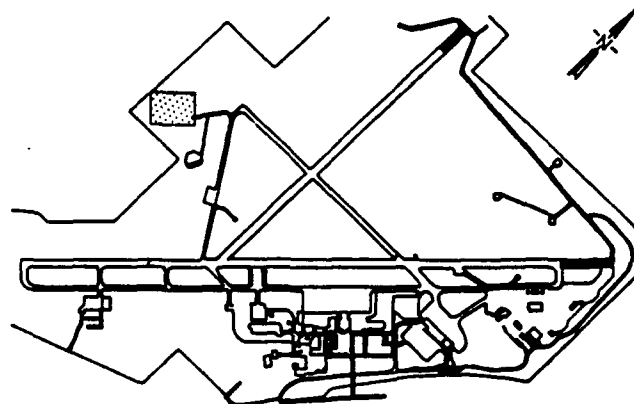
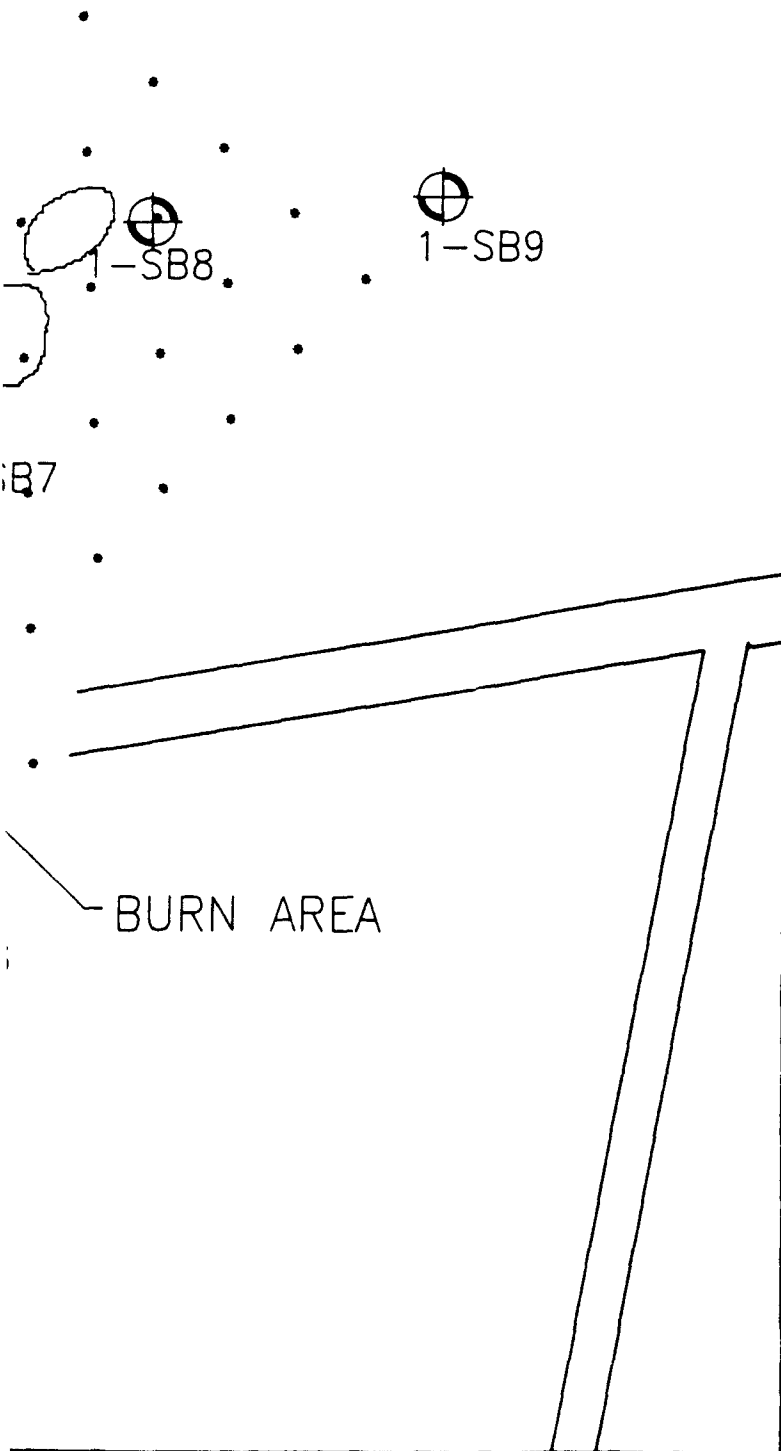
316SB\AU234\BT3-4.WK1

ND = not detected

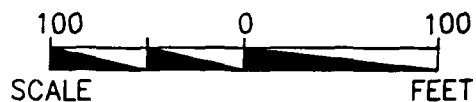
*** Too high to quantify







APPROXIMATE SITE LOCATION



LEGEND

1-SB3 SOIL BORING LOCATION AND NUMBER

• SOV GRID POINT

FIGURE 3.3
LOCATION OF
SOIL BORINGS
SITE 1
CURRENT FIRE
TRAINING AREA

Field HNU. Each soil sample collected at the site was screened with an HNU. The total organic vapor readings for borings at site 1 ranged from 0 to 14 ppm except for boring SB7 which indicated 150 ppm TOV.

Field GC. Soil samples from all nine borings at site 1 were screened with the field GC. The results are summarized in Table 3.5. None of the samples disclosed the presence of high concentrations of organic contaminants, except for SB7. The chromatogram from SB7 was offscale, indicating high organic concentrations. This was expected since this boring was taken in a dark stained area. It was not possible to identify the organics present in the soil at SB7, since the peaks were all offscale. Trace quantities of toluene were detected in several samples. The TCE and o-xylene found in most samples were also present in several blanks, and are likely an artifact of the sampling or analytical procedures.

Piezometer Levels

Four piezometers were installed around sites 1 and 2 collectively in order to determine the optimum placement of a downgradient monitoring well for site 1. Construction data for piezometers is presented in Table 3.6. Groundwater elevations indicate the groundwater flow direction for site 1 to be to the north-northwest; therefore, the downgradient monitor well for site 1 was placed north of the fire training area. Groundwater elevations for each of the piezometers are discussed in section 3.4.3.

Piezometer Screening

Piezometers 1 through 4 from sites 1 and 2 were screened with the field GC. The results of the field GC screening of the piezometers is summarized in Table 3.7. The screening indicated the possible presence of toluene in piezometers 2, 3 and 4; and xylene in piezometers 1, 2, and 3. These constituents were present in the headspace at very low concentrations.

Monitoring Well Observations

Each monitoring well installed was logged during drilling for lithology and other observations that may indicate contamination. MANG-1-MW1 was placed downgradient of the area suspected of contamination, and no observations during drilling indicated the presence of gross contamination in the borehole for the well at site 1.

3.4.2 Confirmation and Delineation Activities

Thirteen soil samples, one duplicate soil sample, and two groundwater samples were collected at site 1 for chemical analyses.

Soil Sampling

Several volatile organics, semivolatile organics, petroleum hydrocarbons, and metals were detected in the analyses run on the soil samples. The organic compounds and the metals detected and their respective concentrations are shown on Table 3.8 and selected analytes are shown on Figure 3.4.

Table 3.5 Organic Constituents Detected in Soil Sample with Field GC Screen
Site 1: Current Fire Training Area

Soil Boring	Sleeve	CLP Sample ID	Constituent
SB-1	A6	MANG-1-SB1-2	TCE o-Xylene*
	B3		TCE*
	B5		TCE* o-Xylene*
SB-2	A4	MANG-1-SB2-1	TCE* o-Xylene*
	B5	MANG-1-SB2-3	TCE o-Xylene*
SB-3	A5	MANG-1-SB3-1	TCE
	B4	MANG-1-SB3-3	TCE*
SB-4	A5	MANG-1-SB4-1.5	TCE* Toluene o-Xylene*
SB-5	A2	MANG-1-SB5-1	TCE* o-Xylene*
	B6	MANG-1-SB5-3.5	TCE* o-Xylene*
SB-6	A4	MANG-1-SB6-1	TCE* Toluene o-Xylene*
	B6	MANG-1-SB6-3.5	TCE* o-Xylene*
SB-7	A4	MANG-1-SB7-1	**
SB-8	A4	MANG-1-SB8-1	TCE* Toluene o-Xylene*
SB-9	A5	MANG-1-SB9-1	TCE* Toluene o-Xylene*

* This compound was also present in an associated blank.

** The peaks on the GC chromatogram were off scale.

**Table 3.6 Organic Constituents Detected in Piezometer Samples
with Field GC Screen, Sites 1 and 2**

Sample	Constituent
MANG (1-2) P1	o-xylene
MANG (1-2) P2	Toluene, o-xylene
MANG (1-2) P3	Toluene, o-xylene
MANG (1-2) P4	Toluene, o-xylene
MANG (1-2) P4, duplicate	Toluene

Table 3.7 Piezometer Construction Data

Piezometer Identification	Location		Elevations (MSL)*		Depth of Well (feet below top of casing)	Screened Interval (feet below top of casing)
	Northing	Easting	Ground	Top of Casing		
MANG-(1-2)-P1	3161.71	6129.37	3,651.16	3,653.54	64.38	59.18-63.67
MANG-(1-2)-P2	4166.54	6651.82	3,650.95	3,653.20	64.25	58.88-63.54
MANG-(1-2)-P3	4546.67	4561.41	3,650.21	3,652.48	62.37	57.00-61.66
MANG-(1-2)-P4	3417.52	4865.73	3,654.04	3,656.02	56.08	50.71-55.37
MANG-3-P1	11503.20	4232.47	3,637.74	3,639.90	57.16	51.79-56.45
MANG-3-P2	11859.67	4133.04	3,635.43	3,637.45	45.02	39.65-44.31
MANG-3-P3	11670.51	4670.89	3,636.64	3,639.03	52.69	47.37-52.03
MANG-(4-8)-P1	7452.61	1271.43	3,678.37	3,680.82	54.95	44.82-49.31
MANG-(4-8)-P2	7589.21	2235.07	3,672.35	3,674.10	55.45	50.25-54.74
MANG-(4-8)-P3	4250.05	1567.89	3,669.21	3,671.45	53.45	48.34-52.83
MANG-(4-8)-P4	4354.81	2528.02	3,659.20	3,661.22	63.02	57.82-62.26
MANG-(4-8)-P5	5809.44	2135.99	3,670.00	3,672.14	59.14	53.77-58.43
MANG-(4-8)-P6	6951.13	1607.27	3,680.85	3,680.67	57.12	54.28-58.78

* MSL = feet above mean sea level

Table 3.8 Chemical Constituents Detected in Soil
Site 1: Current Fire Training Area
(CLP Laboratory Analysis)

Chemical	Background (1)	MANO-1 S81-2	MANO-1 S82-1	MANO-1 S82-3	MANO-1 S83-1	MANO-1 S83-3	MANO-1 S84-1.5	MANO-1 S84-1.5(D)	MANO-1 S85-1	MANO-1 S85-3.5	MANO-1 S86-1	MANO-1 S86-3.5	MANO-1 S87-1	MANO-1 S88-1	MANO-1 S89-1	Health (2)
Volatile organics (µg/kg):																
Acetone	ND-157	ND	ND	15 J	ND	90 J	ND	ND	ND	22 J	226	ND	ND	ND	ND	826
2-Butanone	ND	ND	ND	ND	ND	14 J	ND	ND	ND	ND	ND	ND	ND	ND	ND	456
Toluene	ND-9	ND	ND	ND	ND	92	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,637
Ethyl benzene	ND	ND	ND	ND	ND	16	ND	ND	ND	ND	ND	ND	ND	ND	ND	826
m,p-Xylene (3)	ND	ND	ND	ND	ND	54	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,628
o-Xylene	ND	ND	ND	ND	ND	40	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,628
BNA organics (µg/kg):																
2-Methylphenol	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Diethyltoluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	6,437
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3,286
Pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2,456
M-tol (mg/kg):																
Aromatic	1.9-9.9	13.6	3.8	9.5	11.2	8.6	8.4	6.4	6.2	6.2	10	13.3	6.3	6.7	17.7	80
Barium	ND-1,231	714	127	352	133	382	292	763	217	548	279	315	197	244	136	5,600
Cadmium	0.4	0.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	40
Chromium	8.7-22.7	10.2	13.8	9.2	15.2	9.8	17.7	5.9	15.5	10.3	19.5	9.6	16.8	17.4	14.9	80,000
Copper	3.3-19.7	22.3	8.8	15.3	20.5	18.1	13.8	13.4	15.9	14	20.4	13.7	8.5	13.7	20.4	--
Lead	3.4-13.9	7	13.3	8	18.1	3.3	16.6	11.4	14.9	7.7	11.7	4	196	17	11.2	500
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	0.16	ND	ND	ND	ND	ND	ND	24
Nickel	3.4-17.6	ND	8.2	8.6	7.5	7.9	17.7	ND	10.7	7.1	15.5	ND	10.1	10.6	ND	1,600
Selenium	ND-0.66	0.45	ND	ND	ND	ND	ND	0.38	ND	ND	ND	0.42	ND	0.36	BW	2,400
Zinc	21.6-61.3	41.4	39.5	31.8	62.9	21.9	51.9	23.5	43.4	26.1	46.5	23.5	54.7	43.5	42.7	16,000
Total petroleum hydrocarbons (mg/kg)	ND	11	ND	ND	25	ND	ND	ND	ND	ND	ND	ND	120,000	ND	ND	--

(1) Background is the average background concentration +/- two standard deviations.

(2) Based upon soil ingestion, see section 4.

(3) M-tol - not per -ylene co-oxide and are not distinguishable by this method.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

M-tol:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spilled sample recovery not within control limits set by lab QA/QC.

S Reported value was determined by the method of standard additions.

* Duplicate analysis not within control limits set by lab QA/QC.

W Post-digestion spike for furan AA analysis out of control limits (85 to 115%), while sample shortness is less than 50% of spike shortness.

EIN123456789-4-0-11

MW1 (SITE 1)

CLP semivolatile organics (ug/L)
 bis (2-ethylhexyl) phthalate
 Metals (mg/L):
 Barium
 Lead
 Selenium
 Zinc

SB8 (1 ft.)
 VOA organics (ug/kg):
 Toluene 5 J

SB5 (1 ft.)
 BNA organics (ug/kg):
 Diethylphthalate 120 J
 Metals (mg/kg):
 Lead 14.9 N+S
 Mercury 0.16
 SB5 (3.5 ft.)
 VOA organics (ug/kg):
 Acetone 22 J

SB2 (1 ft.)
 Diethylphthalate 270 J
 Metals (mg/kg):
 Lead 13.3 N+S
 SB2 (3 ft.)
 VOA organics (ug/kg):
 Acetone 15 J

SB4 (1.5 ft.)
 Metals (mg/kg):
 Lead 16.6 N+S
 Nickel 17.7
 SB4 (1.5 ft.) (D)
 Diethylphthalate 150 J

SB1 (2 ft.)
 Metals (mg/kg):
 Arsenic 13.6
 Cadmium 0.4 B
 Copper 22.3
 TPH (mg/kg): 11

SB3 (1 ft.)
 Metals (mg/kg):
 Arsenic 11.1
 Copper 20
 Lead 18
 Zinc 62
 TPH (mg/kg): 1
 SB3 (3 ft.)
 VOA organics (ug/kg):
 Acetone
 2-Butanone
 Toluene
 Ethyl benzene
 m/p-Xylene
 o-Xylene

(1-2)P1

MW1 (SITE 1)	ROUND 1	ROUND 2
CLP semivolatile organics (ug/L):		
bis (2-ethylhexyl) phthalate	ND	62
Metals (mg/L):		
Barium	138 BJ -	107 B
Lead	6.4 J	2.5 BNJ
Selenium	4.2 B	8.5 BS
Zinc	952 *	527

(1-2)P2

SB8 (1 ft.)
VOA organics (ug/kg):
Toluene 5 J

SB9 (1 ft.)
Metals (mg/kg):
Arsenic 17.7 B
Copper 20.4

1-
anics (ug/kg):
ylphthalate 120 J
(mg/kg):
14.9 N+S
ary 0.16
ft.)
anics (ug/kg):
ne 22 J

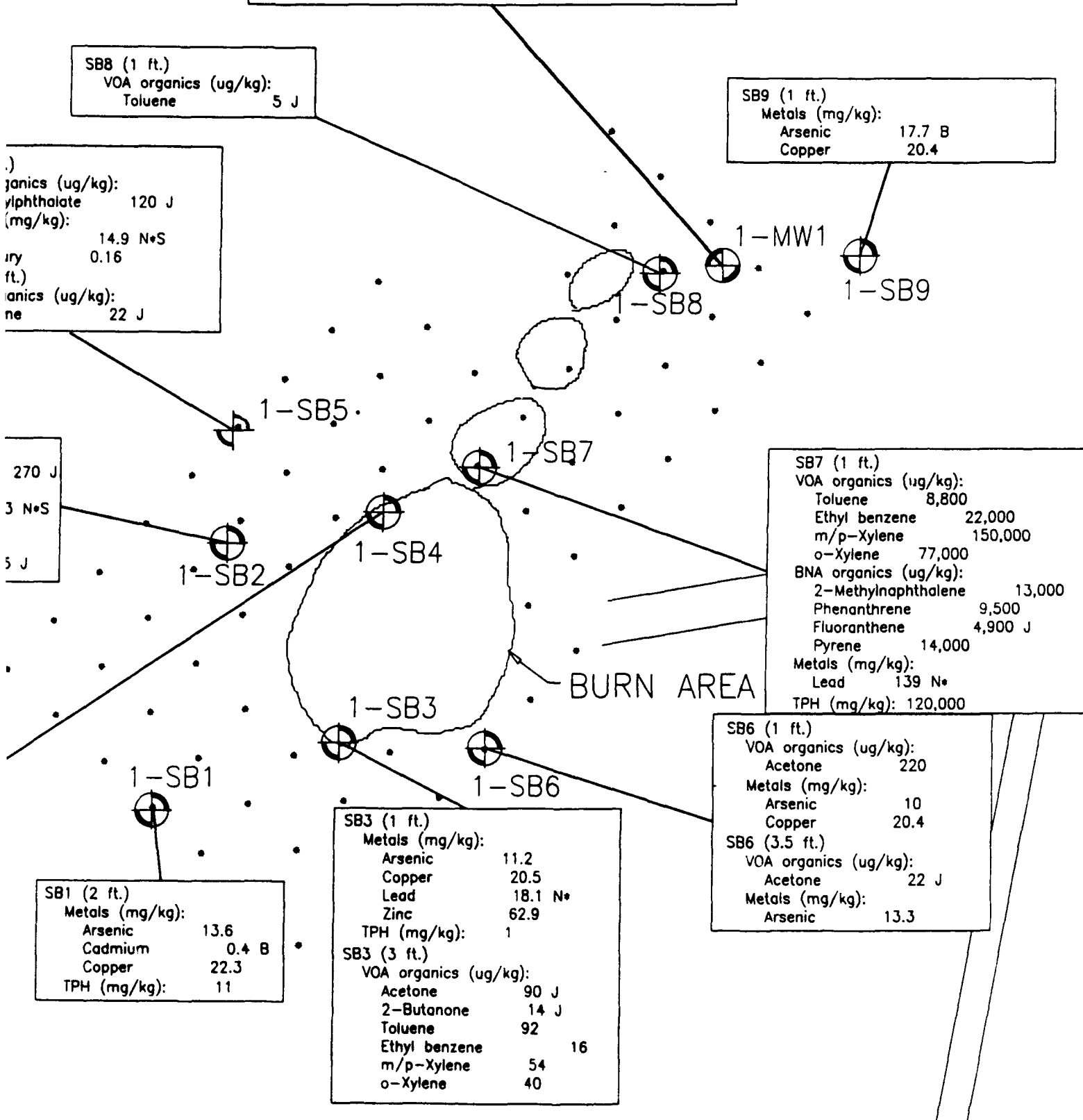
270 J
3 N+S
5 J

SB7 (1 ft.)
VOA organics (ug/kg):
Toluene 8,800
Ethyl benzene 22,000
m/p-Xylene 150,000
o-Xylene 77,000
BNA organics (ug/kg):
2-Methylnaphthalene 13,000
Phenanthrene 9,500
Fluoranthene 4,900 J
Pyrene 14,000
Metals (mg/kg):
Lead 139 N+
TPH (mg/kg): 120,000

SB6 (1 ft.)
VOA organics (ug/kg):
Acetone 220
Metals (mg/kg):
Arsenic 10
Copper 20.4
SB6 (3.5 ft.)
VOA organics (ug/kg):
Acetone 22 J
Metals (mg/kg):
Arsenic 13.3

SB1 (2 ft.)
Metals (mg/kg):
Arsenic 13.6
Cadmium 0.4 B
Copper 22.3
TPH (mg/kg): 11

SB3 (1 ft.)
Metals (mg/kg):
Arsenic 11.2
Copper 20.5
Lead 18.1 N+
Zinc 62.9
TPH (mg/kg): 1
SB3 (3 ft.)
VOA organics (ug/kg):
Acetone 90 J
2-Butanone 14 J
Toluene 92
Ethyl benzene 16
m/p-Xylene 54
o-Xylene 40



ROUND 1	ROUND 2
	62
8 BJ	107 B
1 J	2.5 BNJ
2 B	8.5 BS
2 *	527

(1-2)P2

SB9 (1 ft.)	
Metals (mg/kg):	
Arsenic	17.7 B
Copper	20.4

1-MW1

1-SB9

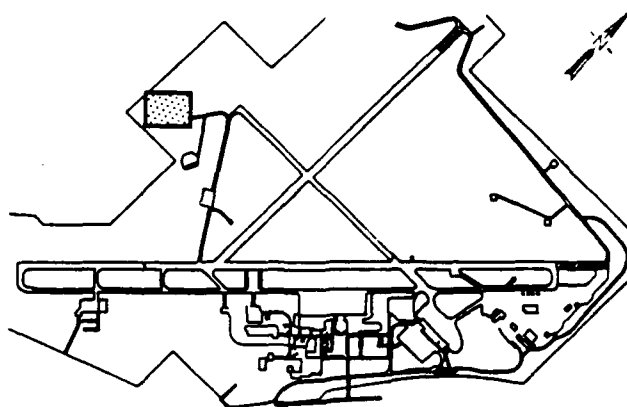
1-SB8

B7

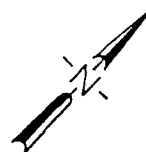
SB7 (1 ft.)	
VOA organics (ug/kg):	
Toluene	8,800
Ethyl benzene	22,000
m/p-Xylene	150,000
o-Xylene	77,000
BNA organics (ug/kg):	
2-Methylnaphthalene	13,000
Phenanthrene	9,500
Fluoranthene	4,900 J
Pyrene	14,000
Metals (mg/kg):	
Lead	139 N*
TPH (mg/kg): 120,000	

BURN AREA

SB6 (1 ft.)	
VOA organics (ug/kg):	
Acetone	220
Metals (mg/kg):	
Arsenic	10
Copper	20.4
SB6 (3.5 ft.)	
VOA organics (ug/kg):	
Acetone	22 J
Metals (mg/kg):	
Arsenic	13.3



APPROXIMATE SITE LOCATION



100 0 100
SCALE FEET

LEGEND

1-SB3 SOIL BORING LOCATION AND NUMBER

1-MW1 MONITOR WELL LOCATION AND NUMBER

(1-2)P1 PIEZOMETER LOCATION AND NUMBER

SOV GRID POINT

NOTE: SEE ANALYTICAL SUMMARY TABLES FOR LABORATORY QUALIFIERS

FIGURE 3.4
SELECTED ANALYTES DETECTED
IN SOIL AND GROUNDWATER
SITE 1
CURRENT FIRE TRAINING AREA

Several volatile organics were found in the soil samples collected at site 1. These compounds include toluene (up to 8,800 $\mu\text{g/kg}$), ethyl benzene (up to 22,000 $\mu\text{g/kg}$), m/p-xylene⁴ (up to 150,000 $\mu\text{g/kg}$), o-xylene (up to 77,000 $\mu\text{g/kg}$), acetone (up to 220 $\mu\text{g/kg}$), and 2-butanone (up to 14 $\mu\text{g/kg}$).

Semivolatile organics detected in the soil sample collected at site 1 include 2-methylnaphthalene (up to 13,000 $\mu\text{g/kg}$), phenanthrene (up to 9,500 $\mu\text{g/kg}$), fluoranthene (up to 4,900 $\mu\text{g/kg}$), and pyrene (up to 14,000 $\mu\text{g/kg}$), and diethylphthalate (up to 270 $\mu\text{g/kg}$). Phthalates are common laboratory and sampling contaminants.

The total petroleum hydrocarbons (TPH) analyses indicated some contamination at the site. The concentrations of TPH range up to 120,000 mg/kg.

The concentrations of the majority of the metals detected in soils at site 1 were below the background levels defined in section 3.3 and presented in Table 3.2. The metals detected above background include lead, arsenic, copper, cadmium, nickel, mercury, and zinc.

Groundwater Sampling

Groundwater was sampled in October 1990 and in February 1991. Field measurements made during sampling are presented in Tables 3.9 and 3.10. The results of the analyses of the groundwater from both rounds of sampling of well MANG-1-MW1 indicated one volatile organic compound, one semivolatile organic, no petroleum hydrocarbons, and several metals were present. The results of the chemical analyses of the groundwater from MANG-1-MW1 are presented in Table 3.11 and selected analytes are shown on Figure 3.4.

Chloroform was the only organic compound detected in the groundwater during the first round of sampling and was not detected during the second round. Bis(2-ethylhexyl)phthalate was the only semivolatile organic detected.

The metals detected in groundwater at site 1 from both rounds of sampling were barium (up to 138 $\mu\text{g/L}$), lead (up to 6.4 $\mu\text{g/L}$), selenium (up to 8.5 $\mu\text{g/L}$), and zinc (up to 952 $\mu\text{g/L}$). In addition, nickel was detected during the second round at 25 $\mu\text{g/L}$. One background well was sampled to establish a baseline for chemical constituents in the groundwater as discussed in section 3.3. The results of these analyses are also presented in Table 3.11. Elevated levels of some metals were apparent from monitoring well data.

Comparison of Screening Results with CLP Results

The results of the soil gas survey compared favorably with the CLP results. The soil gas survey indicated high organic concentrations in and adjacent to the stained areas. The organic concentrations dropped off quickly as the soil gas survey points moved away from the stained area. This was confirmed by the CLP data.

The field headspace readings of soil samples collected at site 1 ranged from 0 ppm to 80 ppm. These readings correspond well to the analytical results from the CLP laboratory.

⁴ The analytical method used by the laboratory cannot distinguish between meta- and para-xylene.

Table 3.9 Groundwater Field Measurements, Round 1 Sampling

Well Name	Depth (feet)	Measured When Developed/ Measured When Sampled			Conductivity (mS/cm)	Remarks
		Static Water Level (feet BTOC)*	pH	Temperature (°C)		
MANG-1-MW1	58.15	51.85/52.23	7.38/7.05	13.6/8.3	1.7	Poor producing well; purged dry after 7 to 8 gallons pumped.
MANG-2-MW1	60.74	44.06/44.09	7.18/7.22	9.8/9.2	2.0	Good producing well; water very clear.
MANG-3-MW1	58.21	45.39/45.43	7.41/7.43	9.9/8.6	0.94	Good producing well; water clear.
MANG-4-MW1	60.68	49.90/49.98	7.55/7.00	11.1/8.7	1.40	Good producing well; slightly cloudy.
MANG-4-MW1A	13.90	8.65/8.63	7.6/7.42	13.8/14.6	0.88	Fair producing well.
MANG-5-MW1	56.71	43.10/43.27	7.36/7.28	11.7/8.7	2.0	Good producing well; water very clear.
MANG-6-MW1	66.30	51.62/51.21	7.62/7.50	12.2/14.0	0.67	Well dry after approximately 10 gallons purged; water clear.
MANG-7-MW1	74.00	53.24/52.95	7.48/7.42	10.3/12.8	0.70	Water has slight plastic smell; poor producing well, dry after approximately 10 gallons purged.
MANG-8-MW1	60.23	53.01/53.22	7.61/7.69	11.3/11.8	0.80	Purged dry after approximately 10 gallons pumped.
MANG-BG-MW1	57.69	44.83/46.75	7.23/7.08	9.0/8.7	1.50	Poor producing well; purged dry after approximately 10 gallons pumped.

* BTOC = below top of casing

Table 3.10 Groundwater Field Measurements, Round 2 Sampling

Well Name	Depth (feet)	Static Water Level (feet BTOC* when developed/feet BTOC when sampled)	pH **	Temperature ** (°C)	Conductivity ** (mS/cm)	Remarks
MANG-1-MW1	58.15	53.57/55.59	7.42	9.8	0.72	Poor producing well; purged dry after 7 to 8 gallons pumped.
MANG-2-MW1	60.74	46.78/46.83	7.47	9.5	1.97	Good producing well; water very clear.
MANG-3-MW1	58.21	45.75/45.95	7.42	10.1	0.93	Good producing well; water clear.
MANG-4-MW1	60.68	52.88/51.60	7.53	9.5	1.70	Good producing well; slightly cloudy.
MANG-4-MW1A	13.90	9.88/8.84	7.50	6.8	0.81	Fair producing well.
MANG-5-MW1	56.71	50.61/50.70	7.10	8.3	1.27	Good producing well; water very clear.
MANG-6-MW1	66.30	53.50/53.65	7.65	11.7	0.86	Well dry after approximately 10 gallons purged; water clear.
MANG-7-MW1	74.00	55.37/55.70	7.41	11.4	1.77	Water has slight plastic smell; poor producing well, dry after approximately 10 gallons purged.
MANG-8-MW1	60.23	53.86/53.98	7.32	11.6	0.82	Purged dry after approximately 10 gallons pumped.
MANG-BG-MW1	57.69	53.63/53.41	6.89	8.7	0.53	Poor producing well; purged dry after approximately 10 gallons pumped.

* BTOC = below top of casing

** pH, temperature, and conductivity readings measured when wells were developed

Table 3.11 Chemical Constituents Detected in Groundwater
Site 1: Current Fire Training Area
(CLP Laboratory Analysis)

Chemical	Round 1 MANG-1 MW1	Round 2 MANG-1 MW1	Background		ARARs(1)
			Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics ($\mu\text{g/L}$):					
Chloroform	1.1 J	ND	ND	ND	100
CLP semivolatile organics ($\mu\text{g/L}$):					
bis(2-Ethylhexyl)phthalate	ND	62	ND	ND	4 (2)
Metals ($\mu\text{g/L}$):					
Arsenic	ND	ND	1.1 BJ	ND	50
Barium	138 BJ	107 B	56	62.2 B	1,000
Lead	6.4 J	2.5 BNJ	4.9	4.3 NJ	50
Nickel	ND	25 B	ND	ND	100
Selenium	4.2 B	8.5 BS	ND	ND	10
Zinc	952 *	527	15	9.8 BJ	5,000
Total petroleum hydrocarbons (mg/L)	ND	ND	1	ND	NA

3205A\AU23409\BT3-11.WK1

(1) ARARs are proposed only. These are MCL's where available, otherwise WQC.

(2) Value is for total phthalate esters (Federal Register, July 25, 1990, pp. 33049-33127).

ND = not detected.

NA = not applicable.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at less than 5 times the amount detected in an associated blank.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

S Reported value was determined by the method of standard additions.

* Duplicate analysis not within control limits set by lab QA/QC.

J The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

The field GC data for site 1 are presented in Table 3.5. There was some correlation between the field GC screening and the CLP analyses.

3.4.3 Geologic and Hydrogeologic Investigation Results

The geology and hydrogeology of sites 1 and 2 were evaluated together since the two sites are so closely spaced. The subsurface lithology in this area consisted of soil and weathered sandstone underlain by hard sandstone. Surface soils consisting of light brown sandy, silty soil extended to 2 feet below ground level (bgl). Weathered sandstone was encountered at depths as shallow as 2 feet. Table 3.12 lists the depths below ground level to top of competent sandstone, the depth to the sandstone-shale contact, and the thickness of the sandstone in each of the wells and piezometers for sites 1 and 2. The thickness of the hard, competent sandstone ranges from 29 to 42 feet at sites 1 and 2. Four piezometers were used to define the lithology and groundwater flow direction for the two sites. The data gathered from the two monitoring wells were also used to help define the hydrogeology of the area associated with sites 1 and 2. The locations of the piezometers and wells for sites 1 and 2 are shown on Figure 3.5. Piezometer and monitoring well construction data are presented in Tables 3.8 and 3.13, respectively.

A cross section was drawn using the lithologic logs (appendix C) of the well and piezometer borings in the study area. The orientation of the cross section is shown on Figure 3.6, while the cross section is shown on Figure 3.7. The cross section shows relatively flat-lying bedrock with no major structural displacement overlain by unconsolidated material. The cross section does not differentiate weathered sandstone from the underlying competent sandstone.

Piezometer data was evaluated and the groundwater flow direction was determined to be to the north-northwest. The monitoring well was then constructed downgradient of site 1. A final round of water level measurements was taken and the data used to compute and contour groundwater elevations in the area. Figure 3.8 is the resulting potentiometric surface map. The areal groundwater flow is to the north-northwest. The groundwater flow in a water table or perched aquifer is variable due to seasonal fluctuations in the water levels surface topography, and the geology of the area. This variability is evident near 1-MW1. Although the general groundwater flow at site 1 is to the north-northwest, the apparent gradient near 1-MW1 is to the east-southeast. The average hydraulic gradient is approximately 36 feet per mile. Table 3.14 lists the water level information from two rounds of measurements. The last round of measurements was used to construct the potentiometric surface map.

3.4.4 Conclusions

The results of screening activities at site 1 indicate the presence of petroleum contaminants over the entire site delineated by the soil gas grid (Figure 3.2). Soil gas survey results were off scale on the perimeter of the visibly contaminated burn areas, preventing soil gas investigation in the actual burn areas. Since the depth to weathered sandstone (is indicated by refusal during the soil boring program) in this area is only about 2 to 4 feet, the soil gas survey and visual observations proved to be sufficient indicators of gross waste fuel contamination of the stained burn areas.

Table 3.12 Bedrock Data Sites 1 and 2
120th Fighter Interceptor Group
Great Falls, Montana

Well/ Piezometer ID	Depth to Top of Competent Sandstone*	Depth to Base of Competent Sandstone*	Thickness of Competent Sandstone (feet)
MANG-1-MW1	17.7	**	**
MANG-2-MW1	15.0	55.0	40.0
MANG-P1	17.7	56.6	38.9
MANG-P2	17.1	58.4	41.3
MANG-P3	15.0	56.8	41.8
MANG-P4	20.8	**	**

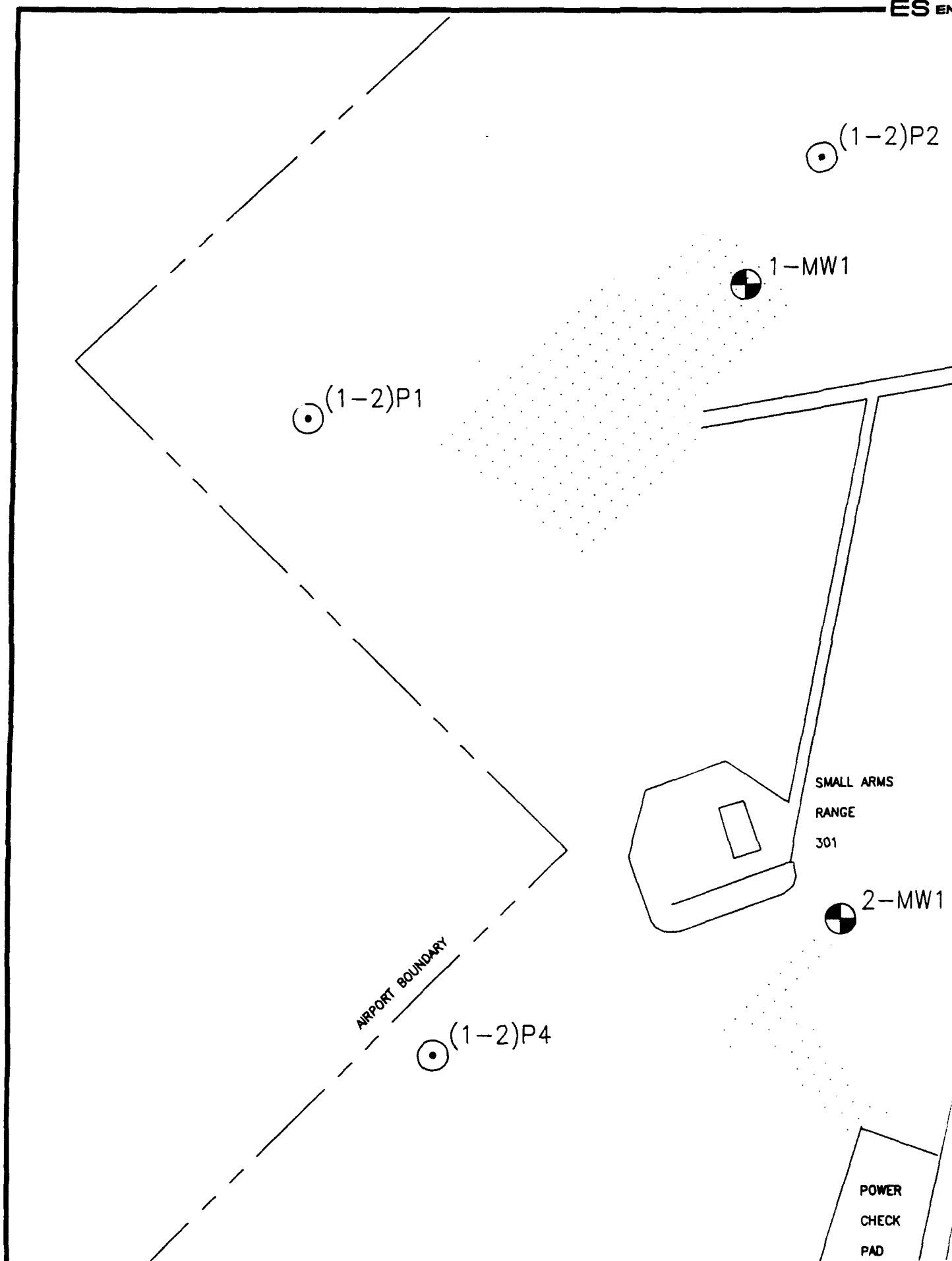
* All depths are in feet below ground level.

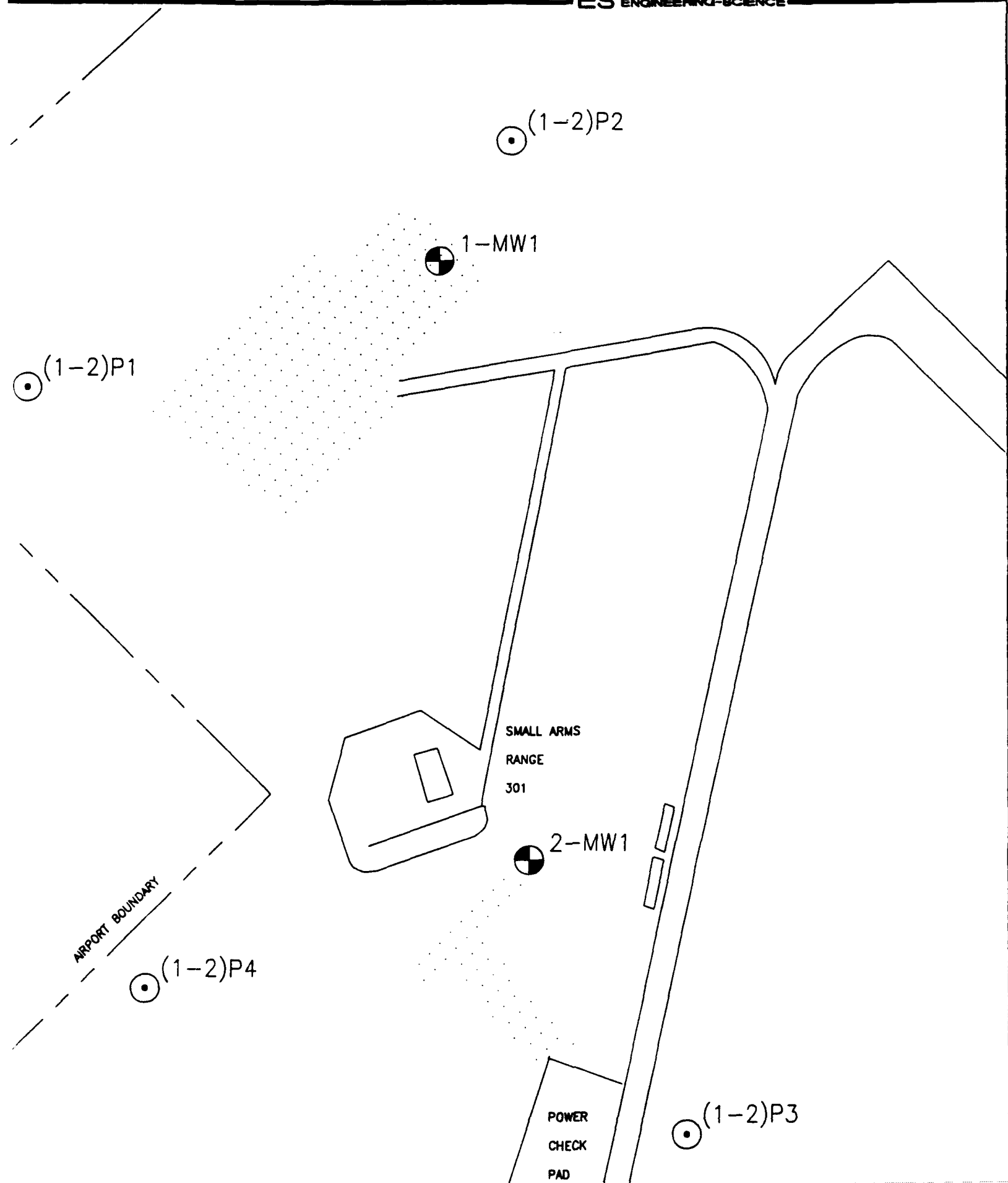
** Base of sandstone was not encountered.

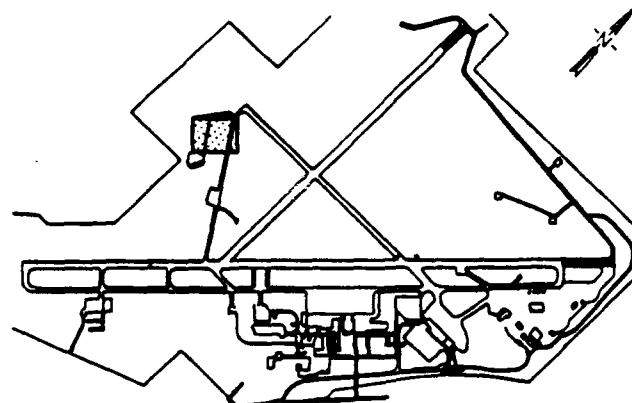
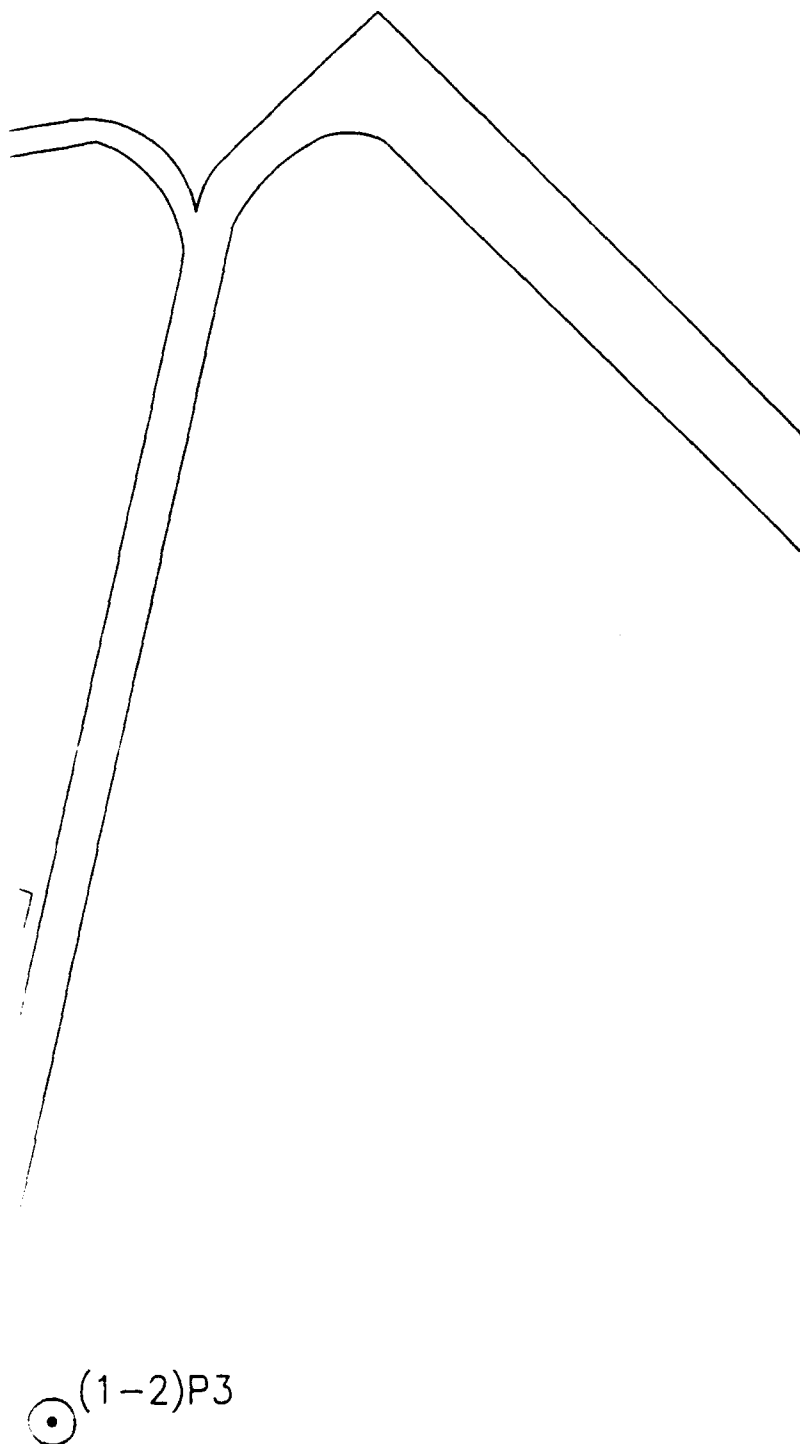
Table 3.13 Monitoring Well Construction Data

Well Identification	Location		Elevations (MSL)*		Depth of Well (feet below top of casing)	Screened Interval (feet below top of casing)
	Northing	Easting	Ground	Top of Casing Brass Pin on Pad		
MANG-BG-MW1	5827.96	934.58	3678.50	3680.89	57.69	37.18-56.94
MANG-1-MW1	4018.41	6395.48	3653.50	3655.74	58.15	37.44-56.64
MANG-2-MW1	4216.72	5134.37	3659.80	3661.99	60.74	40.01-60.11
MANG-3-MW1	11950.75	4368.54	3636.00	3638.33	58.21	36.99-56.72
MANG-4-MW1	4631.85	2415.93	3663.20	3665.61	60.25	39.61-59.56
MANG-4-MW1A	4623.70	2400.53	3662.50	3664.70	13.40	8.11-12.69
MANG-5-MW1	5060.24	2491.77	3661.50	3664.02	56.92	36.43-56.16
MANG-6-MW1	7096.76	2034.19	3675.70	3675.19	64.49	44.09-63.85
MANG-7-MW1	7220.05	2123.93	3674.40	3673.96	73.46	53.05-72.76
MANG-8-MW1	6412.84	2063.06	3674.90	3674.21	58.59	38.24-57.96

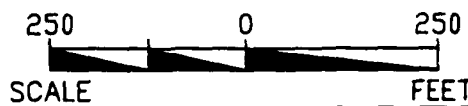
* MSL = feet above mean sea level







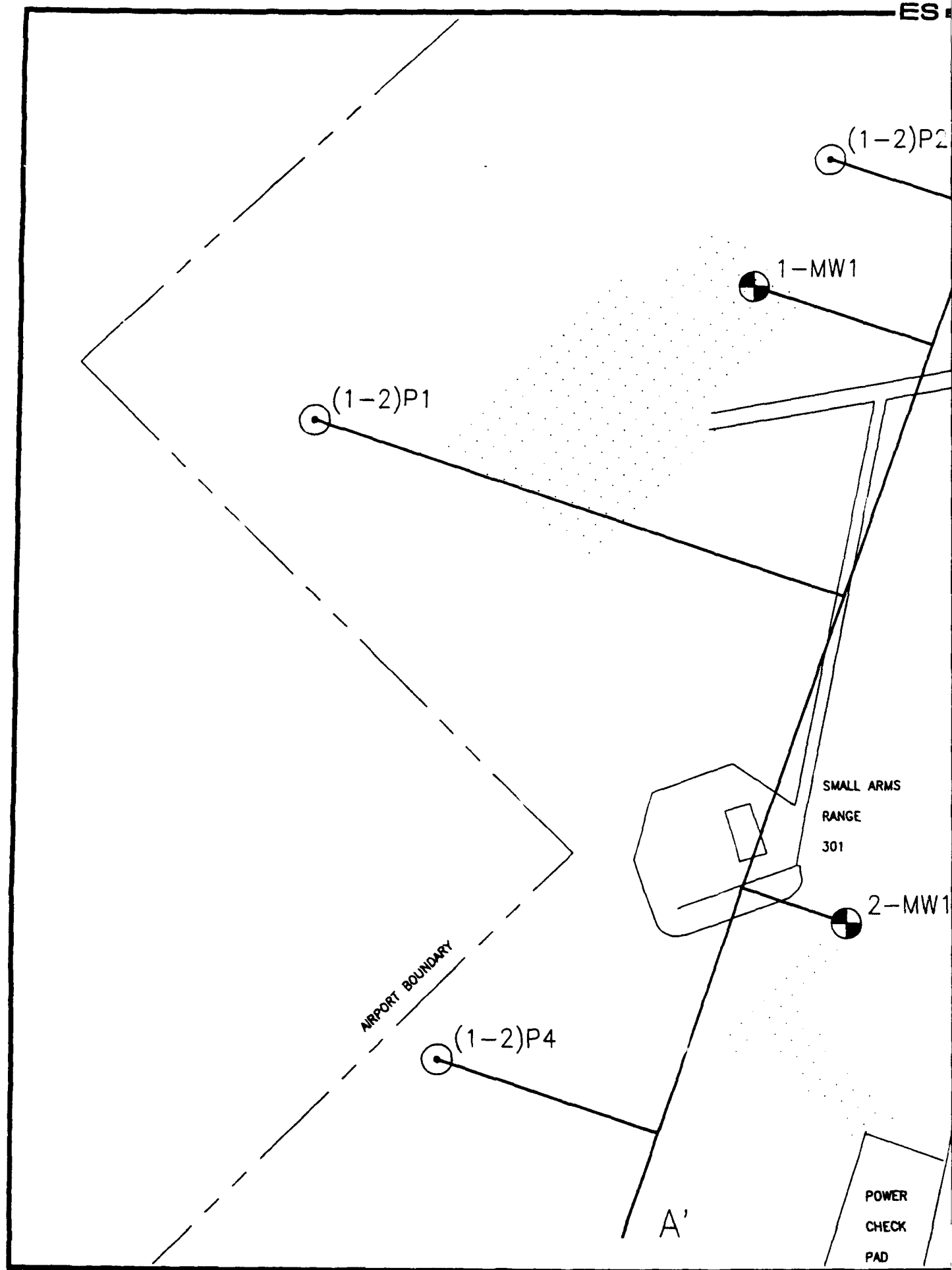
APPROXIMATE SITE LOCATION

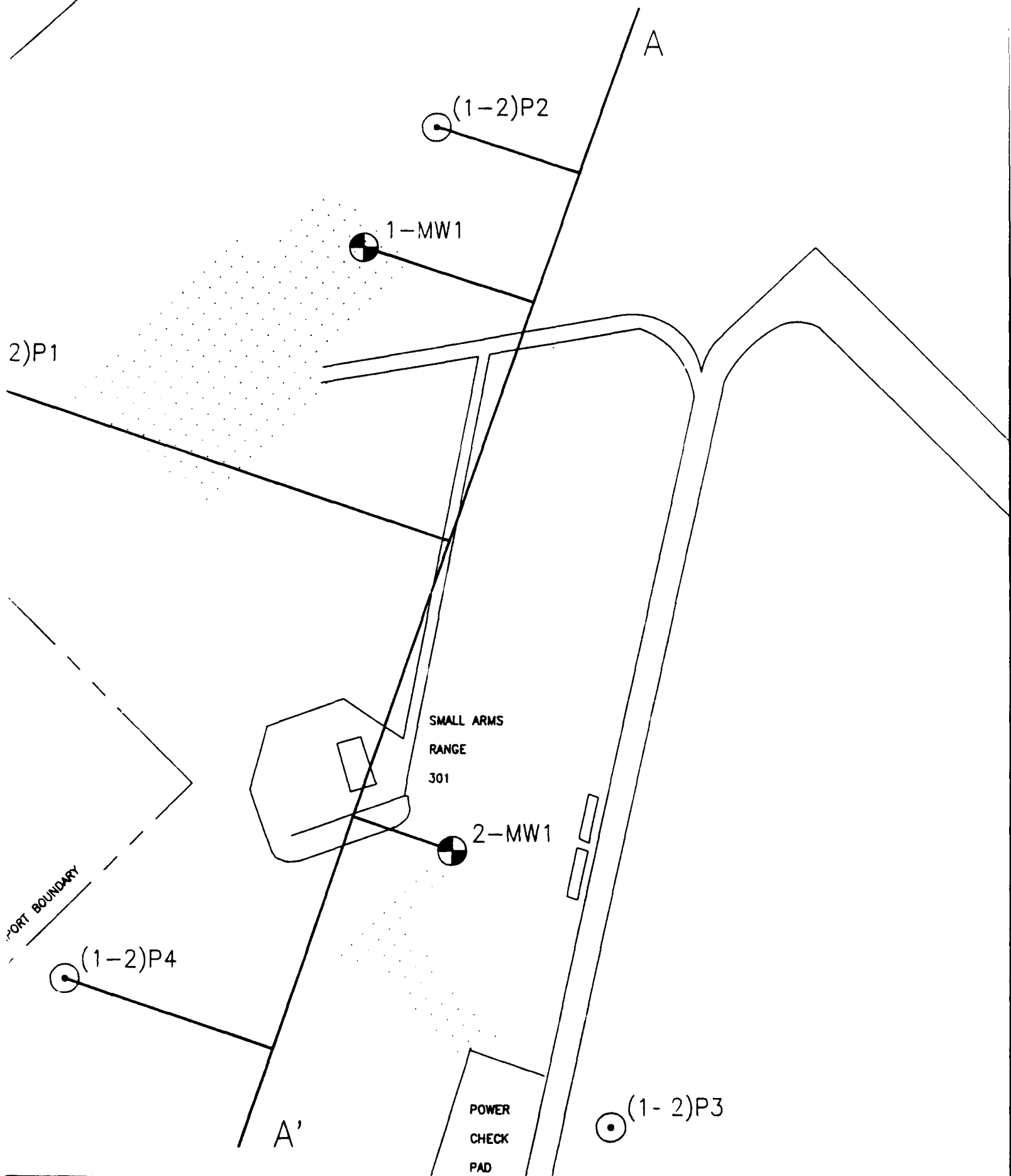


LEGEND

- 
P3
PIEZOMETER LOCATION AND NUMBER
- 
2-MW1
MONITOR WELL LOCATION AND NUMBER
- 
APPROXIMATE SITE LOCATION

FIGURE 3.5
MONITORING WELL AND
PIEZOMETER LOCATIONS
SITES 1 AND 2
CURRENT FIRE TRAINING AREA
AND DRAINAGE DITCH





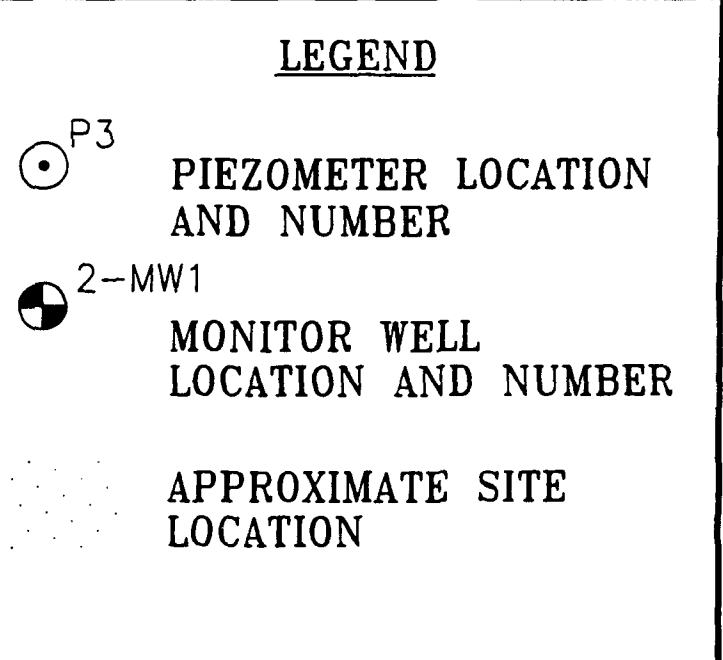
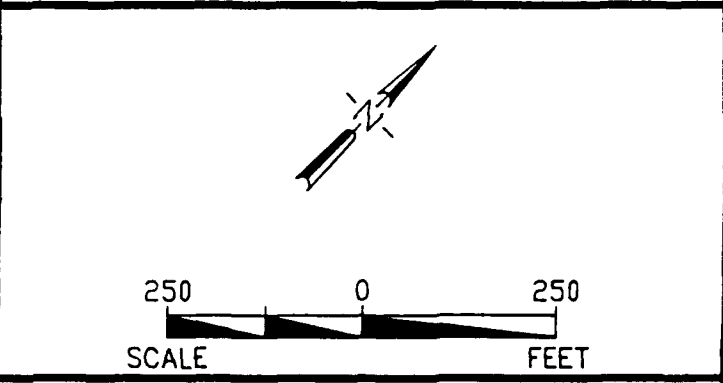
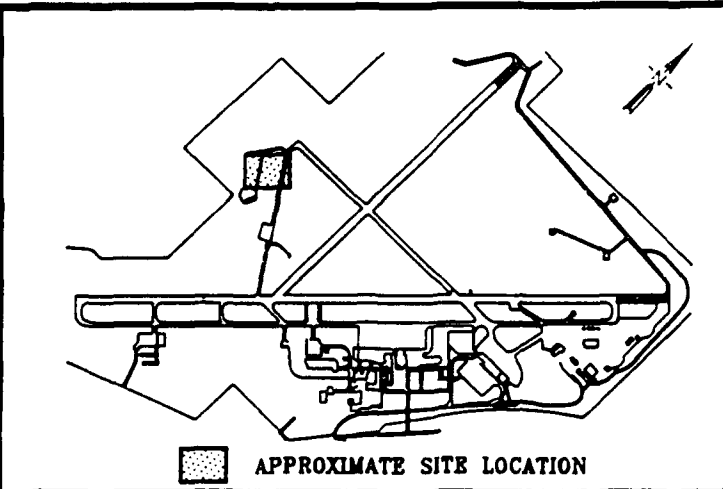
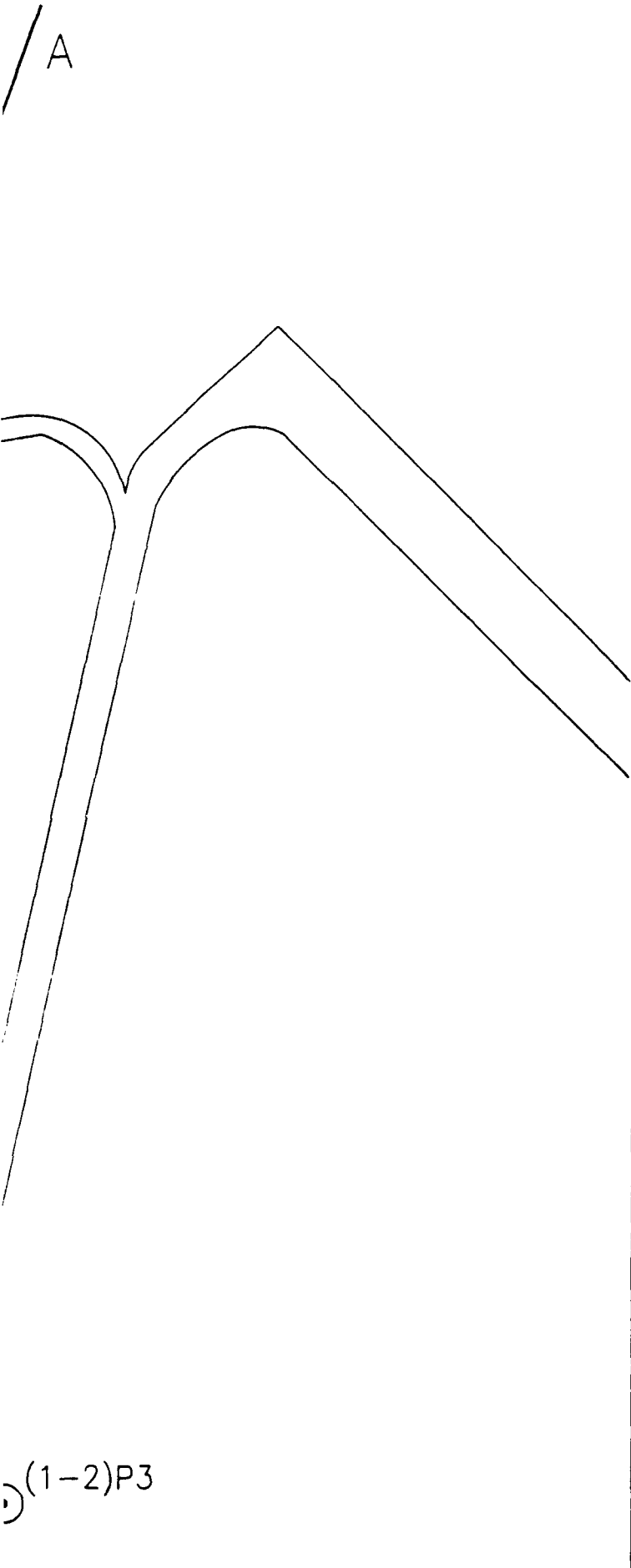
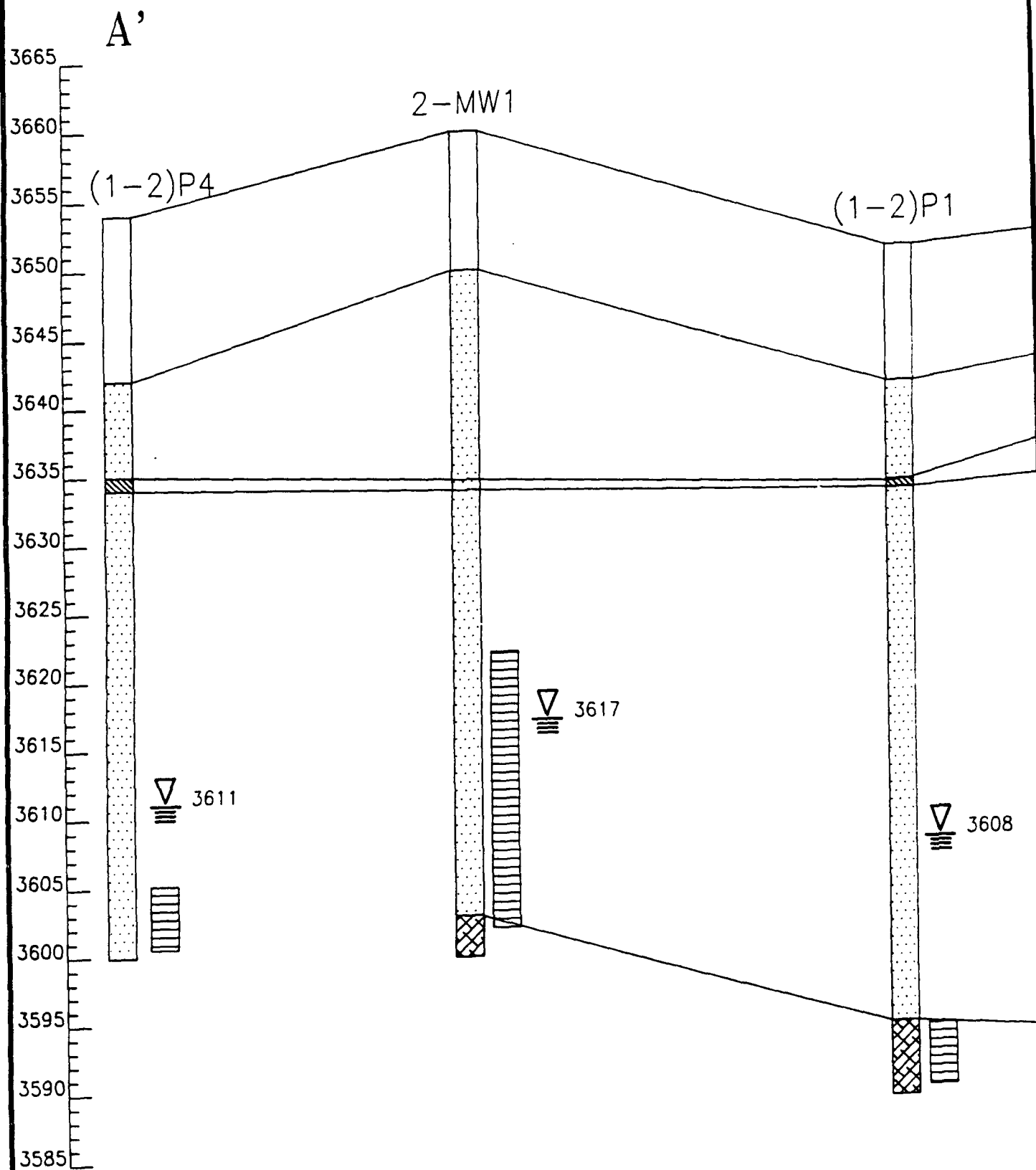
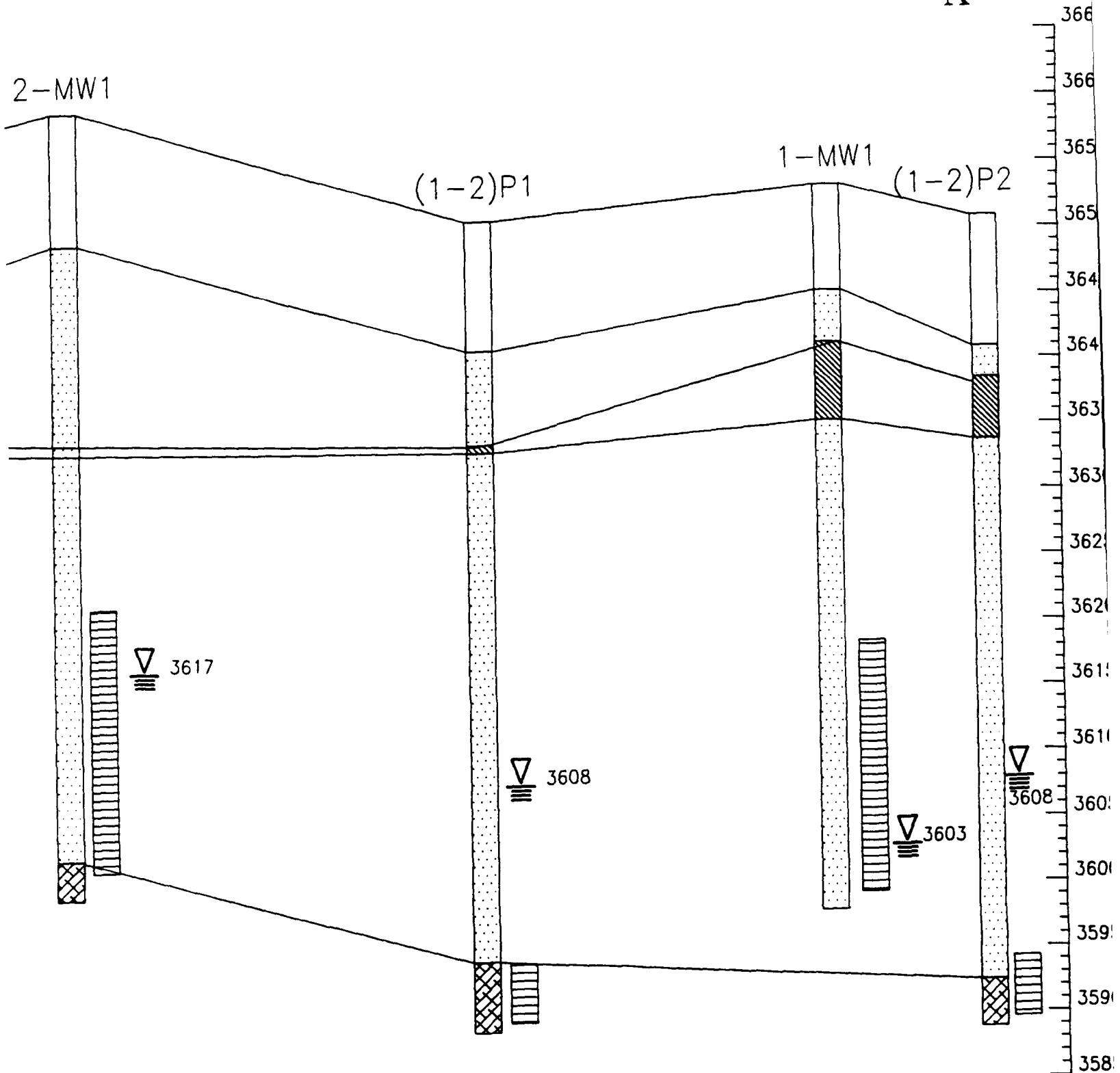


FIGURE 3.6
CROSS SECTION
ORIENTATION
SITES 1 AND 2
CURRENT FIRE TRAINING AREA
AND DRAINAGE DITCH

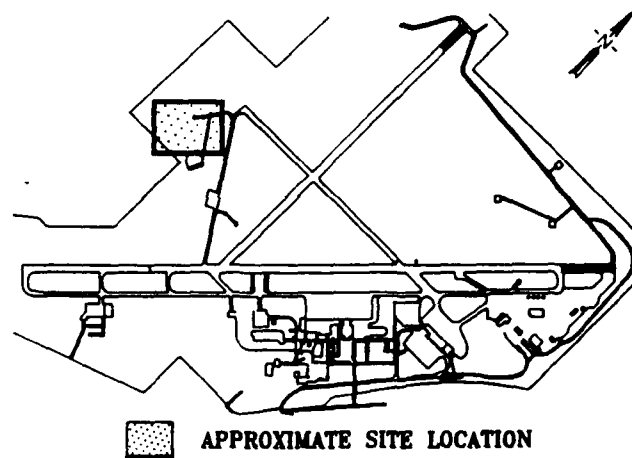
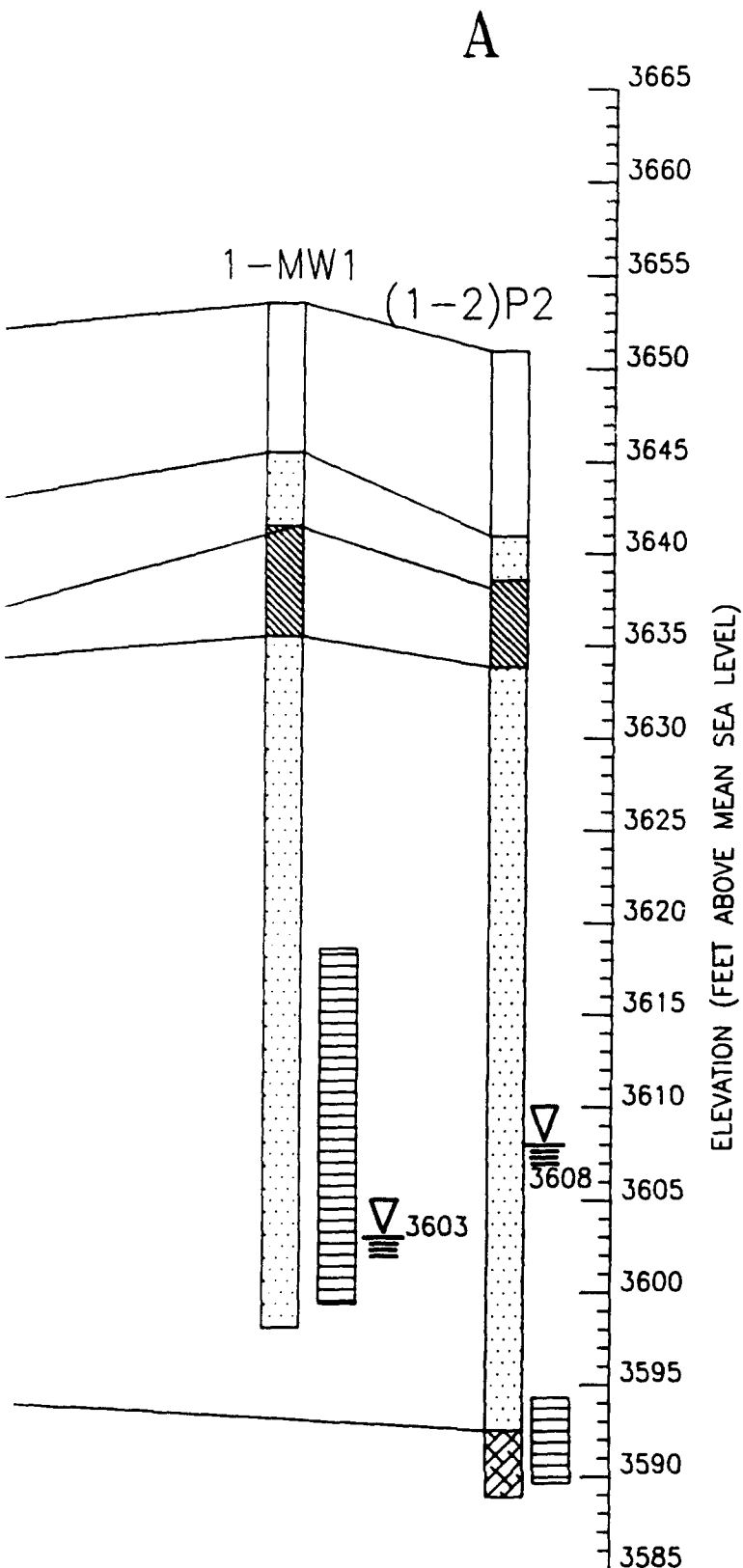


NOTE: WATER LEVEL MEASUREMENT TAKEN IN OCTOBER 1990.

A



MENT TAKEN IN OCTOBER 1990.



LEGEND

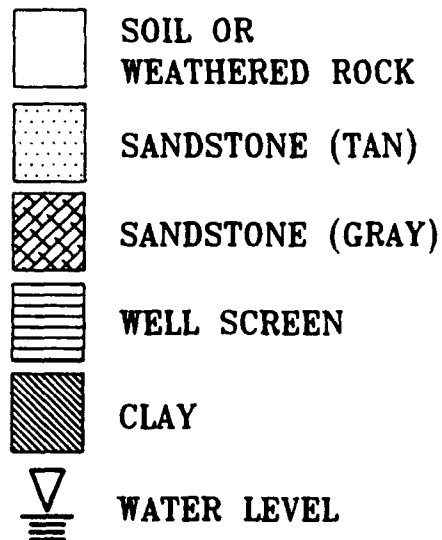
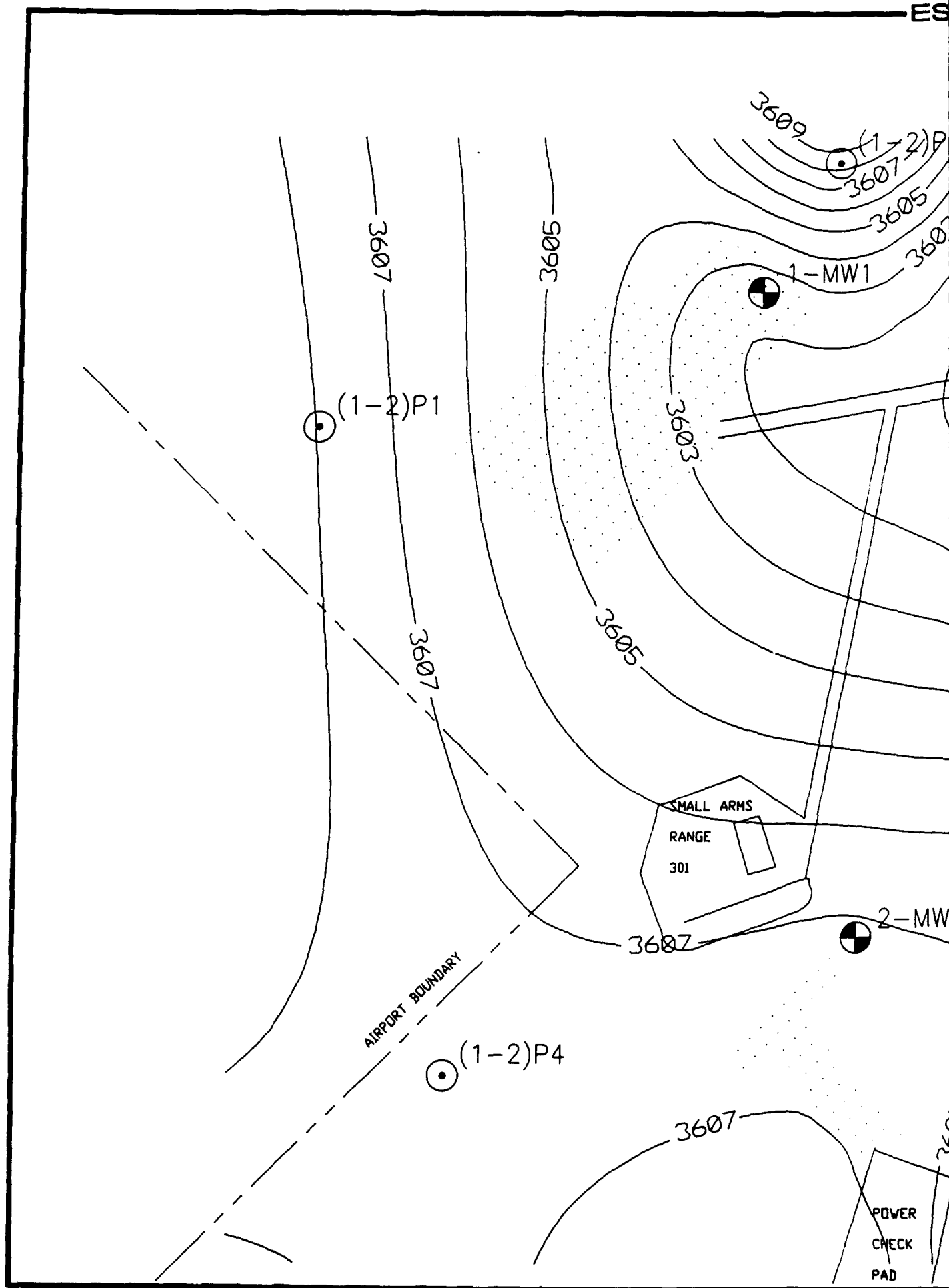
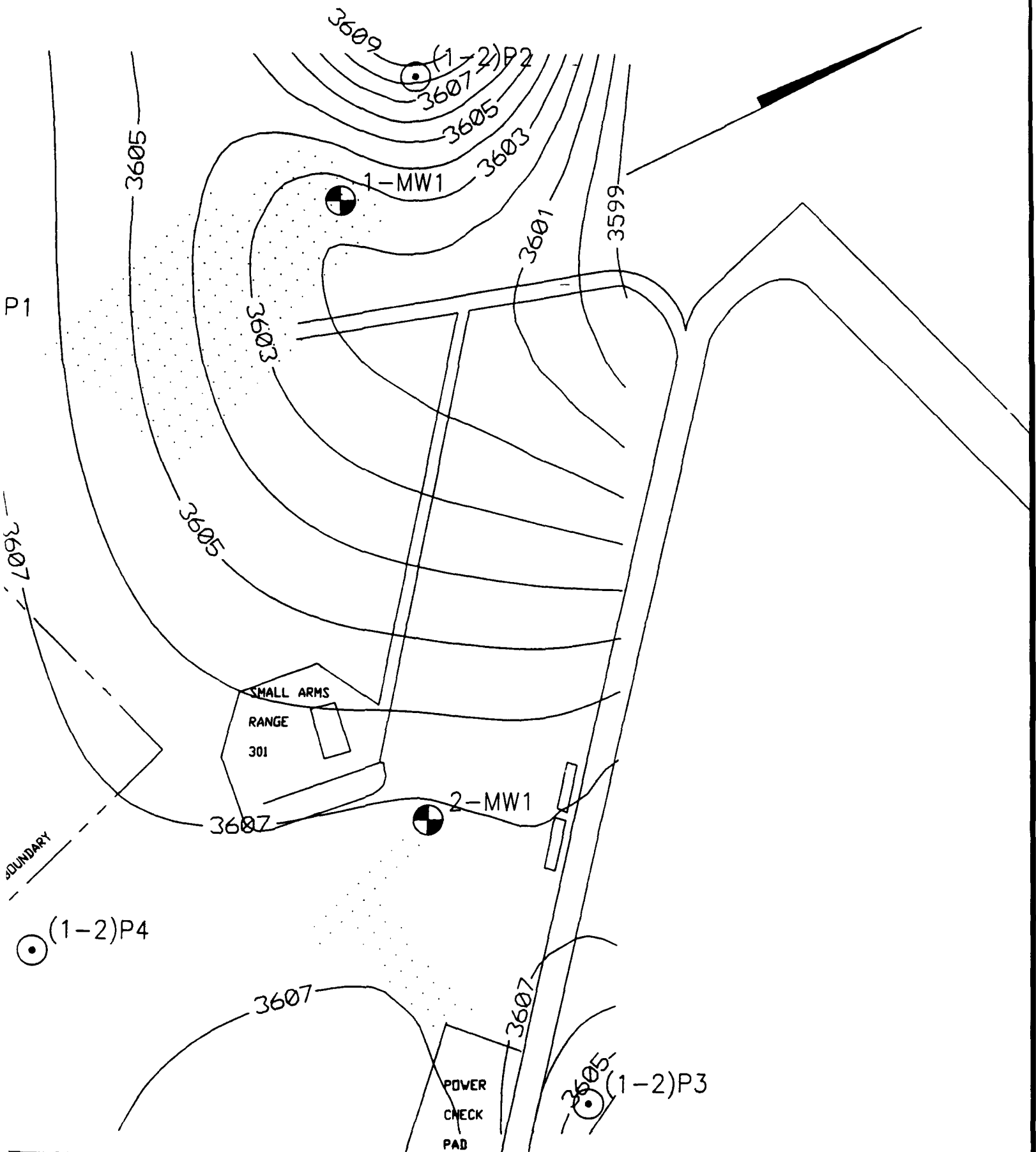
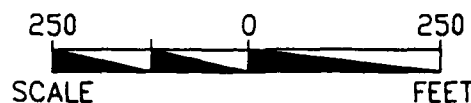
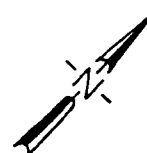
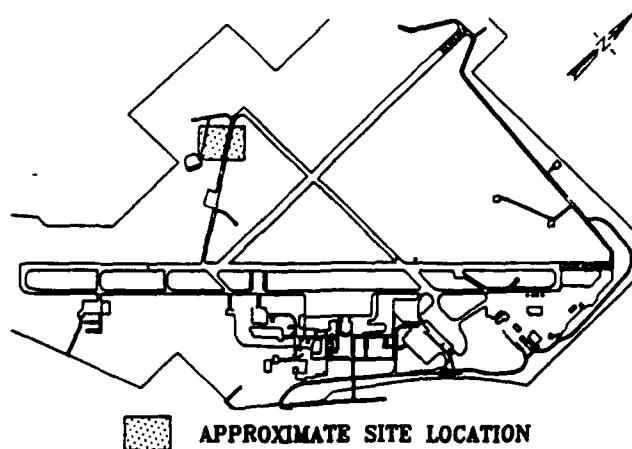
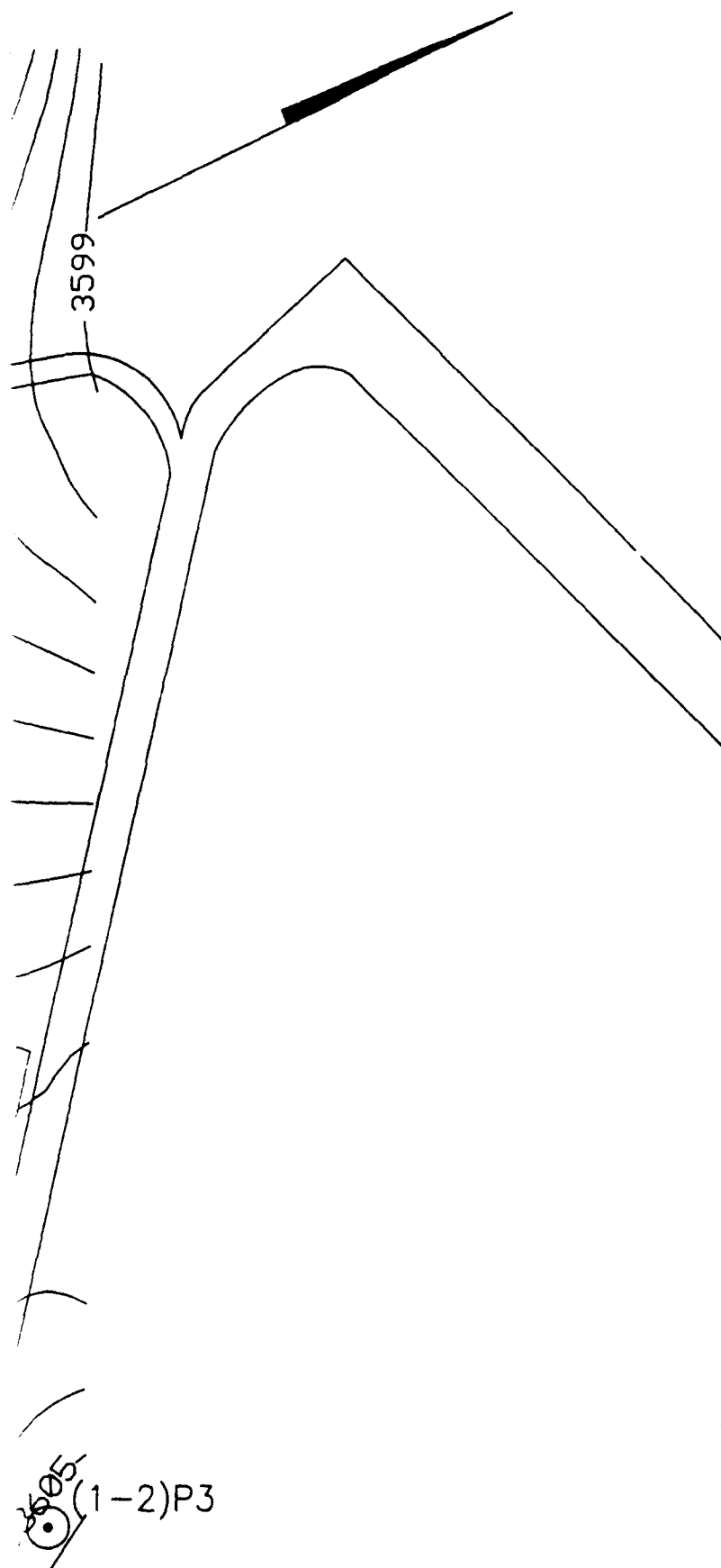


FIGURE 3.7
GENERALIZED
CROSS SECTION
SITES 1 AND 2
CURRENT FIRE TRAINING AREA
AND DRAINAGE DITCH







LEGEND



P5

PIEZOMETER LOCATION
AND NUMBER



2-MW1

MONITOR WELL LOCATION
AND NUMBER



GENERAL DIRECTION OF
WATER FLOW

3607 POTENTIOMETRIC SURFACE
CONTOUR ELEVATIONS
(FEET, MEAN SEA LEVEL)

FIGURE 3.8
POTENTIOMETRIC SURFACE
SITES 1 AND 2
CURRENT FIRE TRAINING AREA
AND DRAINAGE DITCH

Table 3.14 Water Level Data for Sites 1 and 2

Well/ Piezometer ID	10/28/90		2/20/91	
	Depth to Water*	Water Level Elevations*	Depth to Water	Water Level Elevations
MANG-1-MW1	52.31	3,603.43	53.57	3,602.17
MANG-2-MW1	44.51	3,617.48	46.78	3,615.21
MANG-(1-2)-P1	45.48	3,608.06	45.57	3,607.97
MANG-(1-2)-P2	45.65	3,607.55	45.99	3,607.21
MANG-(1-2)-P3	46.47	3,606.01	47.50	3,604.98
MANG-(1-2)-P4	45.24	3,610.78	48.60	3,607.42

* Depth to water is feet below top of PVC casing.

** Water level elevations are in feet above mean sea level.

The volatile and semivolatile organics detected in the soil at site 1 are commonly associated with fuels. As discussed in section 1.3.1 the site was used as a fire training facility. The highest contamination was observed in soil borings 3 and 7. The sample from soil boring 7, which had the highest concentrations of hydrocarbons, was drilled in the middle of one of the burn areas. Soil boring 3, from which the sample contained low concentrations of hydrocarbons, was placed adjacent to the largest burn area. The rest of the samples from the other soil borings indicated no apparent contamination. In light of these results, the extent of contamination appears to be limited to the burn areas.

Analysis of groundwater samples taken from the monitoring well at the site indicates trace quantities of chloroform in the round 1 sample and low concentrations of bis(2-ethylhexyl)phthalate in the round 2 sample. Since bis(2-ethylhexyl)phthalate and chloroform are common laboratory contaminants, the presence of both contaminants was not indicated in both sample analyses, and since groundwater elevation data presented in Figure 3.8 indicate that this monitoring well may not be directly downgradient of the contaminated areas, the presence or absence of groundwater contamination from activities at site 1 cannot be confirmed.

3.5 SITE 2 - DRAINAGE DITCH OFF OLD POWER CHECK PAD

3.5.1 Screening Activity Results

Soil Gas

The soil gas survey results are summarized in Figure 3.9 and Table 3.15. The soil gas results for site 2 were inconclusive. The data points were collected along the pipeline and the centerline of the ditch. The results showed little evidence of organic contamination. The low concentrations of organics present were found at various points, with no obvious trends present.

Soil Borings

Description. A total of six borings were drilled at site 2: two along the side of the underground concrete pipeline, and four in the bottom of the open ditch. Three of the ditch borings were placed downstream of the underground pipe outlet, and one boring was placed upstream of the pipe outlet. Figure 3.10 shows the locations of the soil borings for site 2. Borings 1 and 2 were drilled to 3 and 4 feet deep, respectively, before encountering hard material. Borings 3, 4, 5, and 6, in the drainage ditch, were drilled to a depth of 2 feet. No visual observations, with the possible exception of stained soil in the ditch, indicated significant contamination during the screening activities.

Field HNU. Each soil sample collected at the site was screened with an HNU. The total organic vapor readings for all borings at site 2 ranged from 0 to 6 ppm, with the highest readings being detected along the pipeline in the subsurface.

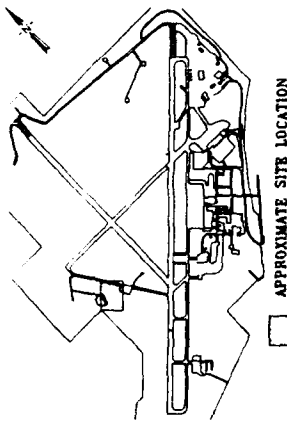
Field GC. The results of the field GC screening are summarized in Table 3.16. Little or no organics were present in any sample. Low concentrations of benzene and toluene were found in borings 1, 2, and 3. The TCE and o-xylene found in all borings were also present in several blanks and are likely an artifact of sampling or analytical procedures.

RANGE
301

SURFACE FLOW
DIRECTION

A4 B5 C6 D7 E8
C4 C3 C2 C1 C0 C00
DRAINAGE
DITCH
BURIED
PIPE

POWER
CHECK
PAD



APPROXIMATE SITE LOCATION



100 0 100
SCALE
FEET

LEGEND

- BENZENE DETECTED
- TCE DETECTED
- TOLUENE DETECTED
- O-XYLENE DETECTED
- SOV GRID POINT

FIGURE 3.9
RESULTS OF
SOIL GAS SURVEY
SITE 2
DRAINAGE DITCH OFF OLD
POWER CHECK PAD

Table 3.15 Organic Constituents Detected in Soil Gas Survey
Site 2: Drainage Ditch Off Old Power Check Pad
 (ppb by volume, GC)

Sample ID	Grid Coordinates		TCE	Toluene	o-Xylene
E8	0	-300	ND	ND	71
D7	50	-300	ND	ND	54,000
C6	100	-300	346	ND	20,000
C4	150	-250	ND	ND	ND
C3	150	-200	ND	ND	ND
C2	150	-150	ND	13	ND
C1	150	-100	ND	15	ND
C0	150	-50	ND	19	ND
C00	150	0	ND	ND	ND
B5	150	-300	ND	14	ND
A4	200	-300	ND	ND	ND

3208A\AU23409\T3-15.WKL

ND = not detected

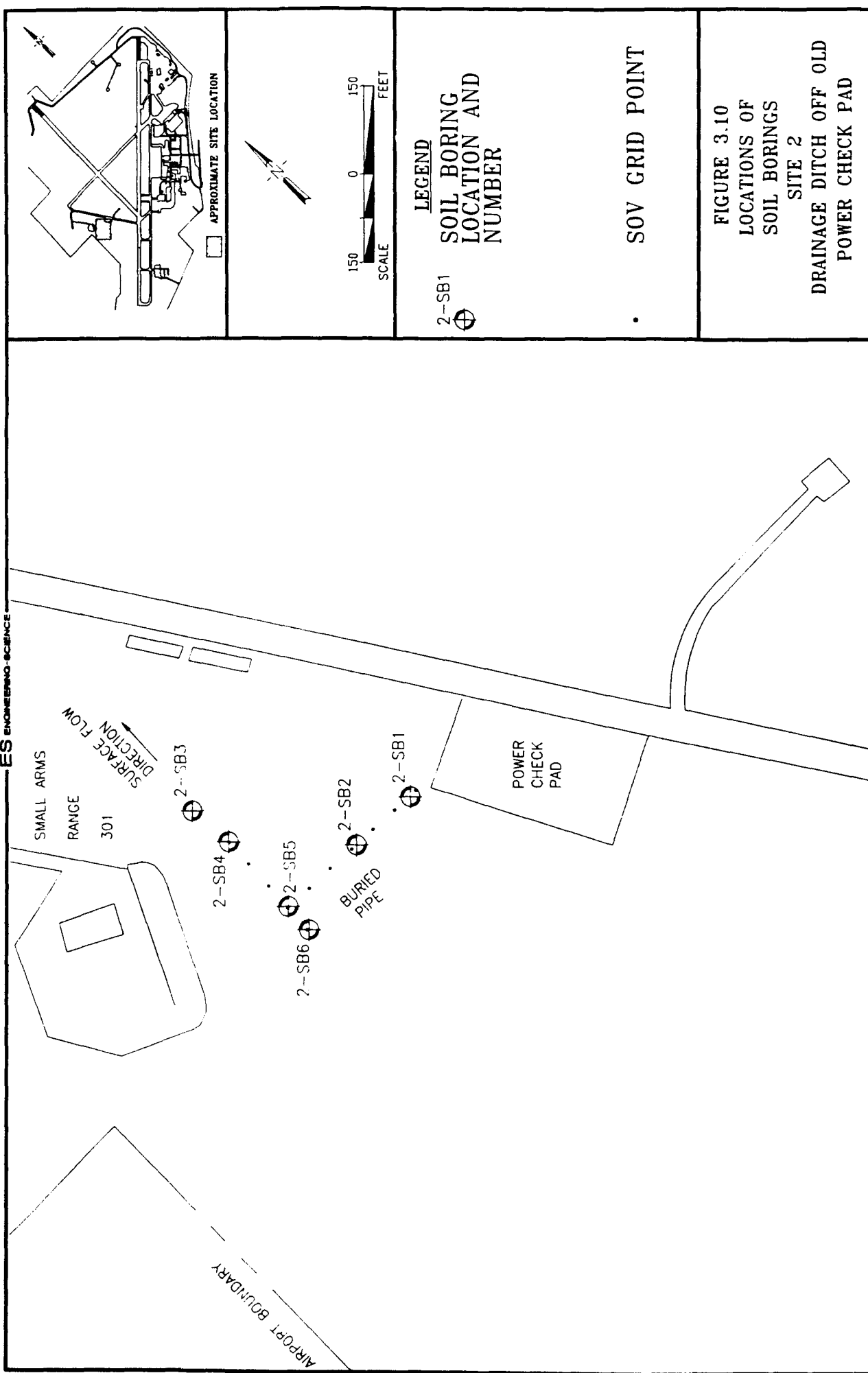


Table 3.16 Organic Constituents Detected in Soil Samples with Field GC Screen
Site 2: Drainage Ditch Off Old Power Check Pad

Soil Boring	Sleeve	CLP Sample ID	Constituent
SB-1	A5	MANG-2-SB1-1.5	TCE
			Toluene
			o-Xylene*
SB-2	A7	MANG-2-SB2-1.5	Benzene
	B6		TCE*
			TCE*
SB-2	A5	MANG-2-SB2-3	Benzene
	A7		TCE*
	B7		TCE*
SB-3		MANG-2-SB3-1	o-Xylene*
	A3		Benzene
			TCE*
SB-4	A5	MANG-2-SB4-2	Toluene
	A2		o-Xylene*
			TCE*
SB-5	A7	MANG-2-SB5-1	TCE*
			o-Xylene*
			TCE*
SB-6	A3	MANG-2-SB6-1	o-Xylene*
			TCE*
			TCE*
SB-6	A7	MANG-2-SB6-2	o-Xylene*
			TCE*
			TCE*

* This compound was also present in an associated blank.

** The peaks on the GC chromatogram were off scale.

Piezometer Levels

Four piezometers were installed around sites 1 and 2 in order to determine the optimum placement of a downgradient monitoring well for site 2. Groundwater elevations indicate the groundwater flow direction for site 2 to be to the north-northwest; therefore, the downgradient monitor well for site 2 was placed north-northwest of the underground pipeline and drainage ditch. Groundwater elevations for each of the piezometers are discussed in section 3.5.3.

Piezometer Screening

The piezometers used for site 2 are the same as those used for site 1. The results of the field GC screening of these are described in section 3.4.

Monitoring Well Observations

Each monitoring well installed was logged during drilling for lithology and other observations that may indicate contamination. MANG-2-MW1 was placed downgradient of the area suspected of contamination, and no observations during drilling indicated the presence of significant contamination in the borehole for the well at site 2.

3.5.2 Confirmation and Delineation Activities

Nine soil samples, two groundwater samples, one duplicate groundwater sample, and three sediment samples were collected at site 2 for chemical analyses.

Soil Sampling

One volatile organic, several semivolatile organics, petroleum hydrocarbons, and metals were detected in the analyses run on the soil samples. The organic compounds and the metals detected and their respective concentrations are shown on Table 3.17, and selected analytes are shown on Figure 3.11.

Acetone was found in several of the soil samples collected at site 2. The concentrations ranged up to 170 $\mu\text{g}/\text{kg}$. The only semivolatile organics detected in soils were phthalates. Acetone and the phthalates are common laboratory and sampling contaminants.

The TPH analyses of soils indicated contamination in one sample from the site. That sample contained TPH concentrations of 46 mg/kg .

The majority of metals detected at site 2 were below the background levels presented in Table 3.2. The metals detected in the soil at site 2 above background include lead, copper, cadmium, mercury, and zinc.

Sediment Sampling

Three sediment samples were collected from the ditch at site 2. The locations of these samples are indicated on Figure 2.3. The results of chemical analyses for the sediment samples are presented in Table 3.18. Bis(2-ethylhexyl)phthalate and benzo(b)fluoranthene, the only semivolatile organics found in the sediment, were detected at concentrations of 2,000 $\mu\text{g}/\text{kg}$ and 1,700 $\mu\text{g}/\text{kg}$, respectively. Benzo(b)fluoranthene is a common product of JP-4 fuel combustion. The volatile results are considered invalid due to compositing. The TPH analyses indicate some

Table 3.17 Chemical Constituents Detected in Soil
Site 2: Drainage Ditch Off Old Power Check Pad
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-2 SB1-1.5	MANG-2 SB2-1.5	MANG-2 SB2-3	MANG-2 SB3-1	MANG-2 SB4-2	MANG-2 SB5-1	MANG-2 SB5-2	MANG-2 SB6-1	MANG-2 SB6-2	Health (2) Criteria
Volatile organics (µg/kg):											
Acetone	ND-157	120 J	72 J	ND	ND	170	19 J	ND	ND	ND	8E06
BNA organics (µg/kg):											
Di-n-butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	4,900 B	3,400 B	8E06
Butylbenzylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	1,400 J	660	1.6E07
bis(2-Ethylhexyl)phthalate	ND	ND	ND	ND	ND	ND	ND	ND	2,000	570	5E04
Metals (mg/kg):											
Arsenic	1.9-9.9	4.9	7.8	6.4	4.4	7.4	8.7	3	5.9	2.9	80
Barium	ND-1,231	218	193	409	160	215	231	91.9	219	174	5,600
Cadmium	ND	ND	ND	0.38 B	ND	ND	ND	ND	ND	ND	40
Chromium	8.7-22.7	10.2	3.7	11.2	9.7	4.8	11.5	10.7	12.3	11.5	8E04
Copper	3.3-19.7	13.5 *	8.3 *	14.8 *	5.5 *	7.7 *	12.7 *	10.9 *	29.6 *	5.3 *	--
Lead	3.4-13.0	14.5	3.7 BW	12	10.2	11.5	12.4	8.7	17.7	9.1	500
Mercury	ND	ND	ND	0.055 B	ND	ND	ND	ND	ND	ND	24
Nickel	3.6-17.6	13.5 *	9.5 *	7.8 *	ND	ND	19.4 *	ND	7.4 B*	ND	1,600
Selenium	ND-0.66	ND	ND	ND	ND	ND	0.5 B	ND	ND	ND	240
Zinc	21.6-61.3	36.6	35.6	36	36.5	32.3	58.6	41.5	82.3	33.6	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND	46	ND	--

3006A/JU2540RTS-17.WK1

(1) Background is the average background concentration +/- two standard deviations.

(2) Based on soil ingestion, see section 4.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

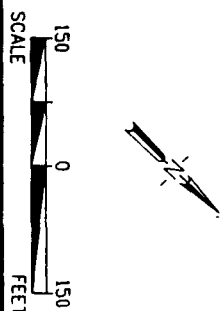
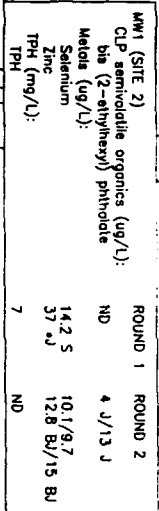
B The analyte is found in the associated blank as well as in the sample.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

* Duplicate analysis not within control limits.

W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.



2-SB1
SOIL BORING
LOCATION AND
NUMBER

2-MW/1
⊕
MONITOR WELL
LOCATION AND
NUMBER

PIEZOMETER
LOCATION AND
NUMBER

SOV GRID POINT
NOTE: SEE ANALYTICAL SUMMARY TABLES
FOR LABORATORY QUALIFIERS

FIGURE 3.11

SELECTED ANALYTES DETECTED
IN SOIL AND GROUNDWATER

Table 3.18 Chemical Constituents Detected in Sediment Samples
Site 2: Drainage Ditch Off Old Power Check Pad
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-2 SED1	MANG-2 SED2	MANG-2 SED3	Health (2) Criteria
Volatile organics ($\mu\text{g/kg}$)	NA	ND R	ND R	ND R	--
Semivolatile organics ($\mu\text{g/kg}$):					
bis(2-Ethylhexyl)phthalate	ND	ND	2,000 J	ND	5E04
Benzo(b)fluoranthene	ND	ND	1,700 J	ND	--
Metals (mg/kg)					
Arsenic	1.9-9.9	6.5 S	10.3 S	5.8	80
Barium	ND-1,231	241	246	150	5,600
Cadmium	ND	ND	24.2	0.76 B	40
Chromium	8.7-22.7	13.8	64.9	14.5	8E04
Copper	3.3-19.7	16.1	66.9	22.1	--
Lead	3.4-13.0	14.5	131	22.6	500
Mercury	ND	0.04 B	0.19	ND	24
Nickel	3.6-17.6	6.2 B	37.5	ND	1,600
Selenium	ND-0.66	0.27 B	1.1	0.43 BW	240
Zinc	21.6-61.3	63.1	555	120	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	82	590	140	--

3205A\AU23409\T3-18.WK1

(1) Background is the average background concentration +/- two standard deviations.

(2) Based on soil ingestion, see section 4.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

R This data is not considered valid.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

S Reported value was determined by the method of standard additions.

W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.

contamination in all three sediment samples. The concentrations of TPH ranged from 82 mg/kg to 590 mg/kg.

The sediment samples contained several metals that were detected above background levels. These metals include arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc.

Groundwater Sampling

The results of the analyses of the groundwater from both rounds of sampling of well MANG-2-MW1 disclosed the presence of no volatile organics, one semivolatile organic, some petroleum hydrocarbons, and several metals. The results of the chemical analyses of the groundwater from MANG-2-MW1 are presented in Table 3.19 and selected analytes are shown on Figure 3.11.

The metals that were detected in groundwater at site 2 include barium (up to 57.8 $\mu\text{g/L}$), lead (up to 4.7 $\mu\text{g/L}$), selenium (up to 14.2 $\mu\text{g/L}$), and zinc (up to 37 $\mu\text{g/L}$). Arsenic and copper were detected in the duplicate sample collected during the second round of sampling but were not detected in the sample.

Comparison of Screening Results to CLP Results

Soil gas survey points were located along the pipeline and in the ditch. No definitive areas of high organic concentrations were identified. This was confirmed by the laboratory data since little or no organic contamination was found.

The field headspace readings of soil samples collected at site 2 ranged from 0 ppm to 6 ppm. These readings compare well with the analytical results from the CLP laboratory. No field screening was performed on the sediment samples collected from site 2.

Field GC data also indicated the presence of small quantities of benzene and toluene in the samples. These were not found in the laboratory analysis. Since the field GC indicated only trace concentrations of organics, and the laboratory analyses indicated little or no organics, there is good correlation between the field GC screening and the laboratory analysis.

3.5.3 Geologic and Hydrogeologic Investigation Results

The geology and hydrogeology of sites 1 and 2 were investigated and evaluated together because of their proximity to one another. Results are reported in section 3.4.3.

3.5.4 Conclusions

The results of the chemical analyses of the samples collected from the soil borings at site 2 indicate no contamination. As discussed in section 1.3.1, site 2 received petroleum, oil, and lubricant waste from overflow of an underground oil-water separator and storage tank. The organics detected from the analyses are those commonly associated with laboratory or sampling procedures. In addition, no significant concentrations of metals were detected in the soil borings. The sediment samples collected at the site indicated that some contamination was present. The sample located at the outfall of the drainage pipe, MANG-2-SED2, showed the highest concentrations by petroleum hydrocarbons and metals. Sample

Table 3.19 Chemical Constituents Detected in Groundwater
Site 2: Drainage Ditch Off Old Power Check Pad
(CLP Laboratory Analysis)

Chemical	Round 1 MANG-2 MW-1	Round 2 MANG-2 MW1	Round 2 MANG-2 MW1-D	Background		ARARs (1)
				Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics (µg/L)	ND	ND	ND	ND	ND	NA
CLP semivolatile organics (µg/L): bis(2-Ethylhexyl)phthalate	ND	13 J	4 J	ND	ND	4
Metals (µg/L):						
Arsenic	ND	ND	2.5 BW	1.1 JB	ND	50
Barium	42 JB	57. JB	57.8 B	56 JB	62.2 B	1,000
Copper	ND	ND	4.7 B	ND	ND	1,300
Lead	4.7 J	4.2 JN	3.7 JN	4.9 J	4.3 JN	50
Selenium	14.2 S	9.7	10.1	ND	ND	10
Zinc	37 J*	15 JB	12.8 JB	15 JB*	9.8 JB	5,000
Total petroleum hydrocarbons (mg/L)	7	ND	ND	1	ND	NA

(1) ARARs are proposed only. These are MCLs when available, otherwise WQC.

NA = not applicable.

ND = not detected.

3208A\AU23409\T3-19.WK1

Data qualifiers follow the data. The qualifiers are:

Organics:

- J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

- B Reported value is less than reporting limit but greater than the instrument detection limit.
- N Spiked sample recovery not within control limits set by lab QA/QC.
- S Reported value was determined by the method of standard additions.
- * Duplicate analysis not within control limits set by lab QA/QC.
- W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.
- J The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

MANG-2-SED3, located downgradient of the outfall, showed some contamination of petroleum hydrocarbons and metals, but at concentrations significantly lower than at the outfall. The sample collected upgradient of the outfall showed the lowest concentrations. Considering these data, the contamination appears to be confined to the surface sediments located adjacent to and immediately downgradient of the outfall. The petroleum hydrocarbons detected in the samples are probably a result of reported discharges from the overflow of the oil-water separator at the site in the past.

Analysis of groundwater samples taken from the monitoring well at the site reveals low levels of TPH in the round 1 sample. The presence of petroleum hydrocarbons in the monitoring well at site 2 was not confirmed in the second round of sampling. This, along with the lack of significant contamination in soils, implies little likelihood of groundwater impact by waste disposal activities at this site.

3.6 SITE 3 – NORTH DISPOSAL AND FIRE TRAINING PIT

3.6.1 Screening Activity Results

Soil Gas

The results of the soil gas survey are summarized in Figure 3.12 and reported in Table 3.20. The soil gas survey was conducted on a 350- by 400-foot grid except in the area where the large asphalt pile was located. The points were taken at 50-foot intervals where possible. It was necessary to move several points due to the presence of the asphalt pile. Few organics were found during the soil gas survey. Only trace concentrations of toluene were found. There was no evidence of a clearly defined waste disposal pit.

Soil Borings

Description. Nine borings plus one duplicate boring were drilled and sampled at site 3. Figure 3.13 shows the locations of the soil borings for site 3. Borings ranged in depth from 1.5 to 4 feet below grade.

Field HNU. Each soil sample collected at the site was screened with an HNU. The total organic vapor readings from the soil samples indicated no organic vapors in any of the soils at site 3.

Field GC. The results of the field GC screening are summarized in Table 3.21. Few organics were detected. Trace concentrations of benzene were found in borings 6, 7, and 9. Trace concentrations of TCE and o-xylene were also present in several samples. TCE and o-xylene were also found in the blanks and are likely an artifact of the sampling or analytical procedures.

Piezometer Levels

Three piezometers were installed at site 3 to determine the groundwater flow direction and select the optimum location for the downgradient monitoring well. Groundwater elevations indicate groundwater flow to the northeast towards the edge of the bench located nearby; therefore, MANG-3-MW1 was located northeast of the area of suspected contamination. Groundwater elevations for each of the piezometers are discussed in section 3.6.3.

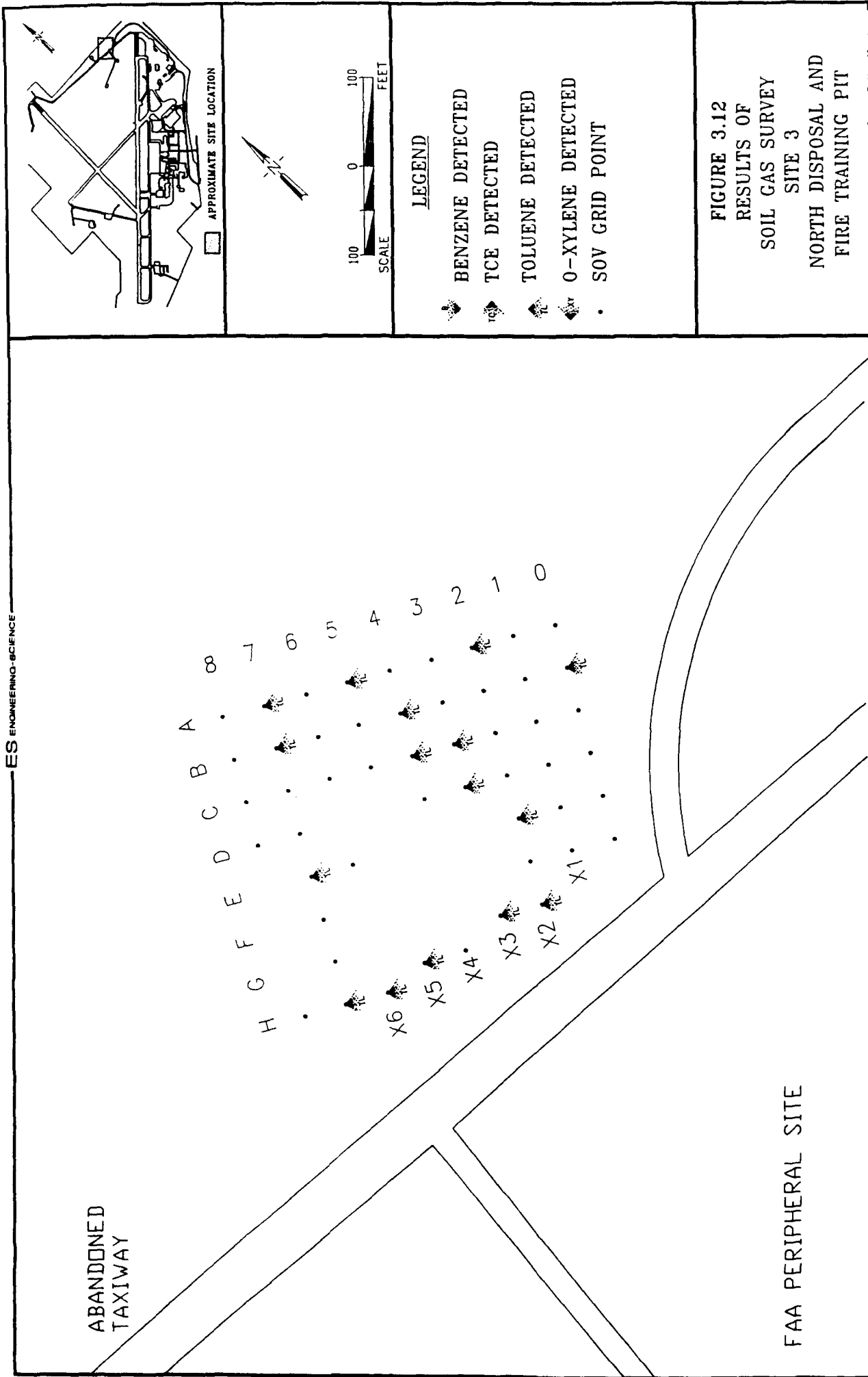


Table 3.20 Organic Constituents Detected in Soil Gas Survey
Site 3: North Disposal and Fire Training Pit
(ppb by volume, GC)

Sample ID	Grid Coordinates		Toluene
A0	0	0	ND
A1	0	-50	ND
A2	0	-100	7
A3	0	-150	ND
A4	0	-200	ND
A5	0	-250	6
A6	0	-300	ND
A7	0	-350	9
A8	0	-400	ND
B0	50	0	19
B1	50	-50	ND
B2	50	-100	ND
B3	50	-150	ND
B4	50	-200	21
B5	50	-250	ND
B6	50	-300	ND
B7	50	-350	14
B8	50	-400	ND
C0	100	0	ND
C1	100	-50	ND
C2	100	-100	ND
C3	100	-150	8
C4	100	-200	9
C5	100	-250	ND
C6	100	-300	ND
C7	100	-350	ND

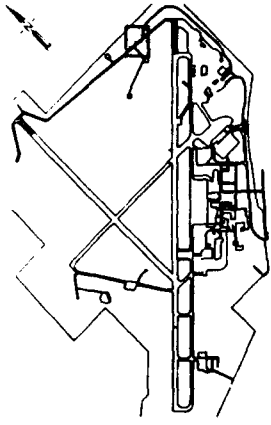
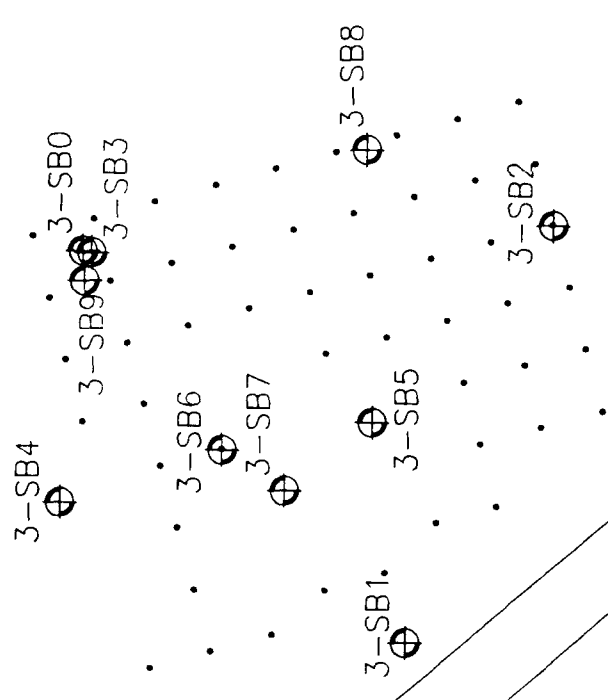
Sample ID	Grid Coordinates		Toluene
C8	100	-400	ND
D0	150	0	ND
D1	150	-50	ND
D2	150	-100	ND
D3	150	-150	19
D4	150	-200	ND
D7	150	-350	ND
D8	150	-400	ND
E0	200	0	ND
E1	200	-50	ND
E2	200	-100	6
E6	200	-300	ND
E7	200	-350	18
E8	250	0	ND
F1	250	-50	ND
F2	250	-100	ND
F7	250	-350	ND
G7	300	-350	ND
H0	350	0	ND
H7	350	-350	14
H8	350	-400	ND
X2	300	-100	9
X3	300	-150	25
X4	327	-200	ND
X5	328	-250	13
X6	350	-300	37

ND = not detected

3208A\AU23409\T3-20.WK1

ABANDONED
TAXIWAY

RTR
FAA PERIPHERAL SITE



APPROXIMATE SITE LOCATION



LEGEND

⊕ 3-SB1
SOIL BORING
LOCATION
AND NUMBER

• SOV GRID POINT

FIGURE 3.13
LOCATIONS OF
SOIL BORINGS
SITE 3
NORTH DISPOSAL AND
FIRE TRAINING PIT

Piezometer Screening

Piezometers 1 through 3 from site 3 were screened with the field GC. The results of the field GC screening of the piezometers are summarized in Table 3.22. The screening indicated the possible presence of trichloroethene (TCE), toluene, and xylenes in piezometer 3. TCE and o-xylene were also present in the blanks. The headspace analysis of piezometers 1 and 2 did not indicate the presence of any volatile organics.

Monitoring Well Observations

Each monitoring well installed was logged during drilling for lithology and other observations that may indicate contamination. MW1 was placed downgradient of the area suspected of contamination, and no observations during drilling indicated the presence of gross contamination in the borehole soils for the well at site 3.

3.6.2 Confirmation and Delineation Activities

Nine soil samples, two duplicate soil samples, and two groundwater samples were collected at site 3 for chemical analyses. Due to problems with the shipment of the samples from borings 1 through 5, it was necessary to resample these borings. The new samples were collected adjacent to the old sample locations. The new borings were numbered 1A through 5A.

Soil Sampling

Some volatile organics and semivolatile organics, no petroleum hydrocarbons, and some metals were detected in the analyses run on the soil samples. The organic compounds and the metals detected and their respective concentrations are shown in Table 3.23 and selected analytes are shown on Figure 3.14.

Two volatile organic compounds were found in the soil samples collected at site 3. Acetone was detected in samples at concentrations ranging up to 250 $\mu\text{g/kg}$. Toluene were also found in several samples at the site. Acetone and toluene are common laboratory contaminants.

Phthalates were the only semivolatile compounds detected in the soils from site 3. Diethylphthalate and butylbenzylphthalate were detected in several samples. Phthalates are common laboratory and sampling contaminants.

Total petroleum hydrocarbon analyses of the soil samples collected at site 3 indicated no petroleum hydrocarbon contamination at the site.

The majority of the metals concentrations detected at site 3 were below the background levels presented in Table 3.2. The metals detected in the soil at site 3 above background include arsenic, chromium, lead, nickel, and zinc.

Groundwater Sampling

The results of groundwater analyses from both rounds of sampling of well MANG-3-MW1 indicate the presence of no volatile or semivolatile organics, some petroleum hydrocarbons, and several metals. The results of the chemical analyses of the groundwater from MANG-3-MW1 are presented in Table 3.24 and selected analytes are shown on Figure 3.14.

**Table 3.21 Organic Constituents Detected in Soil Samples with Field GC Screen
Site 3: North Disposal and Fire Training Pit**

Soil Boring	Sleeve	CLP Sample ID	Constituent
SB-1	A4		TCE* o-Xylene*
SB-2	A5		TCE* o-Xylene*
	B7		TCE* o-Xylene*
SB-3	Not screened		
SB-4	Not collected		
SB-5	A5		TCE*
	B7		TCE*
	A4		Benzene TCE* o-Xylene*
	A8		TCE*
SB-6	A4	MANG-3-SB6-1	Benzene TCE* o-Xylene*
	A8		TCE*
SB-7	A5	MANG-3-SB7-1.5	Benzene TCE*
SB-8	A6	MANG-3-SB8-1.5	TCE*
SB-9	A5	MANG-3-SB9-1.5	Benzene TCE*
SB-9 dup	A5	MANG-3-SB9D-1.5	TCE*
	B5		TCE*

* This compound was also present in an associated blank.

**Table 3-22 Organic Constituents Detected in Piezometer Samples
with Field GC Screen
Site 3: North Disposal and Fire Training Pit**

Sample	Constituent
MANG-3-P1	ND
MANG-3-P2	ND
MANG-3-P3	TCE*, toluene o-xylene*, m/p-xylene

ND = not detected.

* This compound was also present in an associated blank.

Table 3.23 Chemical Constituents Detected in Soil
Site 3: North Disposal and Fire Training Pit
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-3 SB1A-1.5	MANG-3 SB2A-1.5	MANG-3 SB2A-3.5	MANG-3 SB3A-1	MANG-3 SB3A-1(D)	MANG-3 SB5A-1.5	MANG-3 SB6-1	MANG-3 SB7-1.5	MANG-3 SB8-1.5	MANG-3 SB9-1.5	MANG-3 SB9(D)-1.5	Health (2) Criteria
Volatile organics (µg/kg):													
Acetone	ND-157	ND	ND	ND	ND	ND	ND	70 J	170	ND	70 J	250	8E06
Toluene	ND-9	4 J	7	ND	ND	ND	ND	ND	ND	5 J	ND	ND	1.6E07
BNA organics (µg/kg):													
Diethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	590	110 J	6.4E07
Butylbenzylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	200 J	ND	1.6E07
Metals (mg/kg):													
Arsenic	1.9-9.9	7.3	10.2 S	9.2 B	5.4	23.4	6.9	6.9	9.5	2.6	7.2	7.9	80
Barium	ND-1,231	173	665	124	44.7	55.7	181	259	202	51	176	274	5,600
Chromium	8.7-22.7	14.8	17.5	12.2	6.2	7.3	20.8	23.2	29.9	4.8	15.5	13.8	8E04
Copper	3.3-19.7	19.3	17.3	13.3	3.9 B	21.4	15.5	20.2	21.8	13.4	17.6	17.2	--
Lead	3.4-13.0	9.1	10.5	9.7	3.7 B	5.2 B	9.9	13.1	13.9	3.5 B	9	8.9	500
Nickel	3.6-17.6	16.8	16.2	15	ND	ND	16.2	20.2	22.5	ND	9.5	15.7	1,600
Selenium	ND-0.66	ND	0.46 B	ND	ND	0.32 B	ND	ND	ND	ND	ND	ND	240
Zinc	21.6-61.3	51.4	56.8	44.5	24.8	33.8	44.9	58.4	71.1	24	46.4	60.2	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--

(1) Background is the average background concentration +/- two standard deviations.

(2) Based on soil ingestion, see section 4.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J

The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

B

Reported value is less than reporting limit but greater than the instrument detection limit.

S

Reported value was determined by the method of standard additions.

*

Duplicate analysis not within control limits set by lab QA/QC.

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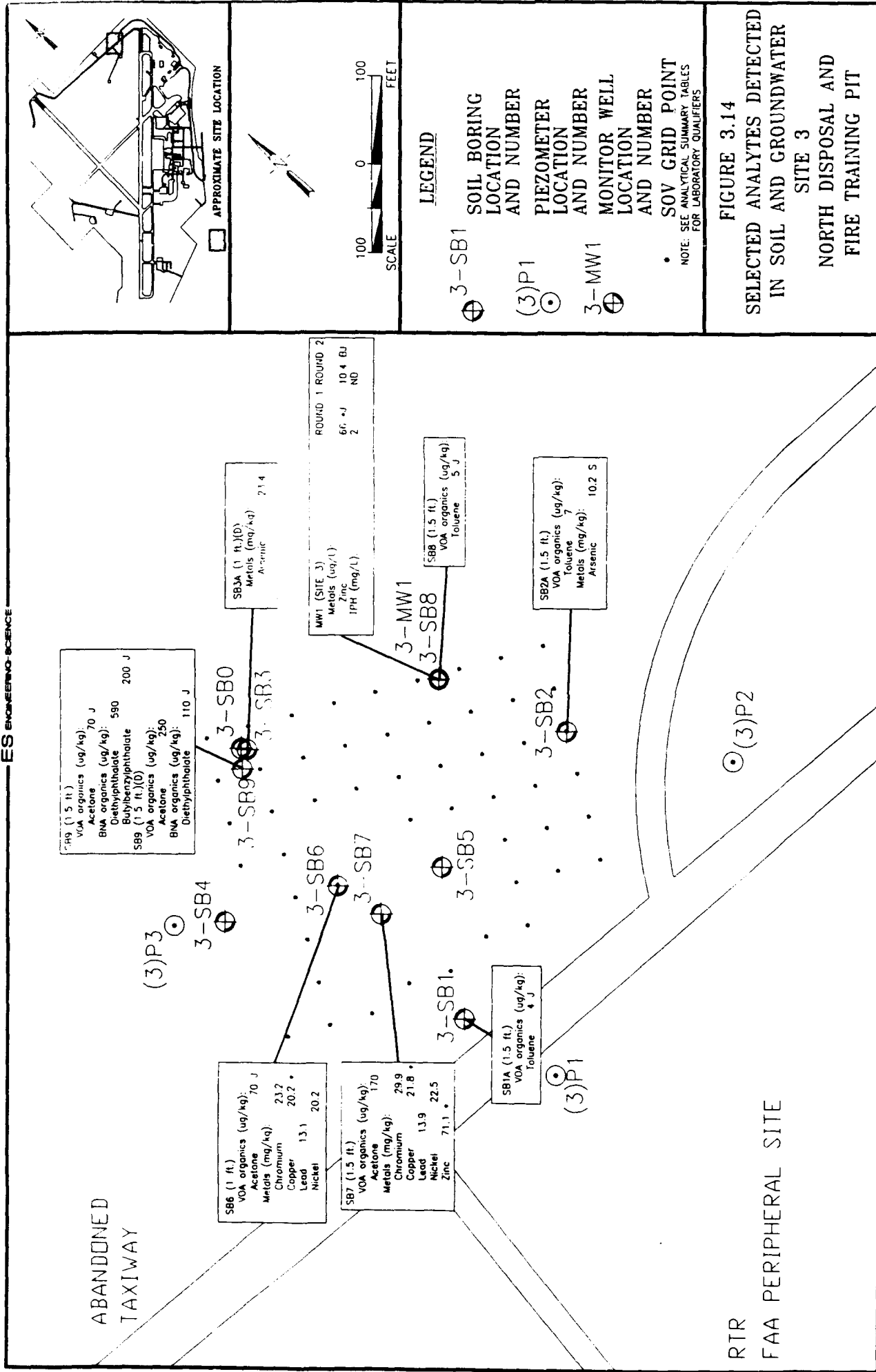


Table 3.24 Chemical Constituents Detected in Groundwater
Site 3: North Disposal and Fire Training Pit
(CLP Laboratory Analysis)

Chemical	Round 1 MANG-3 MW1	Round 2 MANG-3 MW1	Background		ARARs (1)
			Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics ($\mu\text{g/L}$):	ND	ND	ND	ND	NA
CLP semivolatile organics ($\mu\text{g/L}$):	ND	ND	ND	ND	NA
Metals ($\mu\text{g/L}$):					
Arsenic	ND	ND	1.1 JB	ND	50
Barium	36 BJ	44.2 B	56 JB	62.2 B	1,000
Lead	4.9 J	3.3 JN	4.9 J	4.3 JN	50
Zinc	66 J*	10.4 JB	15 JB*	9.8 JB	5,000
Total petroleum hydrocarbons (mg/L)	2	ND	1	ND	NA

320SA\AU23409\T3-24.WK1

(1) ARARs are proposed only. These are MCL's where available, otherwise WQC.

ND = not detected.

NA = not applicable.

Data qualifiers follow the data. The qualifiers are:

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

* Duplicate analysis not within control limits set by lab QA/QC.

J The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

The total petroleum hydrocarbon concentration of the sample collected during the first round of sampling from well MANG-3-MW1 was 2 mg/L. Petroleum hydrocarbons were not detected in the sample collected from the second round of sampling.

Metals detected in groundwater at site 3 include barium (up to 44.2 $\mu\text{g/L}$), lead (up to 4.9 $\mu\text{g/L}$), and zinc (up to 66 $\mu\text{g/L}$).

Comparison of Screening Results with CLP Results

The correlation between the soil gas survey and the CLP analyses was generally good. The soil gas survey indicated little or no organic contamination, and this was confirmed by the CLP analyses.

The field headspace readings of soil samples collected at site 3 detected nothing. These readings compare well with the analytical results from the CLP laboratory since the laboratory analyses showed no to low concentrations of volatiles in the samples.

Several samples showed only trace concentrations of benzene from the field GC screening. No benzene was detected in the CLP analyses of the same samples. This suggests good correlation between the field GC screening and the CLP analyses.

3.6.3 Geologic and Hydrogeologic Investigation Results

The geology of site 3 consists of 1.5 to 4 feet of surface soil composed of brown clayey sand with gravel underlain by weathered sandstone. The thickness of weathered sandstone varied. Competent sandstone occurred at a depth below ground level of 14 feet in MANG-3-MW1, 5 feet in MANG-3-P1, 10 feet in MANG-3-P2, and 11.5 feet in MANG-3-P3. The shale layer was identified at depths of 45 feet, 49 feet, 43 feet, and 45 feet in MANG-3-MW1, MANG-3-P1, MANG-3-P2, MANG-3-P3, respectively. The locations of the well and piezometers for site 3 are shown on Figure 3.15. Piezometer and monitoring well construction data are presented in Tables 3.7 and 3.13, respectively.

A cross section was drawn using the lithologic logs (appendix D) of the monitoring well and piezometer borings drilled at site 3. The orientation of the cross section is shown on Figure 3.16, while the cross section is shown on Figure 3.17. The cross section shows relatively flat-lying bedrock, absent of any major structural displacement, overlain by unconsolidated material.

Piezometer data were evaluated and the groundwater flow direction was determined to be to the north-northeast, the direction of the shortest dropoff, the Sunset Bench. The monitoring well was then constructed downgradient of site 3. A final round of water level measurements was taken, and the data used to compute and contour groundwater elevations in the area. Figure 3.18 is the resulting potentiometric surface map. The areal groundwater flow is to the north-northeast. The average hydraulic gradient is approximately 78 feet per mile. Table 3.25 lists the water level information from two rounds of measurements. The last round of measurements was used to construct the potentiometric surface map.

ABANDONED
TAXIWAY

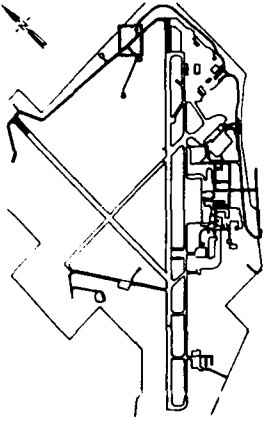
(3)P3

(3)P1

RTR
FAA PERIPHERAL SITE

3-MW1

(3)P2



APPROXIMATE SITE LOCATION



100 0 100
SCALE FEET

LEGEND

APPROXIMATE
SITE LOCATION

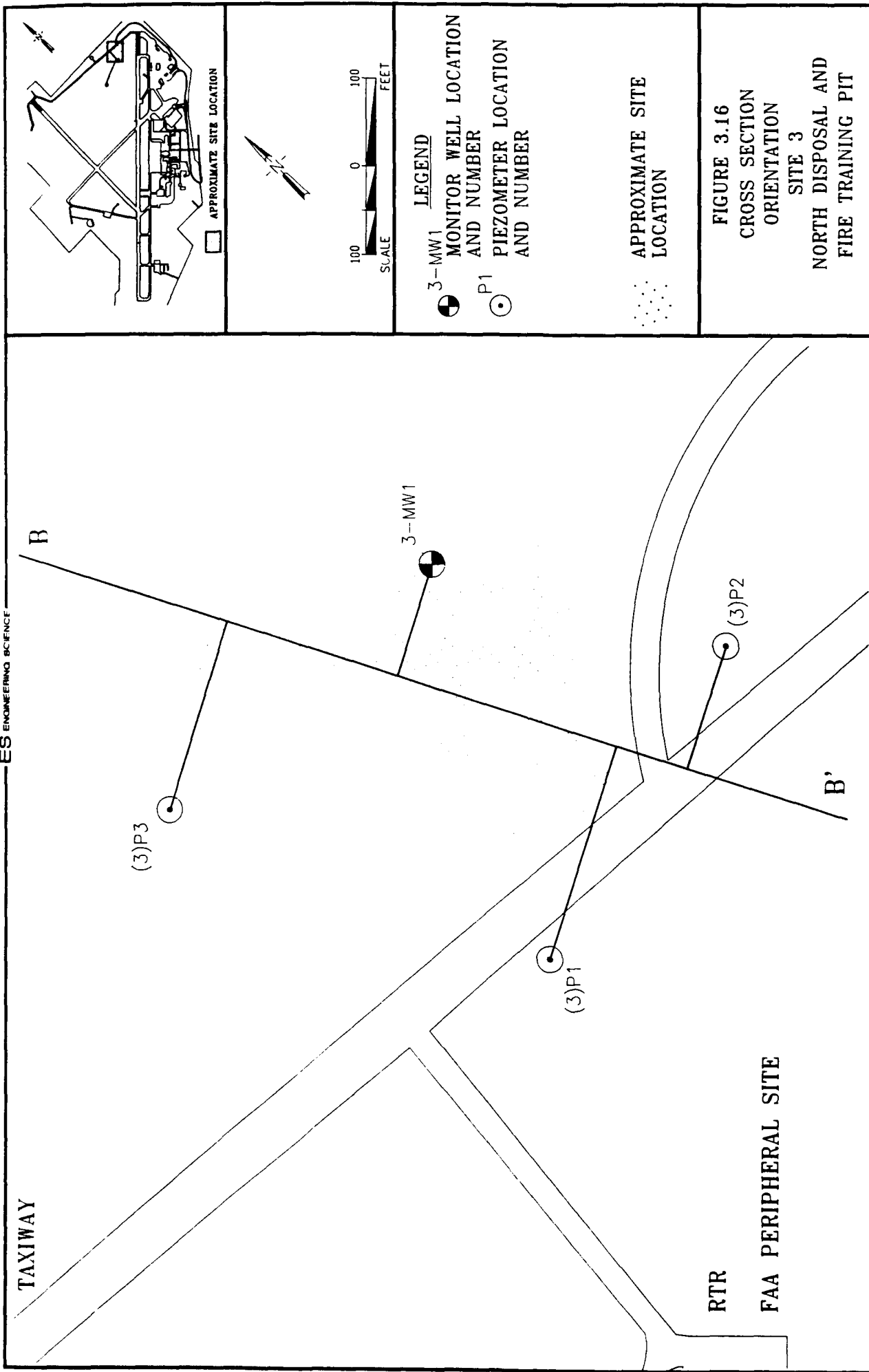
PIEZOMETER
LOCATION
AND NUMBER

MONITOR WELL
LOCATION
AND NUMBER

(3)P1

3-MW1

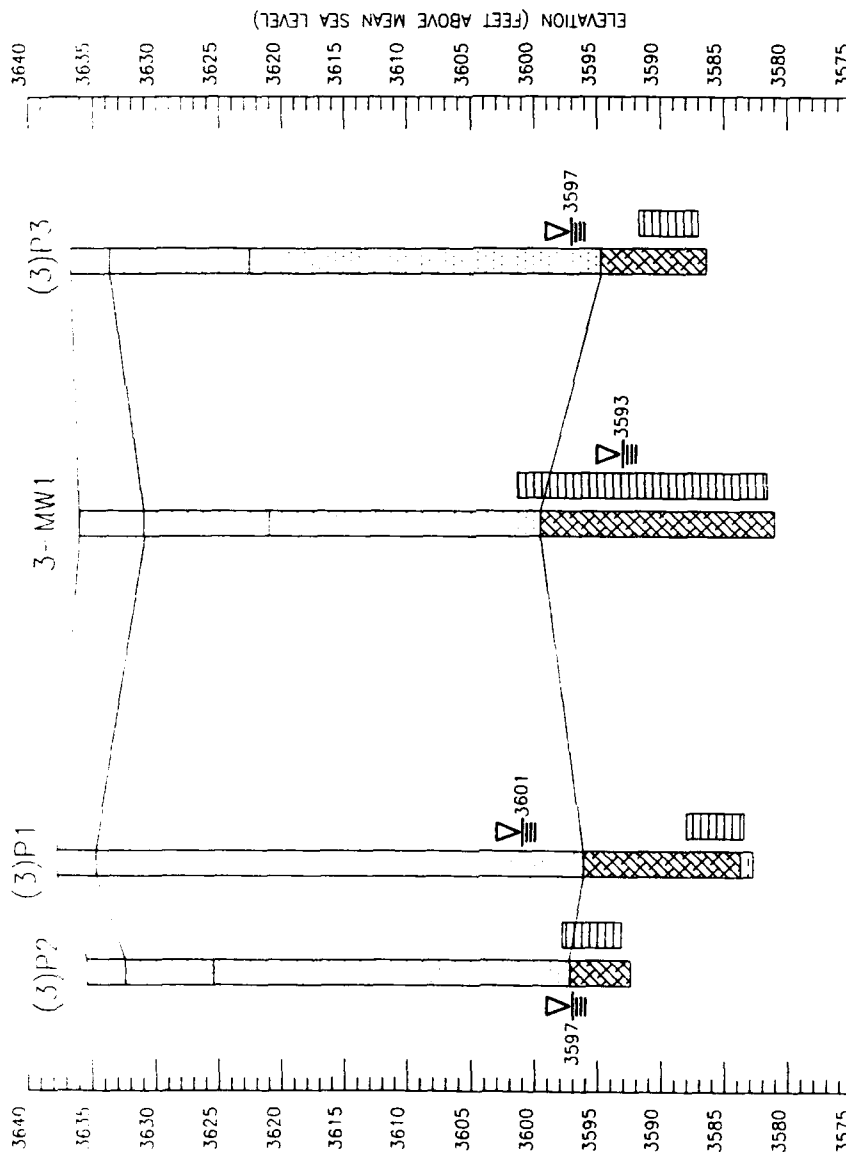
FIGURE 3.15
LOCATIONS OF MONITOR WELLS
AND PIEZOMETERS
SITE 3
NORTH DISPOSAL AND
FIRE TRAINING PIT



SIT3

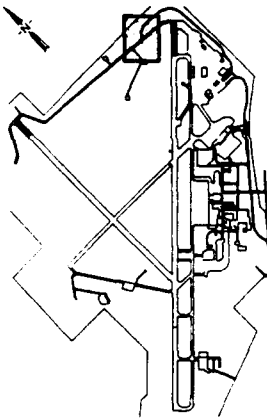
B'

B

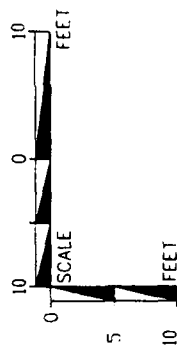


NOTE: WATER LEVEL MEASUREMENT TAKEN IN OCTOBER 1990.

XSEC3 2/6/92



APPROXIMATE SITE LOCATION



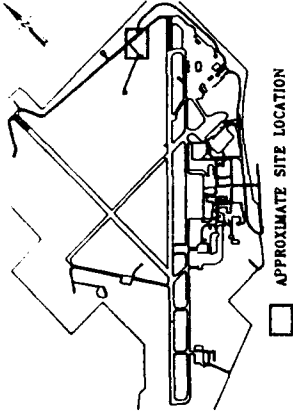
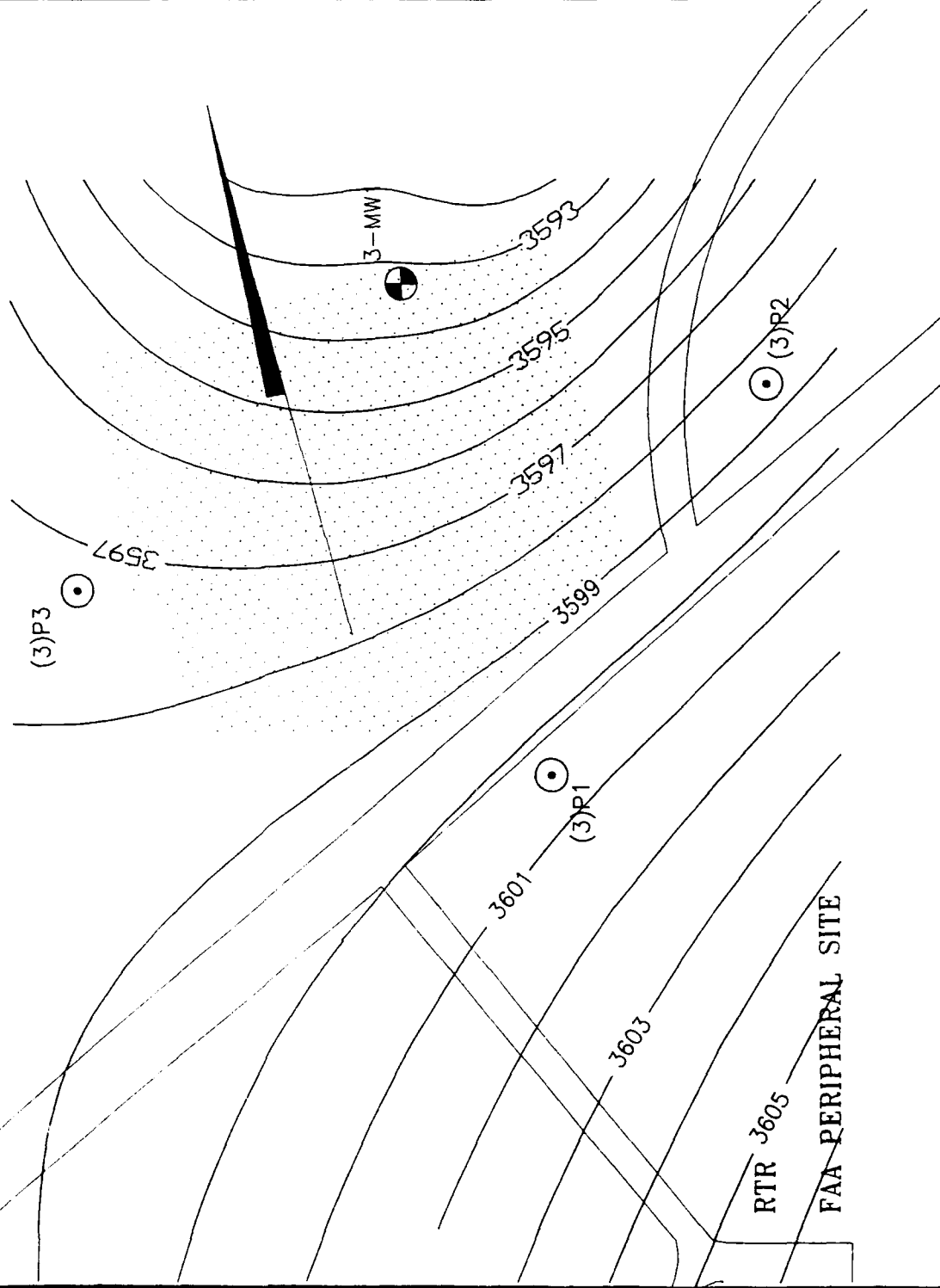
LEGEND

- SOIL OR WEATHERED ROCK
- SANDSTONE (TAN)
- CLAY
- SANDSTONE (GRAY)
- SHALE
- WELL SCREEN
- WATER LEVEL

FIGURE 3.17
GENERALIZED
CROSS SECTION
SITE 3
NORTH DISPOSAL AND
FIRE TRAINING PIT

120th FIG International Airport, Great Falls, Montana

TAXIWAY



APPROXIMATE SITE LOCATION



LEGEND

- 3-MW1
MONITOR WELL LOCATION
AND NUMBER
- ⊙ P1
PIEZOMETER LOCATION
AND NUMBER
- GENERAL DIRECTION OF
WATER FLOW
- 3597- POTENTIOMETRIC SURFACE
CONTOUR ELEVATIONS
(FEET, MSL)
- ⋯ APPROXIMATE
SITE LOCATION

FIGURE 3.18

POTENTIOMETRIC SURFACE
SITE 3
NORTH DISPOSAL AND
FIRE TRAINING PIT

Table 3.25 Water Level Data
Site 3: North Disposal and Fire Training Pit

Well/ Piezometer ID	10/28/90		2/20/91	
	Depth to Water*	Water Level Elevations**	Depth to Water*	Water Level Elevations**
MANG-3-MW1	45.50	3,592.83	45.75	3,592.58
MANG-3-P1	38.80	3,601.10	39.31	3,600.59
MANG-3-P2	40.26	3,597.19	40.39	3,597.06
MANG-3-P3	41.64	3,597.39	41.75	3,597.28

* Depth to water is feet below top of PVC casing.

** Water level elevations are in feet above mean sea level.

3.6.4 Conclusions

The results of screening activities at this site indicate no significant contamination. Trace concentrations of toluene were detected across the site during the soil gas survey. Trace concentrations of benzene were detected by the field GC in some soil samples. No organics were detected in soil samples screened with the HNU meter. Trace concentrations of TCE, o-xylene, and toluene were detected in piezometer samples with the field GC. However TCE and o-xylene were both detected in the blanks as well.

Site 3 was used as a fire training area and disposal pit, as discussed in section 1.3.1. The data from the soil borings and the chemical analyses of the soil and groundwater samples from site 3 provide little indication that an FTA or disposal pit were located in the area investigated. The SOV screening combined with lab soil and groundwater sample results indicate that contamination related to activities at this site is not present.

Analyses of groundwater samples taken from the monitoring well at the site indicate low levels of TPH in the round 1 sample. The presence of petroleum hydrocarbons in the monitoring well at site 3 was not confirmed in the second round of sampling. This, along with the lack of significant contamination in soils, suggests little likelihood of groundwater impact by waste disposal activities at this site.

3.7 SITE 4 – FORMER FIRE TRAINING AREA 1

3.7.1 Screening Activity Results

Soil Gas

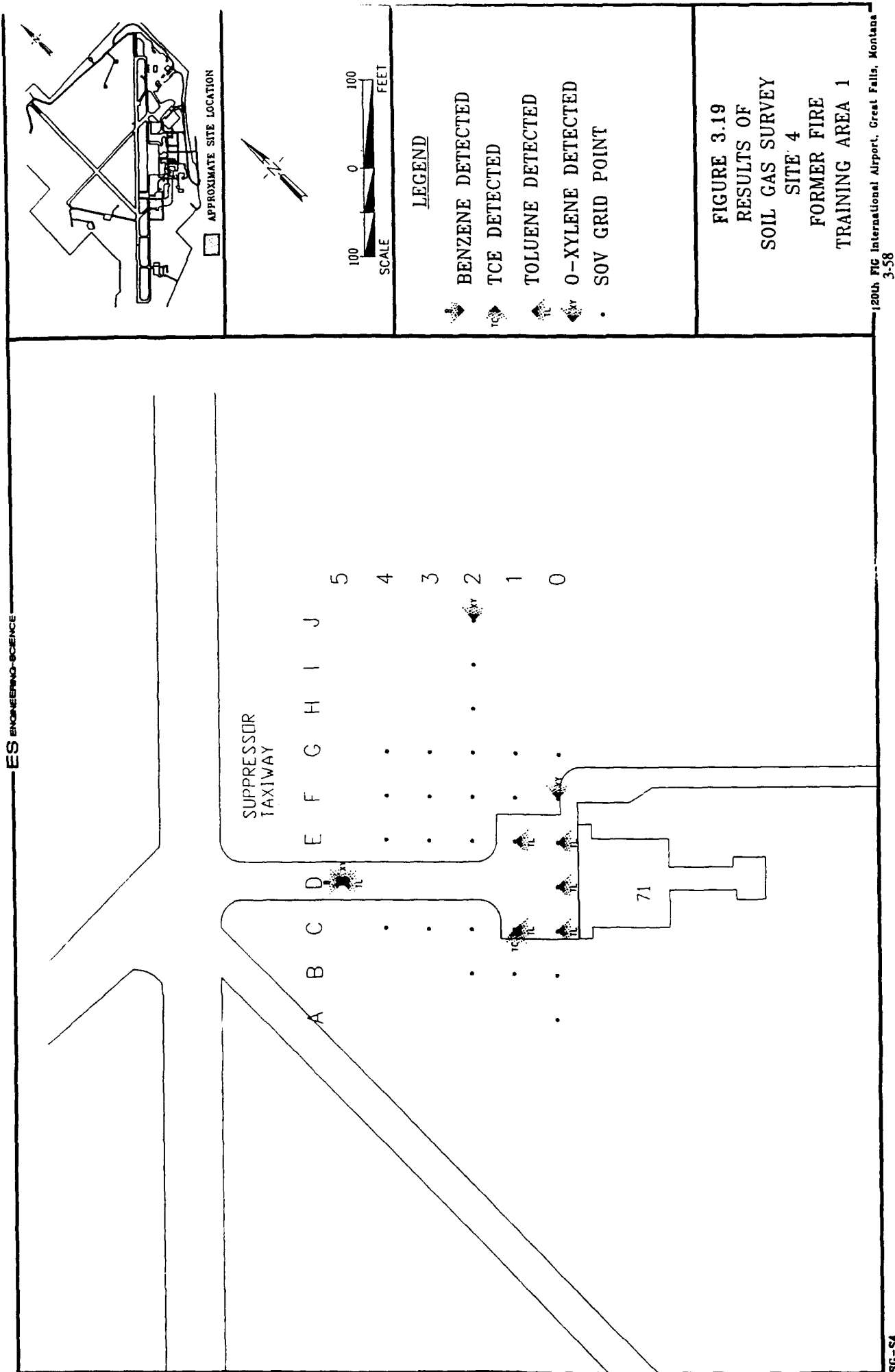
The soil gas survey results are summarized in Figure 3.19 and Table 3.26. Few organics were detected. Toluene was present in high concentrations at one point, and in lower concentrations at several others. The pattern of detection points seemed to indicate an area of high concentration under the asphalt adjacent to the "hush house." Several points had trace concentrations of o-xylene, but there was no pattern to the distribution.

Soil Borings

Description. Five soil borings were drilled and sampled at site 4. Figure 3.20 shows the locations of the soil borings for site 4. The boring depths ranged from 4 to 8 feet below grade. Odors and staining of the soil were observed in SB2 and SB4 at 2 to 4 feet below grade.

Field HNU. Each of the soil samples collected at the site was screened with an HNU. The total organic vapor ranged from 0 to 40 ppm, with the highest readings exhibited in boring SB3 at 4 to 8 feet below grade.

Field GC. The results of the field GC screening are summarized in Table 3.27. Other than the TCE and o-xylene, which were also present in the blanks (indicating possible introduction of error in sampling and analysis procedures), there were no organics detected in borings 1, 3, and 4. There were trace concentrations of benzene, toluene, ethyl benzene, o-xylene, and m/p-xylene detected in boring 2. Soil from boring 5 was not screened by the field GC.



120th FIG International Airport, Great Falls, Montana
3-58

Table 3.26 Organic Constituents Detected in Soil Gas Survey
Site 4: Former Fire Training Area 1
(ppb by volume, GC)

Sample ID	Grid Coordinates		Benzene	TCE	Toluene	o-Xylene
A0	0	0	ND	ND	ND	ND
B0	0	-50	ND	ND	ND	ND
C0	0	-100	ND	ND	6	ND
D0	0	-150	ND	ND	18	ND
E0	0	-200	ND	ND	540	ND
F0	0	-250	ND	ND	ND	100
G0	0	-300	ND	ND	ND	ND
B1	50	-50	ND	ND	ND	ND
C1	50	-100	ND	9	260	ND
E1	50	-200	ND	ND	***	ND
F1	50	-250	ND	ND	ND	ND
G1	50	-300	ND	ND	ND	ND
B2	100	-50	ND	ND	ND	ND
C2	100	-100	ND	ND	ND	ND
E2	100	-200	ND	ND	ND	ND
F2	100	-250	ND	ND	ND	ND
G2	100	-300	ND	ND	ND	ND
H2	100	-350	ND	ND	ND	ND
I2	100	-400	ND	ND	ND	ND
J2	100	-450	ND	ND	ND	25
C3	150	-100	ND	ND	ND	ND
E3	150	-200	ND	ND	ND	ND
F3	150	-250	ND	ND	ND	ND
G3	150	-300	ND	ND	ND	ND
C4	200	-100	ND	ND	ND	ND
E4	200	-200	ND	ND	ND	ND
F4	200	-250	ND	ND	ND	ND
G4	200	-300	ND	ND	ND	ND
D5	250	-150	8	ND	47	194

3208AAU23409/T3-26.WK3

ND = Not detected

*** Too high to quantify

Table 3.27 Organic Constituents Detected in Soil Sample with Field GC Screen
Site 4: Former Fire Training Area 1

Soil Boring	Sleeve	CLP Sample ID	Constituent
SB-1	A3	MANG-4-SB1-1	None
	A7		None
	B3		None
	B7		None
	C5	MANG-4-SB1-5.5	None
SB-2	A4	MANG-4-SB2-1	Benzene
			TCE*
			Toluene
			o-Xylene*
	A6		TCE*
	B2		TCE*
	B7	MANG-4-SB2-3.5	TCE*
			Ethyl benzene
			o-Xylene
			m/p-Xylene
SB-3	A4	MANG-4-SB3-3	TCE*
	B4		TCE*
			o-Xylene*
	C2	MANG-4-SB3-7	TCE*
	D3		TCE*
			o-Xylene*
SB-4	A5	MANG-4-SB4-1.5	TCE*
	B5		TCE*
	C5		o-Xylene*
	D6	MANG-4-SB4-7	None
SB-5	Not screened		

* This compound was also present in an associated blank.

SUPPRESSOR
TAXIWAY

4-SB1

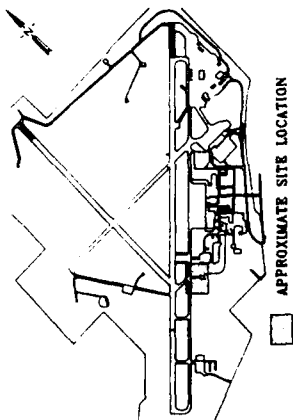
4-SB2

4-SB3

4-SB4

4-SB5

71



APPROXIMATE SITE LOCATION



100 0 100
SCALE FEET

LEGEND

⊕ SB-1 SOIL BORING
LOCATION AND
NUMBER

• SOV GRID POINT

FIGURE 3.20
LOCATIONS OF
SOIL BORINGS
SITE 4
FORMER FIRE
TRAINING AREA 1

Piezometer Levels

Six piezometers were installed around sites 4 through 8 collectively. Groundwater elevations indicate groundwater flow below the base buildings to the west. The downgradient monitor well for site 4 was located just west of the site. Groundwater elevations for each of the piezometers are discussed in section 3.7.3 and piezometer locations are indicated in Figure 3.21 of that section.

Piezometer Screening

Piezometers 1 through 4 at sites 4 through 8 were screened with the field GC. The results of the field GC screening of the piezometers is summarized in Table 3.28. The headspace analysis indicated the possible presence of benzene, ethyl benzene, xylene, and TCE in the headspace from piezometer 2. Trichloroethene was also present in the blanks associated with the field GC screening. The analysis did not indicate the presence of any volatile organics in the headspace from piezometers 1, 3 and 4.

Monitoring Well Observations

Each monitoring well installed was logged during drilling for lithology and other observations that may indicate contamination. During the drilling of MANG-4-MW1, a shallow water-bearing interval was observed at approximately 10 feet below grade. A shallow monitor well (MW1A) was installed into this shallow zone along with a second well completed into the base-wide water table. MW1 and MW1A were placed downgradient of the area suspected of contamination, and no observations during drilling indicated the presence of gross contamination in the borehole soils for the wells at site 4.

3.7.2 Confirmation and Delineation Activities

Ten soil samples, two duplicate soil samples, and four groundwater samples were collected at site 4 for chemical analyses.

Soil Sampling

A few volatile and semivolatile organics, some petroleum hydrocarbons, and some metals were detected in the analyses run on the soil samples. The organic compounds and the metals detected and their respective concentrations are shown on Table 3.29, and selected analytes are shown on Figure 3.21.

The two volatile organic compounds that were found in the soil samples collected at site 4 are acetone and toluene. Acetone and toluene are common laboratory and sampling contaminants.

Phthalates are the only semivolatile compounds detected in the soils from site 4. Phthalates are common laboratory and sampling contaminants.

The TPH analyses of the soil samples collected at site 4 indicated some petroleum hydrocarbon contamination at the site. The TPH concentrations in the samples range up to 1,500 mg/kg.

The majority of the metals detected at site 4 were below the background levels presented in Table 3.2. Metals detected in the soil above background levels include copper and lead.

SUPPRESSOR TAXIWAY

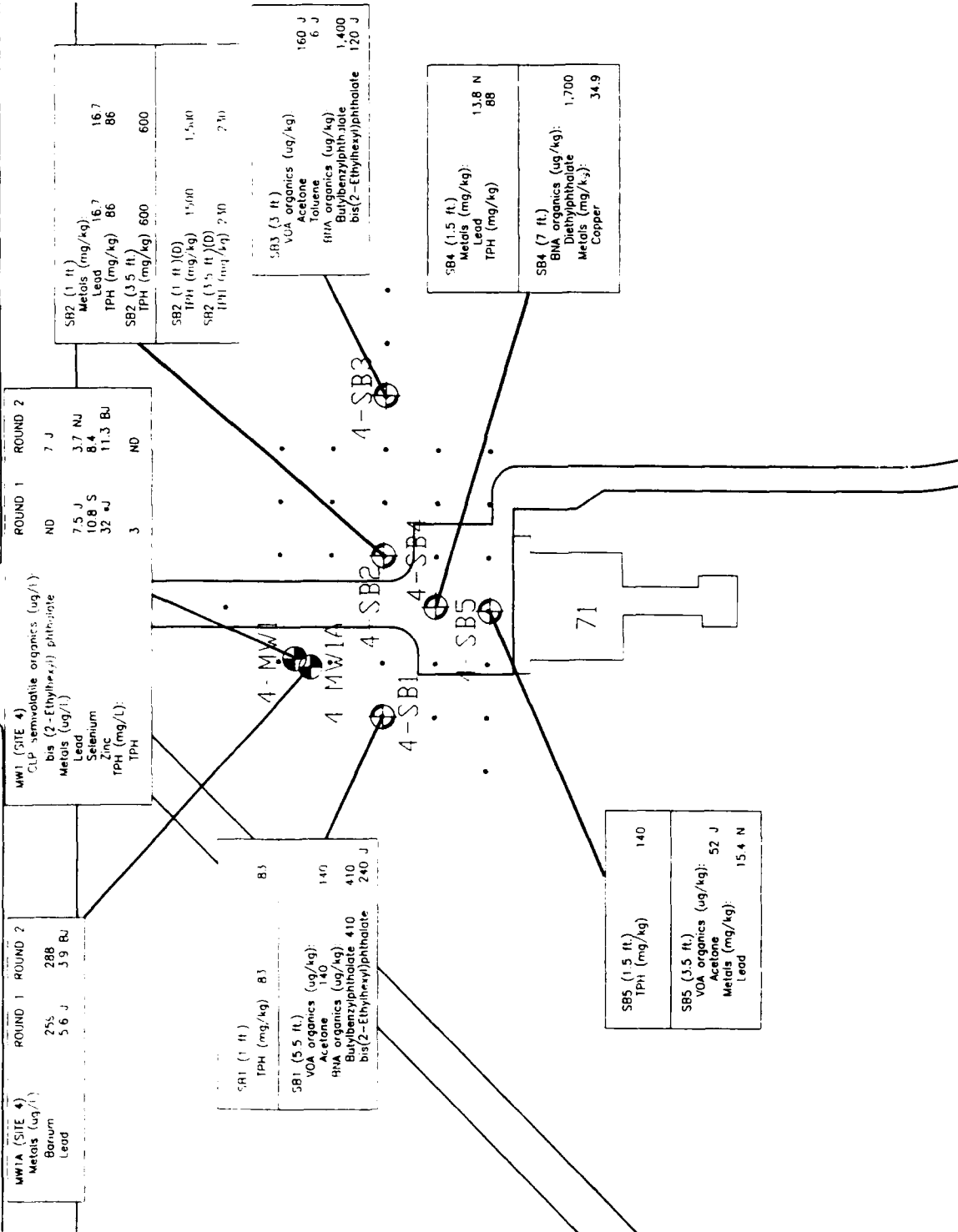


FIGURE 3.21
SELECTED ANALYTES DETECTED
IN SOIL AND GROUNDWATER
SITE 4
FORMER FIRE TRAINING
AREA 1

**Table 3.28 Organic Constituents Detected in Piezometer Samples
with Field GC Screen, Sites 4 through 8**

Sample	Constituent
MANG-(4-8)-P1	ND
MANG-(4-8)-P2	Benzene, TCE*, ethylbenzene, o-xylene, m/p-xylene
MANG-(4-8)-P2-duplicate	Benzene, TCE*, o-xylene, m/p-xylene
MANG-(4-8)-P3	ND
MANG-(4-8)-P4	ND

ND = not detected.

* This compound was also present in an associated blank.

Table 3.29 Chemical Constituents Detected in Soil
Site 4: Former Fire Training Area 1
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-4 SB1-1	MANG-4 SB1-5.5	MANG-4 SB2-1	MANG-4 SB2-1(D)	MANG-4 SB2-3.5	MANG-4 SB2-3.5(D)	MANG-4 SB3-3	MANG-4 SB3-7	MANG-4 SB4-1.5	MANG-4 SB4-7	MANG-4 SB5-1.5	MANG-4 SB5-3.5	Health (2) Criteria
Volatile organics (µg/kg):														
Acetone	ND-157	ND	140	ND	ND	ND	ND	160 J	ND	ND	ND	ND	52 J	8E06
Toluene	ND-9.0	ND	ND	ND	ND	ND	ND	6 J	ND	ND	ND	ND	ND	1.6E07
BNA organics (µg/kg):														
Diethylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1,700	ND	ND	6.4E07
Butylbenzylphthalate	ND	ND	410	ND	ND	ND	ND	1,400	ND	ND	ND	ND	ND	1.6E04
bm(2-Ethylhexyl)phthalate	ND	ND	240 J	ND	ND	ND	ND	120 J	ND	ND	ND	ND	ND	5E04
Metals (mg/kg):														
Arsenic	1.9-9.9	6.5 S	3.9	7.4	5	3.8	5.3	7.9	3.6	6.3	4.5	6.3	7	90
Barium	ND-1,231	214	219	219	170	165	214	290	138	238	1190	260	205	5,600
Chromium	8.7-22.7	9.8	10.5	17	9.3	6.4	11.6	8.4	9.6	12.4	10.6	13.6	20.6	8E04
Copper	3.3-19.7	10.6 *	10.9 *	15.1 *	7.4 *	11.8 *	10.1	7.8 *	7 *	14.2	34.9	18.5	16.1	--
Lead	3.4-13.0	10.5	10.6	16.7	9.3	8.7 B	7.6 N	10.2	9.1	13.8 N	7.5 N	12.2 N	15.4 N	500
Nickel	3.6-17.6	8.4 *	ND	13.8 *	ND	7.5 B*	8.4	9 *	ND	ND	ND	7.1 B	12.1	1,600
Zinc	21.6-61.3	35.8	47.4	48.4	34.3	36	36.5 *	47.5 *	48.8	38.8 *	47.1 *	45.4 *	46.8 *	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	83	ND	86	1500	600	230	ND	ND	88	ND	140	ND	--

3206A/UJ75408T3-28 WK1

(1) Background is the average background concentration +/- two standard deviations.

(2) Based upon soil ingestion, see section 4.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit. For toluene on sample MANG-4-SB3-3, the surrogates were outside QA limits.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

S Reported value was determined by the method of standard additions.

* Duplicate analysis not within control limits set by lab QA/QC.

Groundwater Sampling

The results of the analyses of the groundwater from wells MANG-4-MW1 and MANG-4-MW1A indicate no volatile organics, one semivolatile organic, some petroleum hydrocarbons, and several metals. The results of the chemical analyses of the groundwater from MANG-4-MW1 and MANG-4-MW1A are presented in Table 3.30 and selected analytes are shown on Figure 3.21.

The total petroleum hydrocarbon concentration of the sample collected during the first round from well MANG-4-MW1 was 3 mg/L. No petroleum hydrocarbons were detected from the sample collected during the second round. The samples collected from MANG-4-MW1A showed no petroleum hydrocarbons detected.

The metals detected in groundwater from well MANG-4-MW1 include barium (up to 55.4 $\mu\text{g/L}$), lead (up to 7.5 $\mu\text{g/L}$), selenium (up to 10.8 $\mu\text{g/L}$), and zinc (up to 32 $\mu\text{g/L}$). The metals detected in well MANG-4-MW1A include barium (up to 288 $\mu\text{g/L}$), lead (up to 5.6 $\mu\text{g/L}$), and zinc (up to 12 $\mu\text{g/L}$).

Comparison of Screening Results with CLP Results

The results of the soil gas survey did not compare well with the results of the CLP analyses. The soil gas survey indicated that the highest volatile concentrations were under the asphalt directly in front of the "hush house." Borings 4 and 5, taken in the asphalt area, showed no volatile organic contamination and low TPH contamination. The highest TPH values were found in boring 2, just off the asphalt. The soil gas survey indicated no contamination in the vicinity of boring 2. The field headspace readings of soil samples collected at site 4 indicated concentrations of volatile organics ranging from not detected to more than 20 ppm. There is some slight correlation between the field headspace readings and the CLP analytical results.

The field GC screening of the soil samples indicated trace concentrations of toluene, ethyl benzene, and xylene. Xylene was also detected in the blank. These compounds were not detected in the CLP analyses of the soil samples from site 4. This suggests there is some correlation between the field GC screening and the CLP analyses.

3.7.3 Geologic and Hydrogeologic Investigation Results

The geology and hydrogeology of sites located on the base (sites 4 through 8) were evaluated together because the sites are close together and share subsurface characteristics.

Soil at sites 4 through 8 were observed to be brown sand and clay with gravel that extends to depths of 3 to 4 feet, except at site 5, where the soil is 6 feet deep. Soil at these sites is underlain by weathered sandstone. Competent sandstone was encountered while drilling monitoring well and piezometer boreholes at depths of 8 to 19.5 feet below ground level. Table 3.31 lists the depths below ground level to top of competent sandstone, the depth to the sandstone-shale contact and the thickness of the sandstone in each of the wells and piezometers for sites 4 through 8.

Table 3.30 Chemical Constituents Detected in Groundwater
Site 4: Former Fire Training Area 1
(CLP Laboratory Analysis)

Chemical	Round 1 MANG-4 MW1	Round 2 MANG-4 MW1	Round 1 MANG-4 MW1A	Round 2 MANG-4 MW1A	Background		ARARs (1)
					Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics (µg/L)	ND	ND	ND	ND	ND	ND	NA
CLP semivolatile organics (µg/L): bis(2-Ethylhexyl)phthalate	ND	7 J	ND	ND	ND	ND	4
Metals (µg/L):							
Arsenic	ND	ND	ND	ND	1.1 JB	ND	50
Barium	52 JB	55.4 B	259	288	56 JB	62.2 B	1,000
Lead	7.5 J	3.7 JN	5.6 J	3.9 JB	4.9 J	4.3 JN	50
Selenium	10.8 S	8.4	ND	ND	ND	ND	10
Zinc	32 J*	11.3 JB	12 JB*	8.1 JB	15 JB*	9.8 JB	5,000
Total petroleum hydrocarbons (mg/L)	3	ND	ND	ND	1	ND	NA

320SA\AU\23409\T3-30.WK1

(1) ARARs are proposed only. These are MCLs where available, otherwise WQC.

ND = not detected.

NA = not applicable.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

S Reported value was determined by the method of standard additions.

* Duplicate analysis not within control limits set by lab QA/QC.

J The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

**Table 3.31 Bedrock Data Sites 4 through 8
120th Fighter Interceptor Group
Great Falls, Montana**

Well/ Piezometer ID	Depth to Top of Competent Sandstone*	Depth to Base of Competent Sandstone*	Thickness of Competent Sandstone (feet)
MANG-4-MW1	19.5	53.0	33.5
MANG-5-MW1	14.2	51.0	36.8
MANG-6-MW1	17.0	57.5	40.5
MANG-7-MW1	14.0	58.0	44.0
MANG-8-MW1	18.0	56.5	38.5
MANG-(4-8)-P1	8.0	46.5	38.5
MANG-(4-8)-P2	12.0	51.0	39.0
MANG-(4-8)-P3	10.0	46.6	36.6
MANG-(4-8)-P4	16.0	52.5	36.5
MANG-(4-8)-P5	15.0	53.0	38.0
MANG-(4-8)-P6	12.0	50.3	38.3

* All depths are in feet below ground level.

Six piezometers were drilled to define the lithology and groundwater flow direction for sites 4 through 8. Determinations of groundwater flow direction and gradient were reevaluated during the course of the investigation as data from newly constructed monitoring wells became available. Water level measurements were taken often and compared to previous measurements. Care taken in determining groundwater flow direction and gradient was due to the possibility of artificial recharge to the aquifer from leaks in underground water pipes that occurred during the course of our field investigation.

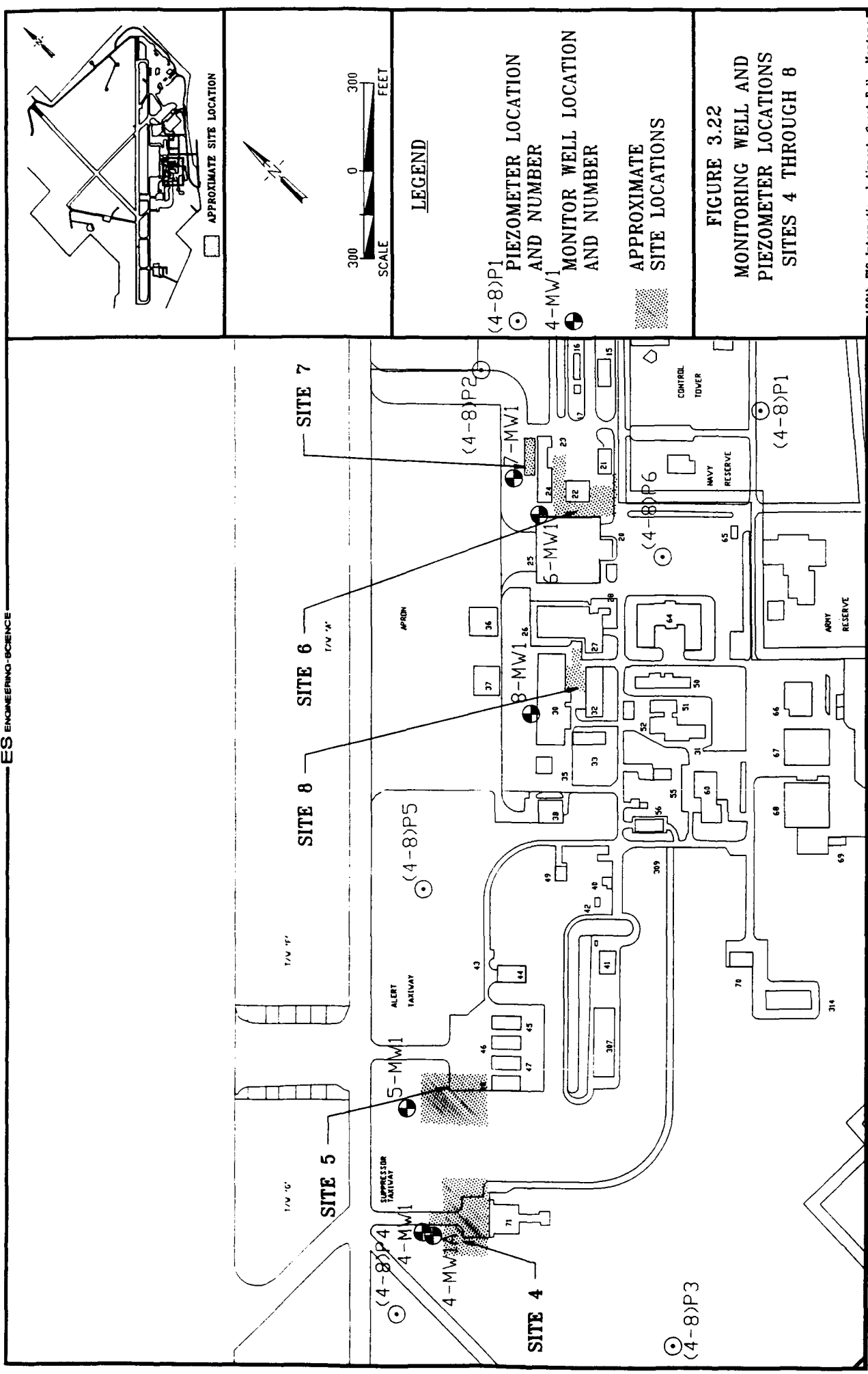
The locations of the wells and piezometers for sites 4 through 8 are shown on Figure 3.22. Piezometer and monitoring well construction data is presented in Tables 3.6 and 3.12, respectively. A cross section was drawn using the lithologic logs (appendix C) of the well and piezometer borings in the study area. The orientation of the cross section is shown on Figure 3.23, while the cross section is shown on Figure 3.24. The cross section shows relatively flat-lying bedrock with no major structural displacement, overlain by unconsolidated material. This supports previous findings in the area (Wilke, 1983; Lemke, 1977; Fox, 1966).

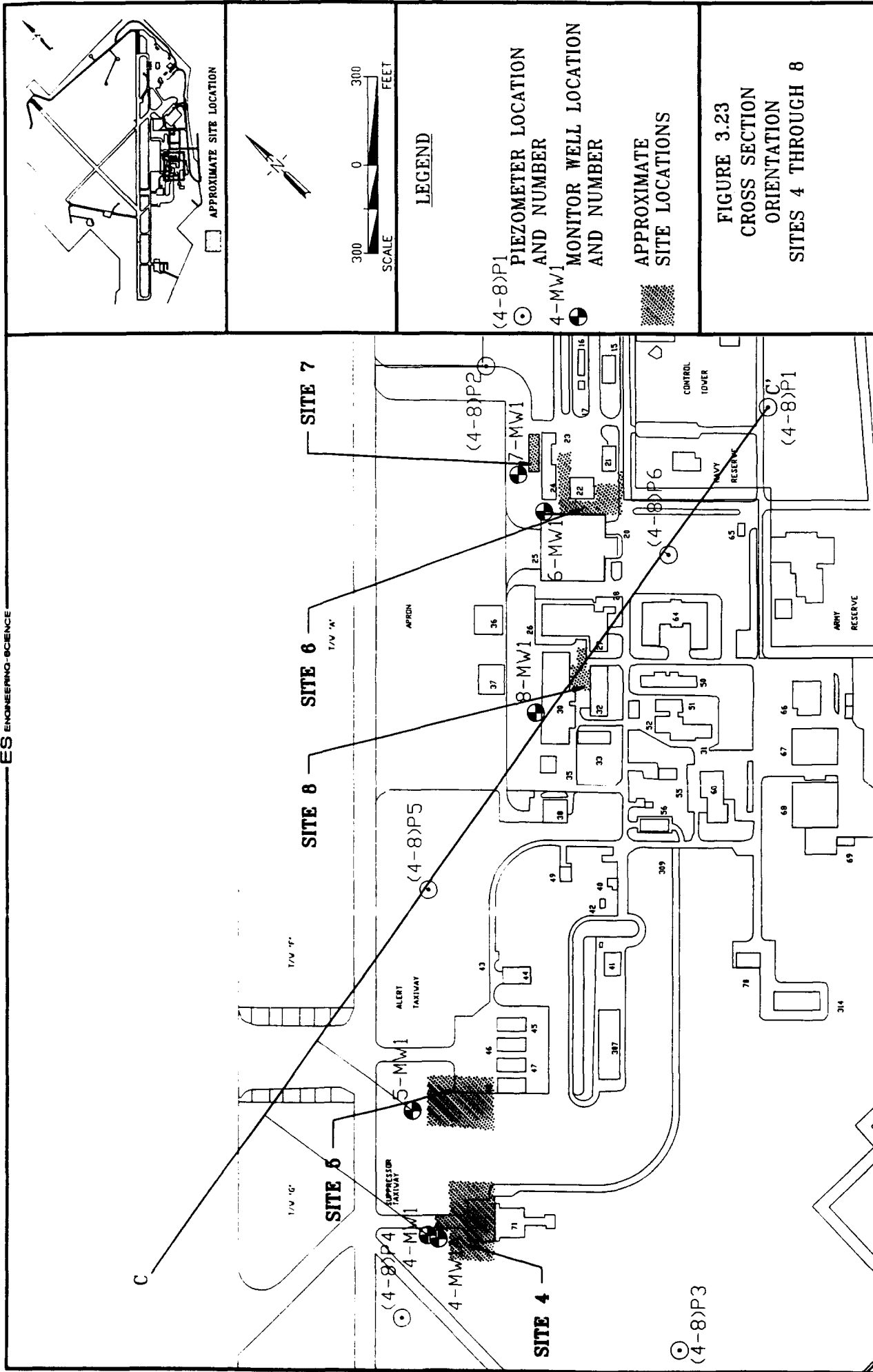
Piezometer water level data was evaluated and the groundwater flow direction was determined. Based on this information, one monitoring well was constructed downgradient of each site (except for site 4 where 2 wells were constructed). A final round of water level measurements was taken after all monitoring wells were in place. The data were used to calculate groundwater elevations for sites 4 through 8. Figure 3.25 is the potentiometric surface map drawn from these data. The areal groundwater flow is to the west-northwest. The average hydraulic gradient is approximately 95 feet per mile. Table 3.32 lists the water level information collected during two rounds of measurements.

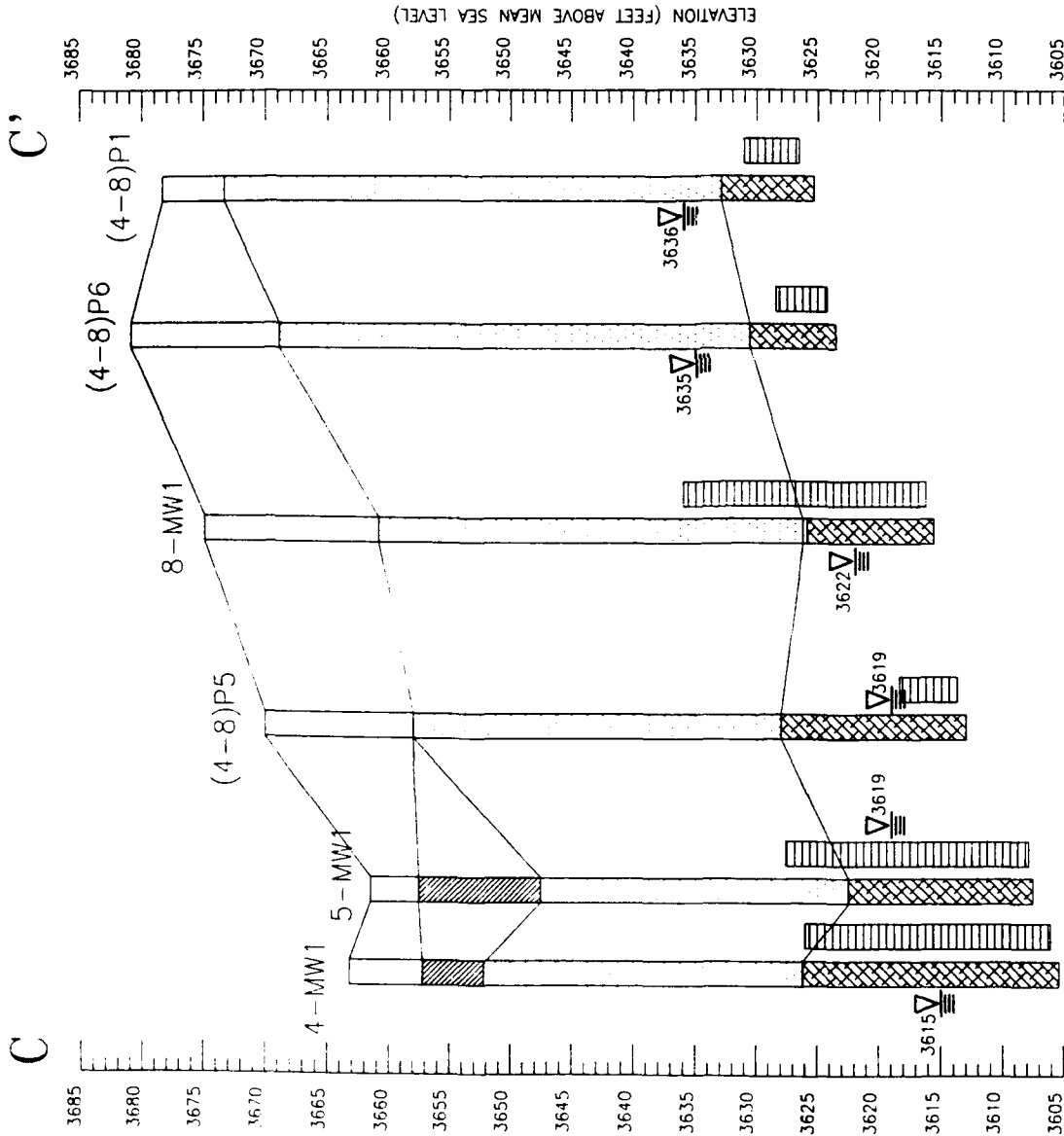
At site 4, two monitoring wells were constructed. A shallow water-bearing zone was encountered at a depth of 6 to 11 feet below ground level during the drilling of the planned site 4 monitoring well. This zone has a static water level of 7 feet below ground level and produced an estimated 3 to 5 gallons per minute. A monitoring well was constructed to screen this shallow water-bearing zone. The location of this well is shown on Figure 3.21, and the well construction log is in appendix D.

During construction of the deeper site 4 monitoring well, a 6-inch diameter, black-steel surface casing was set from ground surface to a depth of 22 feet bgl to prevent shallow contamination from migrating down hole. A cement-bentonite grout was placed between the surface casing and borehole wall to seal the zone. The casing was allowed to sit for 24 hours after placement of the grout to observe the integrity of the seal. After the 24-hour waiting period, water was not observed inside the casing, confirming that the zone had been sealed.

The source of the shallow water is undetermined, but is suspected to come from the numerous water leaks that have historically occurred on the base or from the ditch at site 4 that parallels the taxiway.

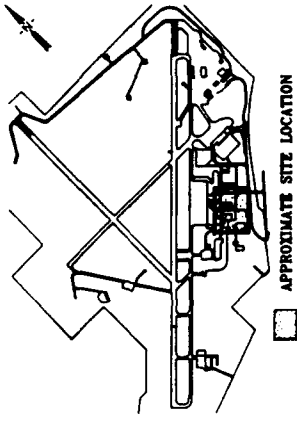




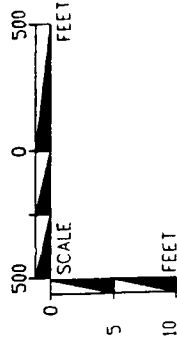


NOTE: WATER LEVEL MEASUREMENT TAKEN IN OCTOBER 1990.

XSEC4-B 2/6/92



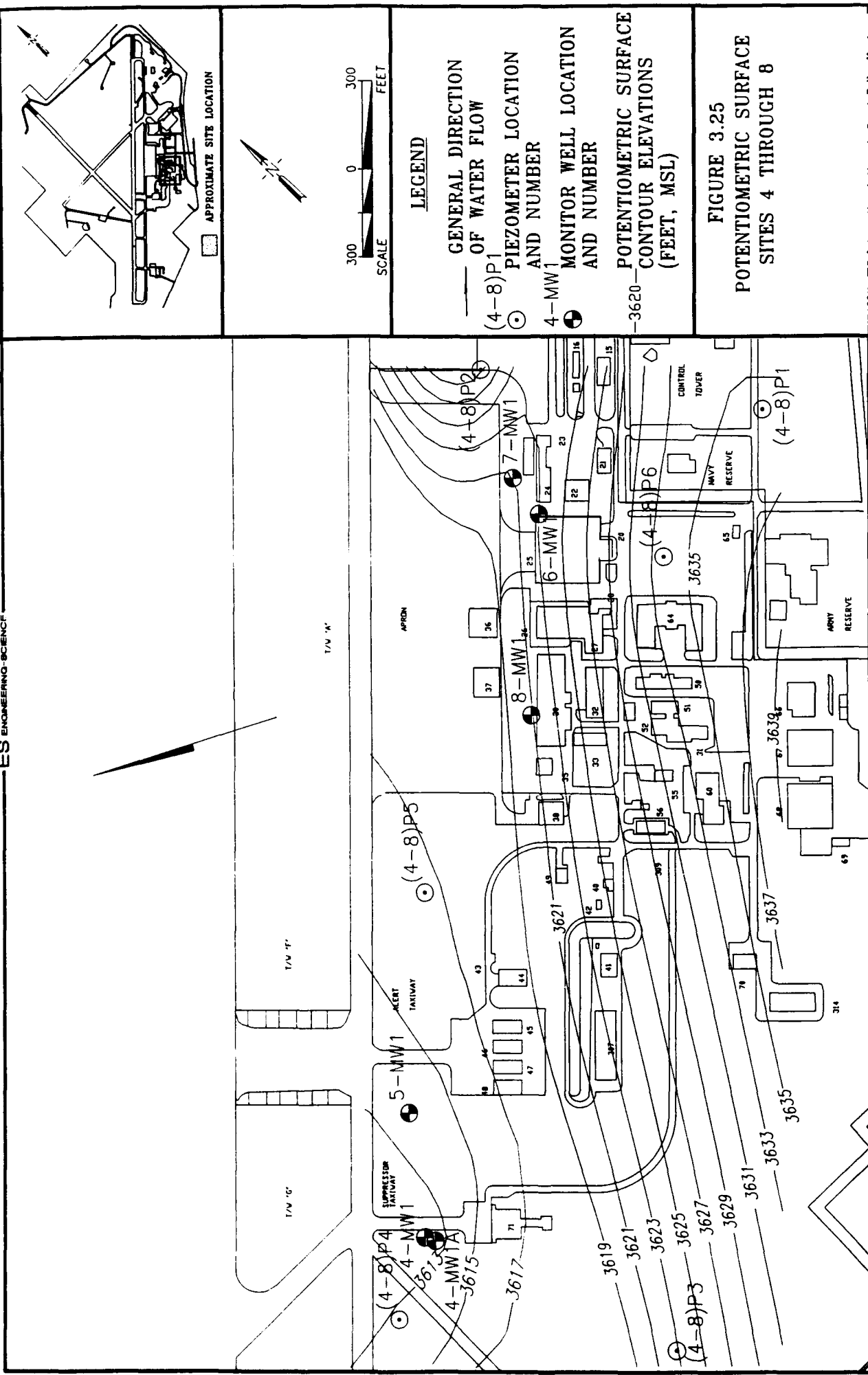
APPROXIMATE SITE LOCATION



LEGEND

- SOIL OR WEATHERED ROCK
- SANDSTONE (TAN)
- CLAY
- SANDSTONE (GRAY)
- WELL SCREEN
- WATER LEVEL

**FIGURE 3.24
GENERALIZED
CROSS SECTION
SITES 4 THROUGH 8**



SIT4-88

120th FIG International Airport, Great Falls, Montana

3-73

FIGURE 3.25
POTENTIOMETRIC SURFACE
SITES 4 THROUGH 8

LEGEND

- OF WATER FLOW
- (4-8)P1 — PIEZOMETER LOCATION AND NUMBER
- 4-MW1 — MONITOR WELL LOCATION AND NUMBER
- 3620— POTENTIOMETRIC SURFACE CONTOUR ELEVATIONS (FEET, MSL)

Table 3.32 Water Level Data for Sites 4 through 8

Well/ Piezometer ID	10/28/90		2/20/91	
	Depth to Water*	Water Level Elevations**	Depth to Water*	Water Level Elevations**
MANG-4-MW1	50.19	3,615.42	52.88	3,612.73
MANG-4-MW1A	9.12	3,655.58	9.88	3,654.82
MANG-5-MW1	44.92	3,619.10	50.61	3,613.41
MANG-6-MW1	51.07	3,624.12	53.50	3,621.69
MANG-7-MW1	52.49	3,621.47	55.37	3,619.59
MANG-8-MW1	52.60	3,621.64	53.86	3,620.38
MANG-BG-MW1	49.31	3,631.58	53.63	3,627.26
MANG-(4-8)-P1	44.43	3,636.39	45.47	3,635.35
MANG-(4-8)-P2	42.63	3,631.47	43.80	3,630.30
MANG-(4-8)-P3	47.55	3,623.90	49.46	3,621.99
MANG-(4-8)-P4	45.44	3,615.78	47.31	3,613.91
MANG-(4-8)-P5	52.86	3,619.28	55.51	3,616.63
MANG-(4-8)-P6	45.68	3,634.99	47.39	3,633.28

* Depth to water is feet below top of PVC casing.

** Water level elevations are in feet above mean sea level.

3.7.4 Conclusions

The results of screening activities at site 4 indicate no significant widespread contamination. However, soil gas and HNU data indicate two points of possible contamination. Field GC screening of piezometer samples indicated the possible presence of some petroleum-related contaminants.

Site 4 was formerly used as a fire training area, as stated in section 1.3.1. The soil samples collected from soil boring 2 and the duplicate boring show some petroleum hydrocarbon contamination. This contamination might have been associated with the former fire training activities. However, judging from the rest of the chemical analyses from the samples that were collected at the site, soil contamination above action levels, from the former fire training area was not detected during this investigation.

Analyses of groundwater samples taken from the monitoring well at the site indicate low levels of TPH in the round 1 sample. The presence of petroleum hydrocarbons in the monitoring well at site 4 was not confirmed in the second round of sampling. Elevated levels of some metals were also apparent from monitoring well data.

3.8 SITE 5 – FORMER FIRE TRAINING AREA 2

3.8.1 Screening Activity Results

Soil Gas

The results of the soil gas survey are summarized in Figure 3.26 and Table 3.33. Samples were collected on a 200-foot by 150-foot grid with 50-foot spacing. Few organics were detected. Trace concentrations of 1,1-DCE, TCE, benzene, and toluene were found in several points. There was no apparent pattern to the distribution of these points.

Soil Borings

Descriptions. Four soil borings were drilled and sampled at site 5. Figure 3.27 shows the locations of the soil borings for site 5. The boring depths ranged from 4 to 8 feet below grade. No odors or other indications of contamination were encountered in the soils at site 5.

Field HNU. Each of the soil samples collected was screened with an HNU. The total organic vapor readings ranged from 0 to 2 ppm.

Field GC. The results of the field GC screening are summarized in Table 3.34. Other than TCE and o-xylene, which were also found in the blanks, no organics were detected in any sample.

Piezometer Levels

Six piezometers were installed around sites 4 through 8 collectively. Groundwater elevations indicate groundwater flow below the base buildings to the west. The downgradient monitor well for site 5 was located just west of the site. Groundwater elevations for each of the piezometers are discussed in section 3.7.3.

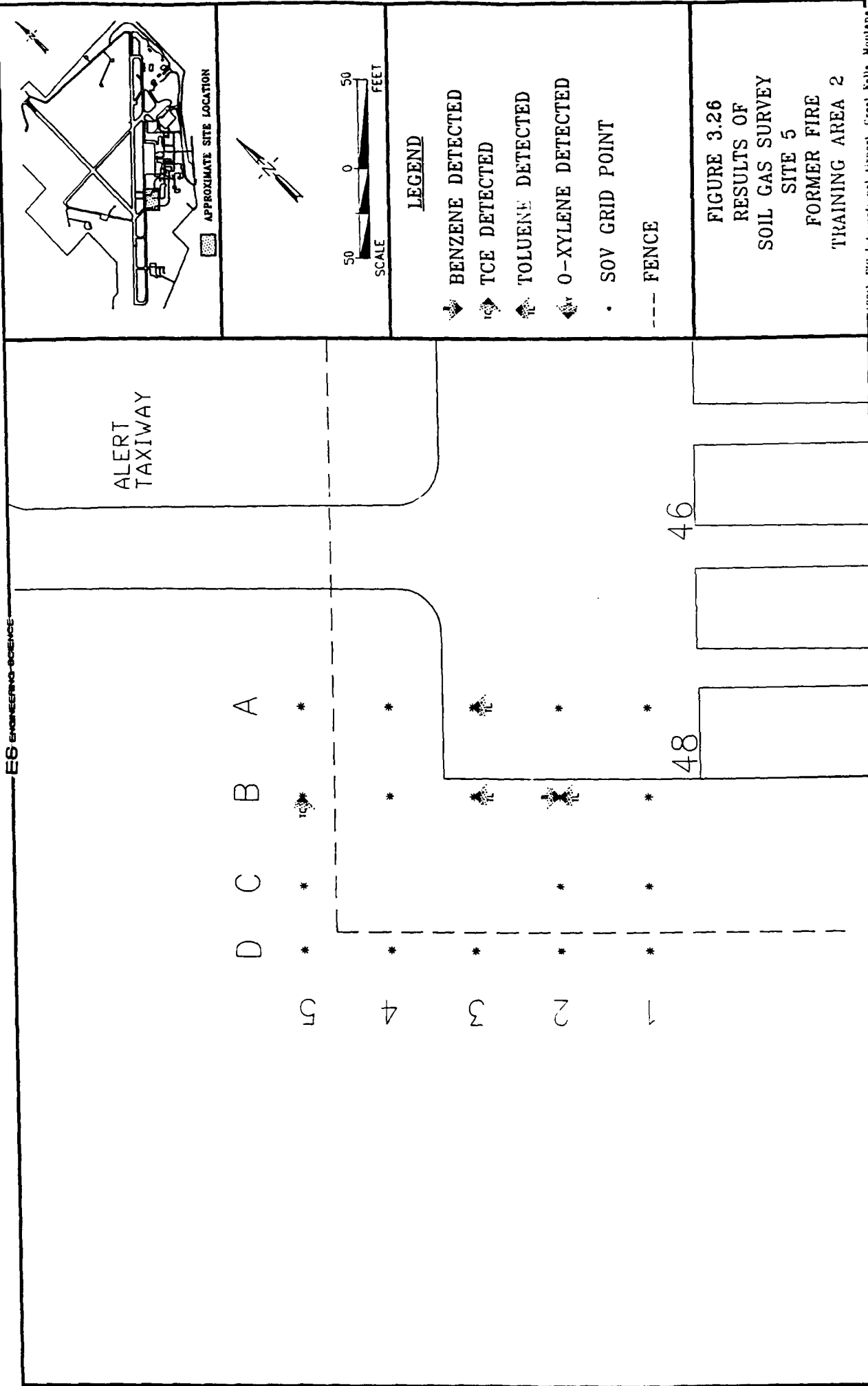


Table 3.33 Organic Constituents Detected in Soil Gas Survey
Site 5: Former Fire Training Area 2
 (ppb by volume, GC)

Sample ID	Grid Coordinates		1,1-DCE	Benzene	TCE	Toluene
A1	0	-50	0	0	0	0
B1	50	-50	0	0	0	0
C1	100	-50	0	0	0	0
D1	150	-50	48	0	0	0
A2	0	-100	0	0	0	0
B2	50	-100	0	11	0	35
C2	100	-100	14	0	0	0
D2	150	-100	0	0	0	0
A3	0	-150	0	0	0	27
B3	50	-150	0	0	0	10
D3	150	-150	0	0	0	0
A4	0	-200	0	0	0	0
B4	50	-200	0	0	0	0
D4	150	-200	0	0	0	0
A5	0	-250	0	0	0	0
B5	50	-250	0	0	8	0
C5	100	-250	0	0	0	0
D5	150	-250	0	0	0	0

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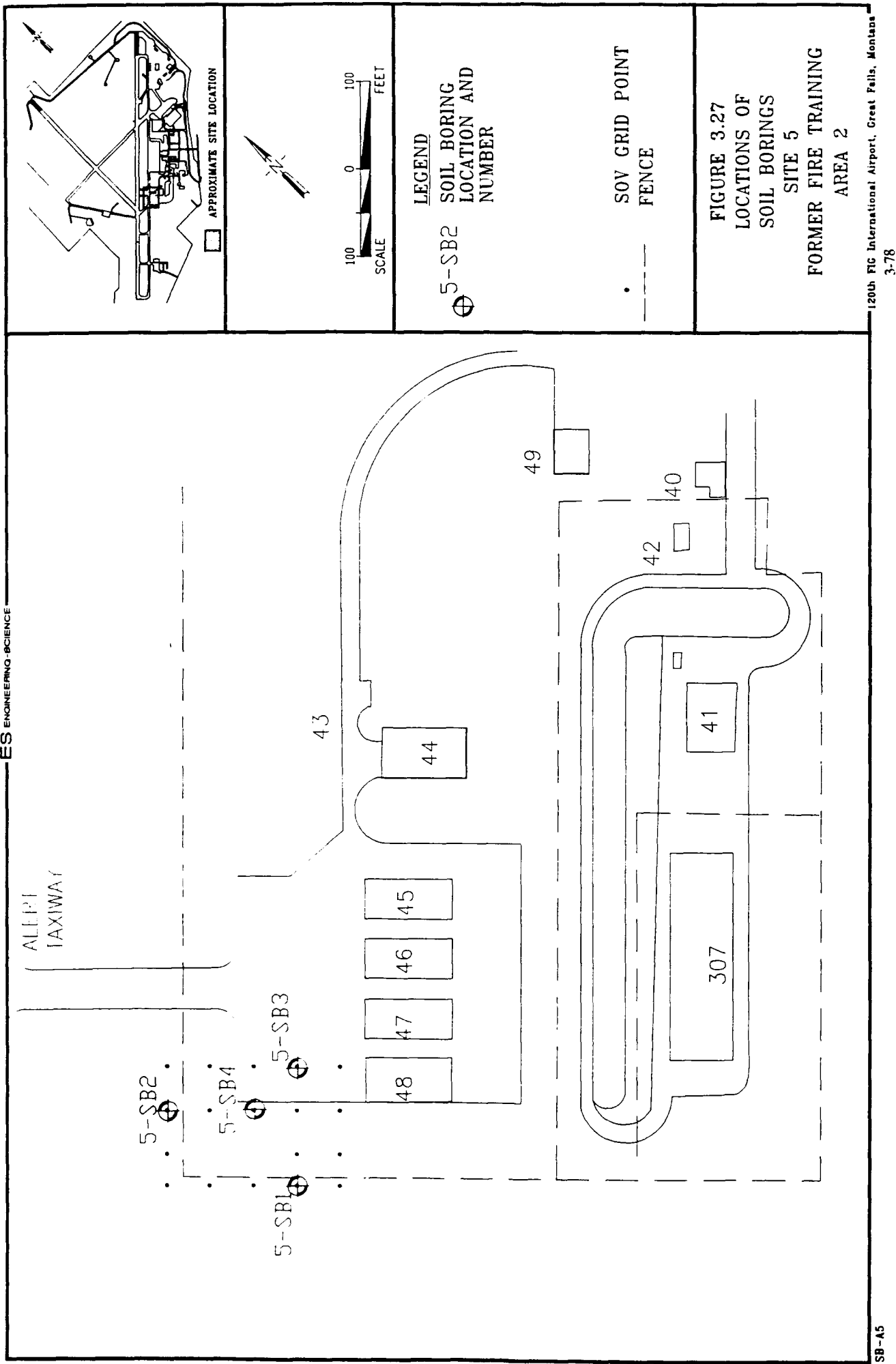


Table 3.34 Organic Constituents Detected in Soil Samples with Field GC Screen
Site 5: Former Fire Training Area 2

Soil Boring	Sleeve	CLP Sample ID	Constituent
SB-1	A4	MANG-5-SB1-3.5	TCE*
	B6		TCE*
	C5		TCE*
	D7	MANG-5-SB1-5.5	TCE*
SB-2	A4	MANG-5-SB2-1	TCE*
	B6		TCE*
SB-3	A5	MANG-5-SB3-1.5	TCE*
	B6	MANG-5-SB3-5	TCE*
	C4		TCE*
	D7		o-Xylene* TCE*
SB-4	A6	MANG-5-SB4-5.5	TCE*
	B6		TCE*
	C7		TCE*

* This compound was also present in an associated blank.

Piezometer Screening

The piezometers used at site 5 were the same as those used for site 4. The results of the headspace screening are described in section 3.7.

Monitoring Well Observations

Each monitoring well installed was logged during drilling for lithology and other observations that may indicate contamination. MANG-5-MW1 was placed downgradient of the area suspected of contamination, and no observations during drilling indicated the presence of gross contamination in the borehole for the well at site 5.

3.8.2 Confirmation and Delineation Activities

Six soil samples and two groundwater samples were collected at site 5 for chemical analyses.

Soil Sampling

A few volatile organics, no semivolatile organics, some petroleum hydrocarbons, and some metals were detected in the analyses run on the soil samples. The organic compounds and the metals detected and their respective concentrations are shown on Table 3.35, and selected analytes are shown on Figure 3.28.

The two volatile organic compounds that were found in the soil samples collected at site 5 were acetone and toluene. Acetone is a common laboratory and sampling contaminant.

There were no semivolatile organic compounds detected in the soil samples from site 5.

The TPH analyses of the soil samples collected at site 5 indicated petroleum hydrocarbon contamination in one sample at the site. The TPH concentration detected was 160 mg/kg.

The majority of the metals concentrations detected at site 5 were below the background levels presented in Table 3.2. The metals detected above background include arsenic, copper, and mercury.

Groundwater Sampling

The results of the analyses of the groundwater from well MANG-5-MW1 indicates no volatile or semivolatile organics, some petroleum hydrocarbons, and several metals were detected. The results of the chemical analyses of the groundwater from MANG-5-MW1 are presented in Table 3.36.

The total petroleum hydrocarbon concentration of the sample collected from well MANG-5-MW1 was 4 mg/L. Petroleum hydrocarbons were not detected in the well during the second round of sampling.

The metals detected in groundwater at site 5 include barium (up to 46 $\mu\text{g/L}$), lead (up to 4.6 $\mu\text{g/L}$), selenium (up to 8.1 $\mu\text{g/L}$), and zinc (up to 51 $\mu\text{g/L}$).

Table 3.35 Chemical Constituents Detected in Soil
Site 5: Former Fire Training Area 2
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-5 SB1-3.5	MANG-5 SB1-7.5	MANG-5 SB2-1	MANG-5 SB3-1.5	MANG-5 SB3-5	MANG-5 SB4-5.5	Health (2) Criteria
Volatile organics ($\mu\text{g/kg}$):								
Acetone	ND-157	ND	120	ND	ND	140	17 J	8E06
Toluene	ND-9	10	ND	ND	ND	6 J	ND	1.6E07
BNA organics ($\mu\text{g/kg}$)	ND	ND	ND	ND	ND	ND	ND	--
Metals (mg/kg)								
Arsenic	1.9-9.9	22.5	3.1	6.5	7 S	7.3	4.2	80
Barium	ND-1,231	155	187	218	258	285	437	5,600
Chromium	8.7-22.7	16.3	9.5	12.7	12	22.8	9.7	8E04
Copper	3.3-19.7	31.6 *	5.7 *	11.5 *	31 *	14.8 *	8.7 *	--
Lead	3.4-13.0	12.7	5.2 B	9.5	7.5	11.4	5.4	500
Nickel	3.6-17.6	ND	ND	9.4	9.7	16.1	ND	1,600
Selenium	ND-0.66	ND	ND	ND	0.29 BW	ND	ND	240
Zinc	21.6-61.3	61.2 *	40.7 *	38.8 *	47 *	50.6 *	26.4 *	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	ND	ND	ND	160	ND	ND	--

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(1) Background is the average background concentration +/- two standard deviations.

(2) Based upon soil ingestion, see section 4.

ND = not detected.

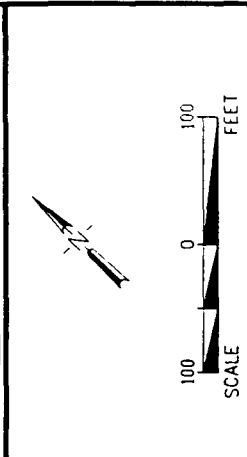
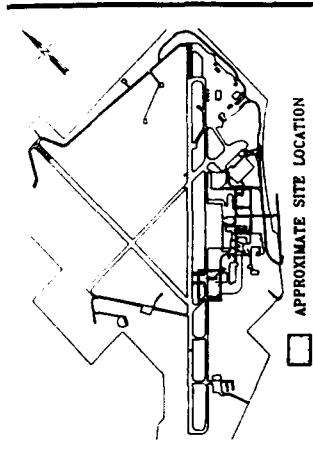
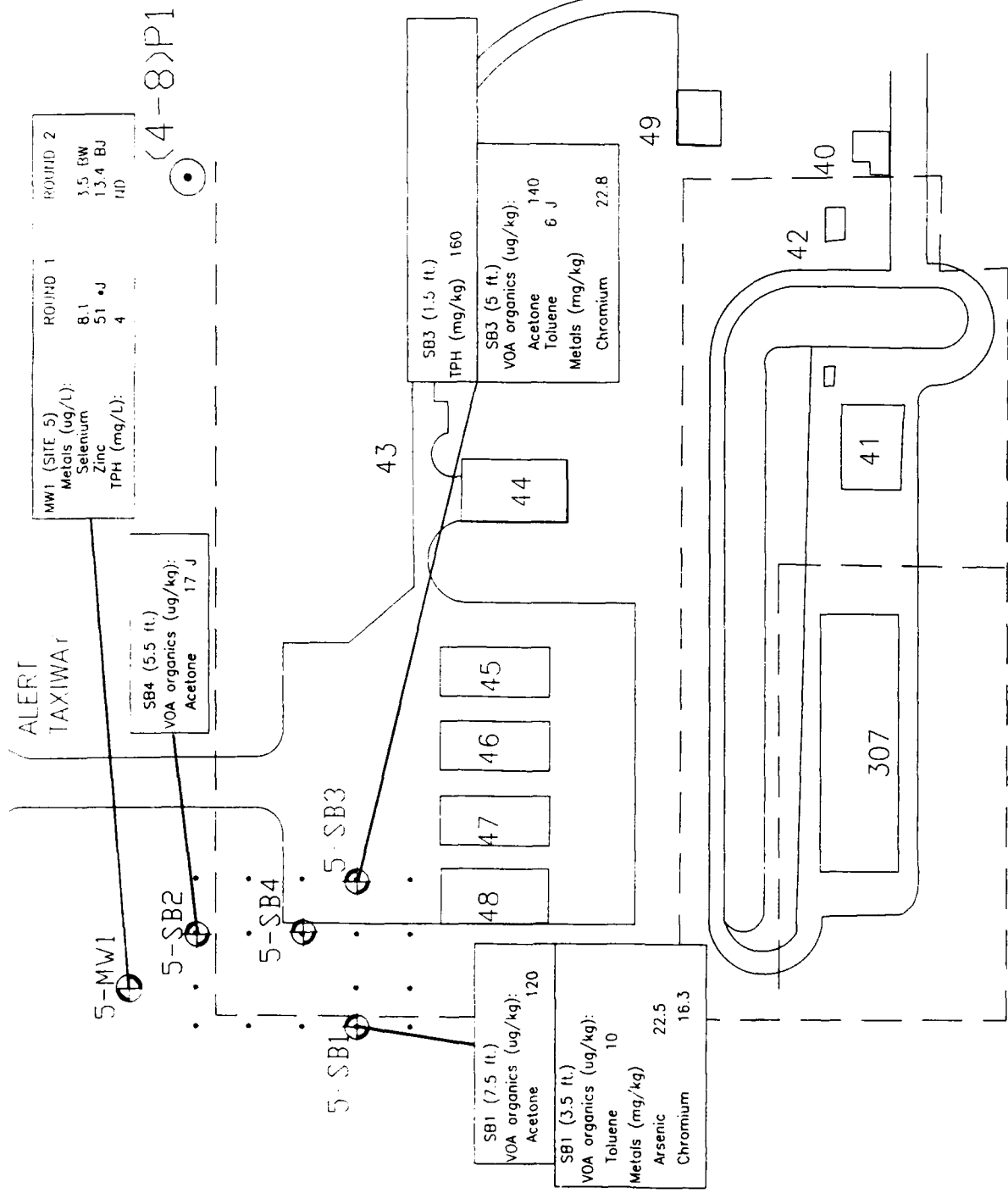
Data qualifiers follow the data. The qualifiers are:

Organics:

- J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

- B Reported value is less than reporting limit but greater than the instrument detection limit.
- S Reported value was determined by the method of standard additions.
- * Duplicate analysis not within control limits set by lab QA/QC.
- W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.



LEGEND

5-SB2 SOIL BORING LOCATION AND NUMBER

5-MW1 MONITOR WELL LOCATION AND NUMBER

P1 PIEZOMETER

SOV GRID POINT

FENCE

NOTE: SEE ANALYTICAL SUMMARY TABLE FOR LABORATORY QUALIFIERS

FIGURE 3.28

SELECTED ANALYTES DETECTED IN SOIL AND GROUNDWATER

SITE 5

FORMER FIRE TRAINING AREA 2

Table 3.36 Chemical Constituents Detected in Groundwater
Site 5: Former Fire Training Area 2
(CLP Laboratory Analysis)

Chemical	Round 1 MANG-5 MW1	Round 2 MANG-5 MW1	Background		ARARs (1)
			Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics ($\mu\text{g/L}$)	ND	ND	ND	ND	NA
CLP semivolatile organics ($\mu\text{g/L}$)	ND	ND	ND	ND	NA
Metals ($\mu\text{g/L}$):					
Arsenic	ND	ND	1.1 BJ	ND	50
Barium	46 JB	44.9 B	56 BJ	62.2 B	1,000
Lead	4.6 J	4.2 JN	4.9 J	4.3 NJ	50
Selenium	8.1	3.5 BW	ND	ND	10
Zinc	51 J*	13.4 JB	15 B*J	9.8 BJ	5,000
Total petroleum hydrocarbons (mg/L)	4	ND	1	ND	NA

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(1) ARARs are proposed only. These are MCLs where available, otherwise WQC.

NA = not applicable.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Metals:

- B** Reported value is less than reporting limit but greater than the instrument detection limit.
- N** Spiked sample recovery not within control limits set by lab QA/QC.
- *** Duplicate analysis not within control limits set by lab QA/QC.
- W** Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.
- J** The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

Comparison of Screening Results with CLP Results

The results of the soil gas survey compare well with the CLP results. The soil gas survey indicated little or no organic contamination throughout the site with trace concentrations of volatile organics along the west edge of the paved area. Soil boring 3, taken in this area, had a low concentration of TPH. Otherwise, there were little or no organics or TPH detected.

The field headspace readings of soil samples collected at site 5 indicated concentrations of volatile organics ranging from not detected to 2 ppm. This compares moderately well with the results of the analyses of the samples sent to the CLP laboratory.

The field GC screening of the soil samples indicated concentrations of TCE. However, TCE was also indicated in the associated blanks. TCE was not detected in the CLP analyses of the soil samples from site 5. This suggests there is good correlation between the field GC screening and the CLP analyses.

3.8.3 Geologic and Hydrogeologic Investigation Results

The results of geologic and hydrogeologic investigation of sites 4 through 8 were evaluated as a group because the sites were close together and share subsurface characteristics. This information is presented in the first portion of section 3.7.3. Geologic and hydrogeologic information specific to site 5 is discussed below.

During the construction of MANG-5-MW1, a shallow water-bearing zone was encountered at the interval from 3 to 5 feet bgl. This zone is thought to correlate with the shallow water-bearing zone encountered at site 4. According to the lithologic log (appendix D), the zone consists of a fine to medium-grained sand, with some weathered sandstone.

The shallow zone at site 5 had a static water level of about 4 feet bgl and produced significantly less water (< 0.5 gallons per minute) than the shallow water-bearing zone at site 4. Therefore, it was decided not to construct a shallow monitoring well at site 5. To avoid the possibility of contaminating the lower water-bearing unit, a 6-inch-diameter, black-steel surface casing was set from ground surface to 10 feet bgl. A cement-bentonite grout was placed between the surface casing and borehole wall to seal the zone and prevent water from migrating down hole. The casing was allowed to sit for 24 hours after placement of the grout to observe the integrity of the seal. After the 24-hour waiting period, water was not observed inside the casing, confirming that the zone had been sealed.

The source of the shallow water is undetermined, but is suspected to come from the numerous water leaks that have historically occurred on the base or from the ditch that parallels the taxiway immediately west of site 5.

3.8.4 Conclusions

Site 5 is a former fire training area, as mentioned in section 1.3.1. Chemical analyses of the soil and water samples collected at the site indicate no clear identification of a former fire training area or any remaining wastes.

The results of screening activities at site 5 indicate no significant soil contamination. Trace concentrations of solvent and fuel constituents were detected during the soil gas survey.

Analyses of groundwater samples taken from the monitoring well at the site indicate low levels of TPH in the round 1 sample. The presence of petroleum hydrocarbons in the monitoring well at site 5 was not confirmed in the second round of sampling. Elevated levels of some metals were also apparent from monitoring well data.

3.9 SITE 6 - AEROSPACE GROUND EQUIPMENT (AGE, BLDG. 22) AREA

3.9.1 Screening Activity Results

Soil Gas

The results of the soil gas survey are summarized in Figure 3.29 and Table 3.37. The samples were collected on several grids located north, south, and west of building 22. The soil gas survey indicated three areas of high organic concentrations: along the fence line southeast of building 22, at the northeast corner of building 24, and between buildings 22 and the aircraft maintenance hangar. Organics identified at these points were 1,1-DCE, 1,2-DCE, TCE, benzene, toluene, and o-xylene. The soil gas survey points between buildings 24 and 23 and building 22 were part of additional activities (soil gas and soil borings) initiated to gather data related to apparent fuel contamination encountered during maintenance activities.

Geophysics

A GPR⁵ survey was conducted to determine the presence and location of an abandoned dry well. Figure 3.30 shows the GPR grid and area investigated. Also shown on the Figure is an adjacent area surveyed to determine the possible existence of an underground storage tank abandoned prior to 1984.

The survey indicated the presence of a reinforced concrete slab at the reported location of the dry well. Base personnel subsequently removed the asphalt from above the concrete slab and uncovered the top of a brick-lined dry well extending to a depth of about 4 feet.

No indication of a buried tank was found in the area near the dry well.

Soil Borings

Description. Fourteen borings were drilled and sampled at site 6, six as part of the site 6 investigation and eight as part of the additional activities described above. Figures 3.31 and 3.32 present the locations of the soil borings for site 6. Boring depths ranged from 2 to 8 feet below grade. Some soil staining was observed in borings SB2 and SB3 at 4 to 6 feet below grade. The soil in a few of the borings was saturated at approximately 5 feet below grade. Those borings which were saturated are indicated in the boring logs in appendix D. The saturation is assumed to be from leaky fire hydrant lines in the area.

⁵ GPR = ground-penetrating radar

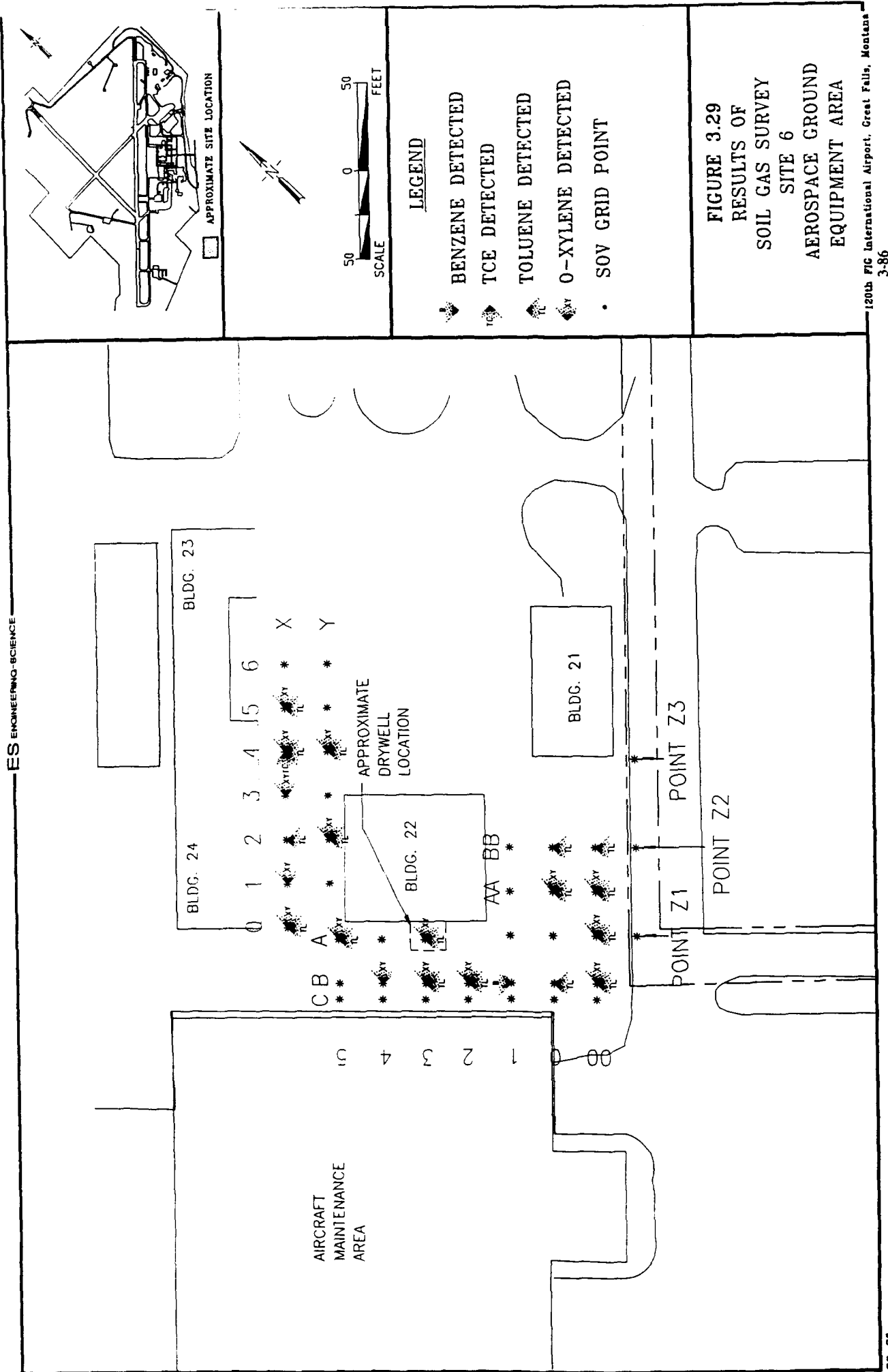


FIGURE 3.29
RESULTS OF
SOIL GAS SURVEY
SITE 6
AEROSPACE GROUND
EQUIPMENT AREA

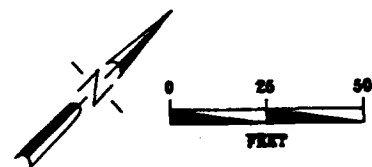
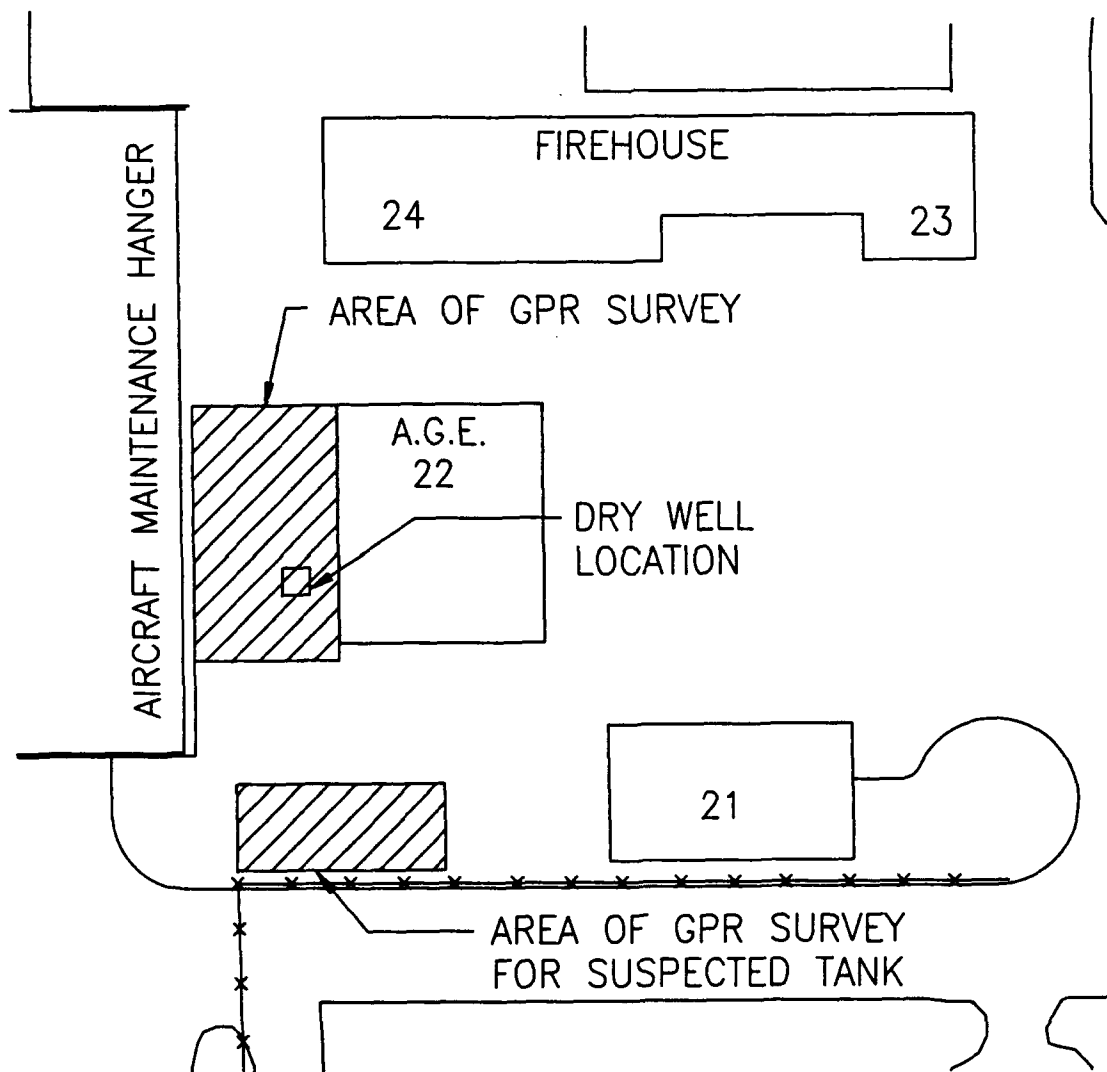
Table 3.37 Organic Constituents Detected in Soil Gas Survey
Site 6: Aerospace Ground Equipment (AGE, Bldg. 22) Area
(ppb by volume, GC)

Sample ID	Grid Coordinates		1,1-DCE	1,2-DCE	Benzene	TCE	Toluene	o-Xylene
X0	50	0	ND	ND	ND	ND	8	1,450
X1	75	0	ND	ND	ND	ND	0	1,450
X2	100	0	ND	ND	ND	ND	32	ND
X3	125	0	ND	ND	ND	ND	ND	1,000
X4	150	0	ND	ND	ND	135,000	327,000	***
X5	175	0	ND	ND	ND	ND	***	***
C5	0	-30	ND	ND	ND	ND	ND	ND
B5	25	-30	ND	ND	ND	ND	ND	ND
A5	50	-30	ND	ND	ND	ND	18	93
Y1	75	-30	ND	ND	ND	ND	ND	ND
Y2	100	-30	ND	ND	ND	ND	210	1,100
Y3	125	-30	ND	ND	ND	ND	ND	ND
Y4	150	-30	ND	ND	ND	ND	16	340
Y5	175	-30	ND	ND	ND	ND	ND	ND
C4	0	-55	ND	ND	ND	ND	ND	ND
B4	25	-55	ND	ND	ND	ND	ND	458
A4	50	-55	ND	ND	ND	ND	ND	ND
C3	0	-80	ND	ND	ND	ND	ND	ND
B3	25	-80	ND	ND	ND	ND	***	***
A3	50	-80	ND	ND	ND	ND	***	***
C2	0	-105	ND	ND	ND	ND	ND	ND
B2	25	-105	ND	ND	ND	ND	***	***
C1	0	-130	ND	ND	ND	ND	ND	ND
B1	25	-130	ND	ND	21	ND	ND	ND
A1	50	-130	ND	ND	ND	ND	ND	ND
C0	0	-155	ND	ND	ND	ND	ND	ND
B0	25	-155	1,670	ND	ND	ND	660	ND
A0	50	-155	ND	58	ND	ND	ND	ND
C00	0	-180	ND	ND	ND	ND	ND	ND
B00	25	-180	ND	ND	ND	ND	***	***
A00	50	-180	ND	ND	ND	ND	***	***
AA1	75	-130	ND	ND	ND	ND	ND	ND
BB1	100	-130	ND	ND	ND	ND	ND	ND
AA0	75	-155	ND	ND	ND	ND	3,100	2,000
BB0	100	-155	ND	ND	ND	ND	104	ND
AA00	75	-180	ND	ND	ND	ND	170,000	***
BB00	100	-180	ND	ND	ND	ND	***	ND

ND = not detected

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FIGURE 3.30
SITE 6
GPR SURVEY



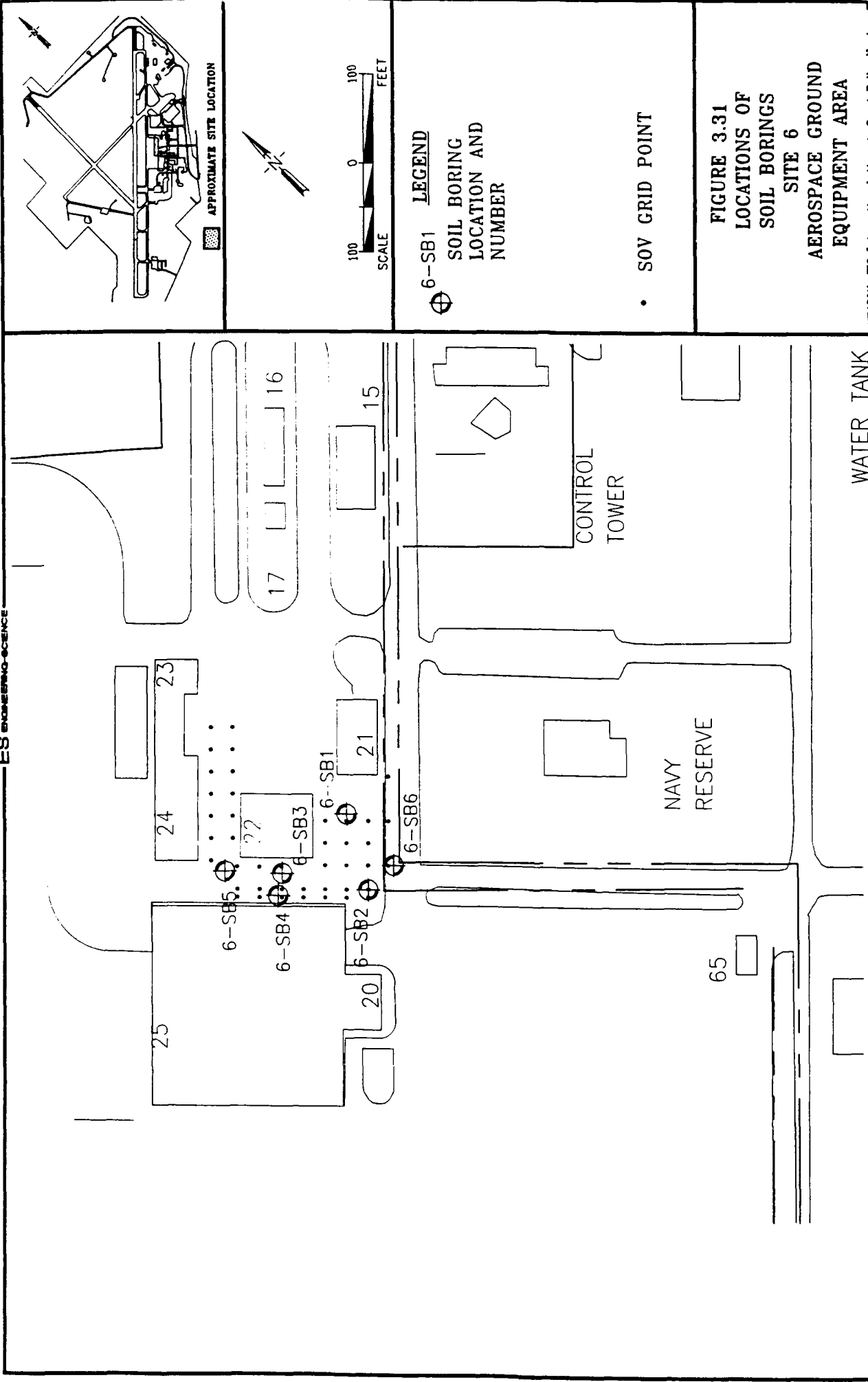


FIGURE 3.31
LOCATIONS OF
SOIL BORINGS
SITE 6
AEROSPACE GROUND
EQUIPMENT AREA

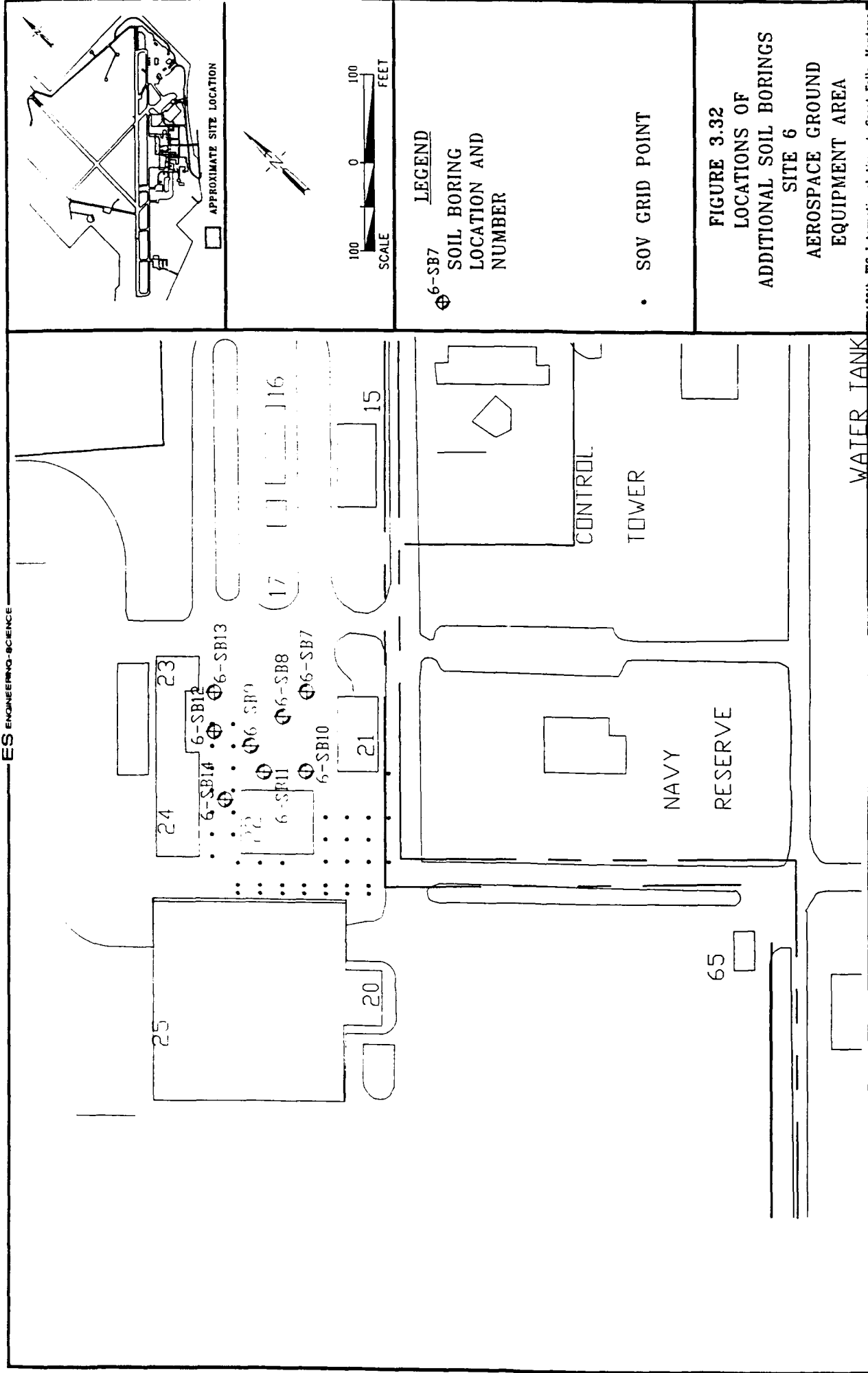


FIGURE 3.32
LOCATIONS OF
ADDITIONAL SOIL BORINGS
SITE 6
AEROSPACE GROUND
EQUIPMENT AREA

Field HNU. Each of the soil samples collected at the site was screened with an HNU. The total organic vapor readings ranged from 0 to 220 ppm with the highest readings exhibited near the dry well location at 4 to 6 feet below ground level.

Field GC. The results of the field GC screening are summarized in Table 3.38. Organic contamination was detected in borings 2, 3, and 4. Compounds identified were benzene, toluene, ethyl benzene, o-xylene, and m/p-xylene.

Piezometer Levels

Six piezometers were installed around sites 4 through 8 collectively. Groundwater elevations indicate the groundwater below the base buildings to flow to the west. The downgradient monitor well for site 6 was located just west of the site. Groundwater elevations for each of the piezometers are discussed in section 3.7.3.

Piezometer Screening

The piezometers used at site 6 were the same as those used for site 4. The results of the headspace screening are described in section 3.7.

Monitoring Well Observations

Each monitoring well installed was logged during drilling for lithology and other observations that may indicate contamination. MANG-6-MW1 was placed downgradient of the area suspected of contamination, and no observations during drilling indicated the presence of gross contamination in the borehole for the well at site 6.

3.9.2 Confirmation and Delineation Activities

Eight soil samples, two groundwater samples, two groundwater duplicates, and three sediment samples were collected at site 6 for chemical analyses.

Soil Sampling

Several volatile organics, semivolatile organics, petroleum hydrocarbons, and metals were detected in the analyses run on the soil samples. The organic compounds, and the metals detected and their respective concentrations are shown on Table 3.39 and 3.40, and selected analytes for the original site 6 study area are shown on Figure 3.33

Several volatile organics were found in the soil samples collected in the original site 6 study area: TCE (up to 4,000 $\mu\text{g/kg}$), toluene (up to 17,000 $\mu\text{g/kg}$), ethyl benzene (up to 1,600 $\mu\text{g/kg}$), m/p-xylene (up to 7,900 $\mu\text{g/kg}$), and o-xylene (up to 2,600 $\mu\text{g/kg}$).

The semivolatile organics detected in the soil samples collected in the original site 6 study area include naphthalene (up to 3,000 $\mu\text{g/kg}$), and 2-methylnaphthalene (up to 2,700 $\mu\text{g/kg}$). Bis-(2-ethylhexyl)phthalate was also detected in soil at the site. Phthalates are common laboratory and sampling contaminants.

The TPH analyses indicated some contamination at the site. The total petroleum hydrocarbon concentrations range up to 8,100 mg/kg.

Table 3.38 Organic Constituents Detected in Soil Sample with Field GC Screen
Site 6: Aerospace Ground Equipment (AGE, Bldg. 22) Area

Soil Boring	Sleeve	CLP Sample ID	Constituent
SB-1	A7	MANG-6-SB1-1.5	TCE*
	B5	MANG-6-SB1-3.5	None
SB-2	A5	MANG-6-SB2-1.5	TCE*
			Toluene
			Ethyl benzene
			m/p-Xylene
	B4		TCE*
			o-Xylene*
	C8	MANG-6-SB2-7	Toluene
			Ethyl benzene
			o-Xylene
			m/p-Xylene
SB-3	A4	MANG-6-SB3-1	**
	B7		Benzene
			TCE*
			Toluene
			Ethyl benzene
			o-Xylene*
	C7	MANG-6-SB3-5.5	**
SB-4	A4	MANG-6-SB4-5	None
	B6		None
	C8		**
SB-5	A4	MANG-6-SB5-3.5	TCE*
			o-Xylene
	B7		TCE*
			o-Xylene
SB-6	A5		None

* This compound was also present in an associated blank.

** The peaks on the GC chromatogram were off scale.

Table 3.39 Chemical Constituents Detected in Soil
Site 6: Aerospace Ground Equipment (AGE, Bldg. 22) Area
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-6 SB1-1.5	MANG-6 SB1-3.5	MANG-6 SB2-1.5	MANG-6 SB2-7	MANG-6 SB3-5.5	MANG-6 SB4-5	MANG-6 SB5-3.5	MANG-6 SB6-3.5	Health (2) Criteria
Volatile organics (µg/kg):										
Acetone	ND-157	520 D	570 D	ND	99 J	ND	ND	ND	ND	8E06
Trichloroethene	ND	ND	ND	ND	ND	4,000 J	ND	ND	ND	6.4E04
Toluene	ND-9	4 J	5 J	ND	ND	17,000 J	4,000 J	ND	ND	1.6E07
Ethyl benzene	ND	ND	ND	ND	ND	1,600 J	770 J	ND	ND	8E06
m/p-Xylene (3)	ND	ND	ND	ND	ND	7,900 J	4,200 J	ND	ND	1.6E08
o-Xylene	ND	ND	ND	ND	ND	2,600 J	2,300 J	ND	ND	1.6E08
BNA organics (µg/kg):										
Naphthalene	ND	ND	ND	ND	ND	3,000 J	2,100 J	ND	ND	3.2E05
2-Methylnaphthalene	ND	ND	ND	ND	ND	2,700 J	2,600 J	ND	ND	--
bis(2-Ethylhexyl)phthalate	ND	ND	ND	ND	130 J	ND	ND	ND	ND	5E04
Metals (mg/kg)										
Arsenic	1.9-9.9	6.2	4.5	4.4	3.4	3.2 B	2.6	2.2	2.1	80
Barium	ND-1,231	187	189	155	73	145	164	261	333	5,600
Cadmium	ND	ND	ND	ND	ND	0.41 B	ND	ND	ND	40
Chromium	8.7-22.7	12.2	10.4	12.3	7.7	18.3	8.1	9.5	11.5	8E04
Copper	3.3-19.7	18.5 *	14.4 *	12.3 *	4.2 B*	7.4	8.5	4.7 B	6.1	--
Lead	3.4-13.0	11.7	12.6	28.3	14.7	52.3 N	12 N	7.5 N	7.6 N	500
Nickel	3.6-17.6	10.4 *	ND	ND	ND	ND	11	ND	7.7 B	1,600
Selenium	ND-0.66	ND	ND	ND	ND	ND	ND	ND	ND	240
Zinc	21.6-61.3	51.1	38.5	36.8	10.1	33.7 *	35.8 *	17.7 *	15.6 *	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	12	ND	120	ND	3,300	8,100	12	52	--

320SA\AU23409\T3-39.WK1

(1) Background is the average background concentration +/- two standard deviations.

(2) Based upon soil ingestion, see section 4.

(3) Meta- and para-xylene coelute and are not distinguishable by this method.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit. For samples MANG-6-5.3-5.5 and MANG-6-5B4-5, hold time was exceeded.

The data are still usable, but should be considered estimates.

D This flag identifies a compound whose reported analytical results are calculated from a greater dilution than the primary analysis.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits.

* Duplicate analysis not within control limits.

W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.

Table 3.40 Chemical Constituents Detected in Alternate Soil Borings
Site 6: Aerospace Ground Equipment (AGE, Bldg. 22) Area

Chemical	Background (1)	MANG-6 SB7-1	MANG-6 SB7-1(D)	MANG-6 SB8-1.5	MANG-6 SB9-1	MANG-6 SB10-1.5	MANG-6 SB11-1.3	MANG-6 SB12-3.5	MANG-6 SB13-1	MANG-6 SB14-5.5	Health (2) Criteria
Volatile organics (µg/kg):											
Acetone	ND-157	ND	ND	ND	170	ND	100	200	180	66 J	8E06
Toluene	ND-9	ND	ND	ND	ND	ND	ND	ND	7	ND	1.6E07
BNA organics (µg/kg):	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Metals (mg/kg)											
Arsenic	1.9-9.9	5.9	4.5	3.6	7.2	3.8	3	4.3 S	4.8	2.4	80
Barium	ND-1,231	267	132	152	464	171	165	168	140	108	5,600
Cadmium	ND	ND	ND	ND	ND	ND	0.35 B	ND	ND	ND	40
Chromium	8.7-22.7	12.9 *	14.4 *	10.3 *	11.3 *	7.9 *	9.5 *	16.7 *	7.2 *	8.9 *	8E04
Copper	3.3-19.7	43.4	15.2	5.6	16.7	11.2	26.3	13.5	9.1	10	--
Lead	3.4-13.0	9.5	9.6	2.5 B	8.2	4.9 B	6.1	4.6 B	4.7 B	4.3 B	500
Nickel	3.6-17.6	ND	12.4	ND	7.3 B	ND	9	9.6	ND	ND	1,600
Selenium	ND-0.66	ND	ND	ND	ND	ND	0.37 BW	0.35 BW	ND	ND	240
Zinc	21.6-61.3	60.8	43.1	36.6	42.1	38.7	48.4	45.7	27.7	53.7	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	310	ND	170	650	130	13,000	16	60	ND	--

3206AVAL7240913-40WK1

(1) Background range is the average +/- two standard deviations.

(2) Based upon soil ingestion, see section 4.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

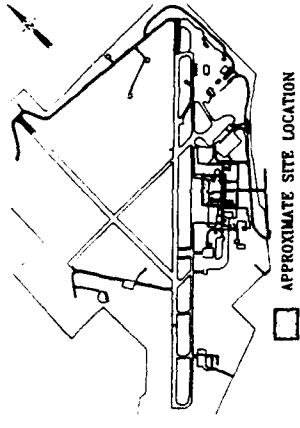
J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

* Duplicate analysis not within control limits.

W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.



6-SB1
⊕
LEGEND
SOIL BORING
LOCATION AND
NUMBER

6-MW1
⊕
MONITOR WELL LOCATION
AND NUMBER
(4-8)P1
⊙
PIEZOMETER

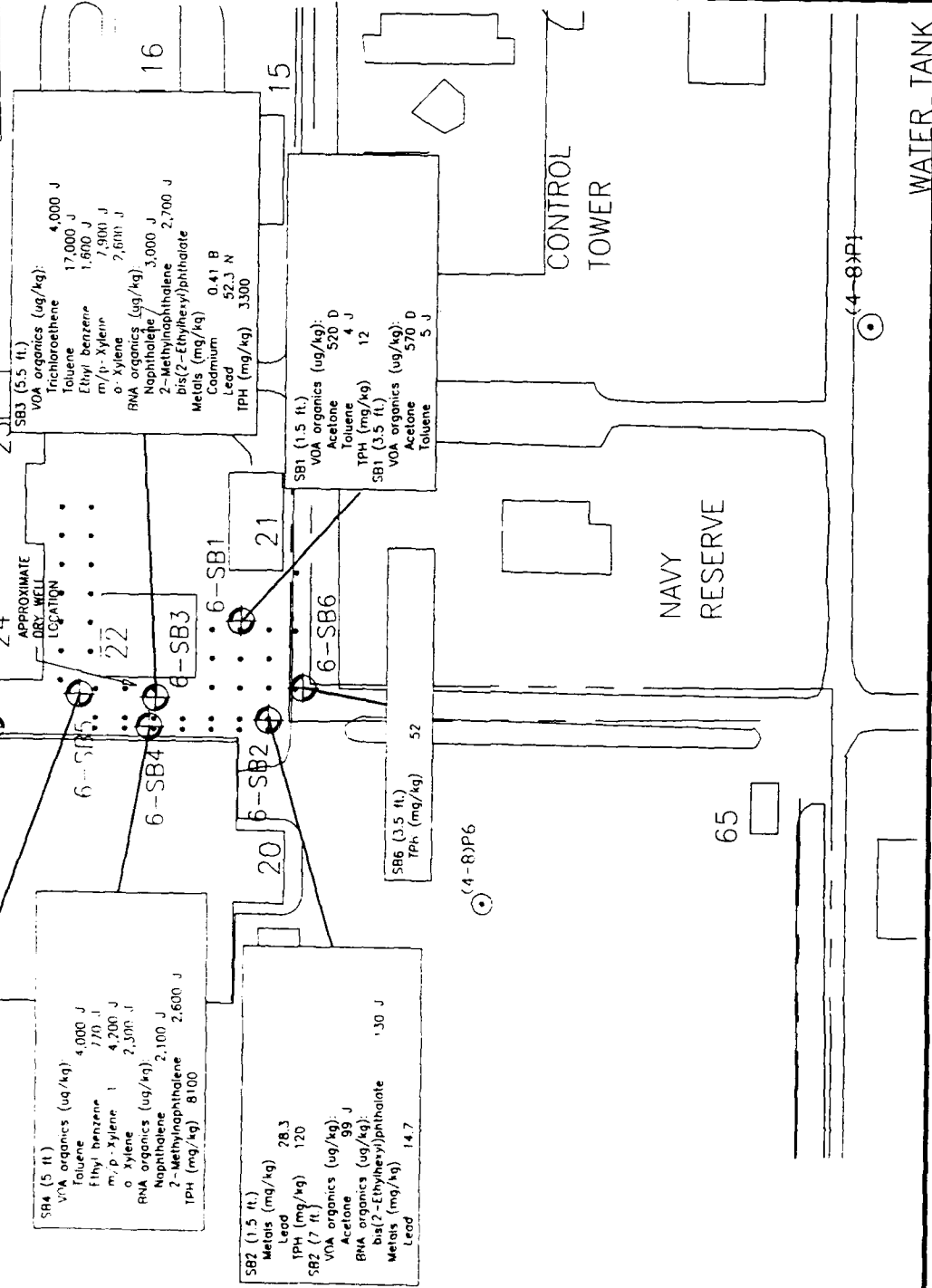
• SOV GRID POINT
NOTE: SEE ANALYTICAL SUMMARY TABLES
FOR LABORATORY QUALIFIERS

FIGURE 3.33
SELECTED ANALYTES DETECTED
IN SOIL AND GROUNDWATER
SITE 6
AEROSPACE GROUND
EQUIPMENT AREA

120th FIG International Airport, Great Falls, Montana
3-95

MW1 (SITE 6)

ROUND 1 (WITH DUPLICAT)	ROUND 2 (WITH DUPLICAT)
Volatiles organics (ug/L)	1.8
Ethyl benzene	ND
CIP semivolatile organics (ug/L):	3.3/3.4
bis (2-Ethylhexyl) phthalate	6 J / 21
Metals (ug/L):	ND
Barium	212 J / 215 J 248/250
Lead	3.8 J / 6.3 J 4.2 NJ
Zinc	15 BA / 52 J ND/9.4 BI



The majority of metals concentrations detected in the original site 6 study area were below the background levels presented in Table 3.2. The metals that were detected in the soil above background include cadmium and lead.

Few organic compounds were detected in the site 6 additional borings. Acetone was found in five borings at concentrations ranging from 66 to 200 $\mu\text{g/kg}$. Toluene was found in boring 13 at 7 $\mu\text{g/kg}$. These organics were generally within the background range determined by the background samples. A complete discussion of the determination of the background range is in section 3 of this report. There were no semivolatile organics detected.

TPH were detected in every additional boring except SB-14. The concentrations ranged from 16 to 13,000 mg/kg, with most concentrations below 650 mg/kg. Soil boring 11 had the 13,000 g/kg concentration.

Several metals were detected in the additional borings. Arsenic, barium, cadmium, chromium, copper, lead, nickel, selenium, and zinc were all found in at least one sample. As shown in Table 3.40, only cadmium and copper in boring 11 and copper in boring 7 exceeded the background range.

Sediment Sampling

Four sediment samples, including one duplicate, were collected at site 6. The locations of these samples are indicated in Figure 2.4. The results of the chemical analyses for the sediment samples are presented in Table 3.41. No semivolatile organics were detected in the sediment samples. The volatile analyses were considered invalid due to compositing.

The TPH analyses indicated high concentrations in all four sediment samples. The concentrations of TPH ranged up to 3,000 mg/kg.

The results of the metals analyses are also presented in Table 3.41. The metals that were detected in the sediment samples above background include chromium, copper, lead, mercury, nickel and zinc.

Groundwater Sampling

The results of the analyses of the groundwater sample and duplicate from well MANG-6-MW1 reveal two volatile organic compounds, one semivolatile organic compound, no petroleum hydrocarbons, and several metals. The results of the chemical analyses of the groundwater from MANG-6-MW1 is presented in Table 3.42 and selected analytes are shown in Figure 3.33.

Benzene and ethyl benzene were the only volatile organics detected in the groundwater sample collected from well MANG-6-MW1. The groundwater samples and duplicates from both rounds of sampling contained benzene at concentrations up to 6.8 $\mu\text{g/L}$. Ethyl benzene was found in the sample and duplicate from the second round of sampling only at concentrations up to 3.4 $\mu\text{g/L}$. Bis(2-ethyl-hexyl)phthalate was the only semivolatile organic detected in the groundwater at site 6. Phthalates are common laboratory and sampling contaminants. No semivolatile organics were detected during the second round of sampling.

Table 3.41 Chemical Constituents Detected in Sediment Samples
Site 6: Aerospace Ground Equipment (AGE, Bldg. 22) Area
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-6 SD1	MANG-6 SD2	MANG-6 SD2(D)	MANG-6 SD3	Health (2) Criteria
Volatile organics ($\mu\text{g/kg}$)	ND	ND R	ND R	ND R	ND R	--
BNA organics ($\mu\text{g/kg}$)	ND	ND	ND	ND	ND	--
Metals (mg/kg)						
Arsenic	1.9-9.9	6.3	4.9	5.9 S	5.3	80
Barium	ND-1,231	294	269	344	311	5,600
Cadmium	ND	5.4	6.4	6.0	5.9	40
Chromium	8.7-22.7	43.2 *	57.1 *	53.4 *	58.8 *	8E04
Copper	3.3-19.7	34.6	34.8	42.3	48.5	--
Lead	3.4-13.0	236	529	211	284	500
Mercury	ND	ND	0.061 B	0.06 B	0.061 B	24
Nickel	3.6-17.6	18.9	15.6	16.7	17.1	1,600
Selenium	ND-0.66	0.41 B	ND	ND	ND	240
Zinc	21.6-61.3	238	284	251	249	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	1,700	3,000	2,600	2,500	--

3208A\A\U23409\T3-41.WK1

(1) Background range is the average $\pm$ two standard deviations.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics

R This data is not considered valid.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

S Reported value was determined by the method of standard additions.

* Duplicate analysis not within control limits.

Table 3.42 Chemical Constituents Detected in Groundwater
Site 6: Aerospace Ground Equipment (AGE, Bldg. 22) Area
(CLP Laboratory Analysis)

Chemical	Round 1 MANG-6 MW1	Round 1 MANG-6 MW1-D	Round 2 MANG-6 MW1	Round 2 MANG-6 MW1-D	Background		ARARs (1)
					Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics ($\mu\text{g/L}$)							
Benzene	1.8	1.8	6.8	5.9	ND	ND	5
Ethyl benzene	ND	ND	3.3	3.4	ND	ND	700
CLP semivolatile organics ($\mu\text{g/L}$):							
bis(2-Ethylhexyl)phthalate	6 J	21	ND	ND	ND	ND	4
Metals ($\mu\text{g/L}$):							
Arsenic	ND	1.5 JB	ND	ND	1.1 JB	ND	50
Barium	212 J	215 J	248	250	56 JB	62.2 B	1,000
Cadmium	ND	ND	2.7 B	ND	ND	ND	10
Copper	6 BJ	ND	ND	ND	ND	ND	1,300
Lead	6.3 J	3.8 J	4.2 JN	4.2 JN	4.9 J	4.3 JN	50
Mercury	0.19 B	ND	ND	ND	ND	ND	2
Zinc	52 J*	15 JB*	9.4 JB	ND	15 JB*	9.8 JB	5,000
Total petroleum hydrocarbons (mg/L)	ND	ND	ND	1	1	ND	NA

320SA\AU23409\T3-42.WK1

(1) ARARs are proposed only. These are MCLs where available, otherwise WQC.

NA = not applicable.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

* Duplicate analysis not within control limits set by lab QA/QC.

J The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

Metals detected in groundwater samples and duplicates at site 6 were arsenic (up to 1.5 $\mu\text{g/L}$) barium (up to 250 $\mu\text{g/L}$), copper (up to 6 $\mu\text{g/L}$), lead (up to 6.3 $\mu\text{g/L}$), mercury (up to 0.19 $\mu\text{g/L}$), and zinc (up to 52 $\mu\text{g/L}$).

Comparison of Screening Results with CLP Results

There was only moderate correlation between the soil gas survey and the CLP data. The soil gas survey indicated three areas of high organic concentrations: near the fence line behind buildings 21 and 22, between buildings 20 and 22, and at the northeast corner of building 23. Soil samples taken in these locations showed only low organic concentrations near the fence line and at the northeast corner of building 23. The CLP soils data and the soil gas survey data both indicated high concentrations between building 20 and 22.

The field headspace readings of soil samples collected at site 6 for chemical analysis ranged from 0 ppm to 220 ppm. These readings compare well with the analytical results from the CLP laboratory.

The field GC data indicated that benzene, toluene, ethyl benzene, and xylenes were detected in the soil samples collected at site 6. However, the CLP analyses of the same samples did not indicate that these compounds were present. This suggests there is partial correlation between the field GC screening and the CLP analyses in determining specific compounds. However, there was some correlation between the two methods in detecting high concentrations of volatile organics.

3.9.3 Geologic and Hydrogeologic Investigation Results

The results of geologic and hydrogeologic investigation of sites 4 through 8 were evaluated as a group because the sites are close together and share subsurface characteristics. This information is presented in the first portion of section 3.7.3. Geologic and hydrogeologic information specific to site 6 is discussed below.

During the construction of MANG-6-MW1, a shallow water-bearing zone within the unconsolidated material was encountered at a depth interval of 5 to 15 feet bgl. The zone was not observed during piezometer construction or during the initial drilling of the borehole. Due to extenuating circumstances, the hole was allowed to sit overnight after drilling to a depth of 55 feet bgl. The next morning the water level was approximately 30 feet bgl, and water could be heard entering the hole from above the measured water level. Since it could not be determine at what level the water was coming in, it was decided to abandon the hole. This was accomplished by pumping a bentonite slurry from the bottom of the hole back to ground level. As the water was brought out of the hole, a small hydrocarbon layer (<0.05 feet) was observed on top of the water. All fluids and cuttings produced during drilling were contained in 55-gallon drums. No signs of contamination had been observed while drilling the borehole.

After the borehole was abandoned, a new hole was located about 10 feet west of the previous one. This hole was drilled to 17 feet bgl and allowed to sit for approximately 1 hour. After the waiting period, a depth to water of about 10 feet bgl was measured. An HNU measurement of the borehole yielded a reading of 150 ppm. The hole was then reamed to 20 feet bgl and a 6-inch-diameter, black steel surface casing was grouted into place. The casing was allowed to sit for 24 hours

after placement of the grout, to observe the integrity of the seal. After the 24-hour waiting period, water was not observed inside the casing, confirming that the zone had been sealed.

The source of the shallow water is undetermined, but is suspected to come from the numerous water leaks that have historically occurred on the base.

3.9.4 Conclusions

The results of screening activities at this site indicate soil contamination in the runoff path along the fence southeast of building 22 and in the area of the dry well between building 22 and the maintenance hangar.

Site 6 is described in section 1.3.1 as a dry well located at the AGE building. As described, the dry well received POL waste, hydraulic fluid, and solvents. In addition, small amounts of waste oils were discharged to a ditch located southeast of the AGE building. The analytical results of the soil samples collected at the site indicate high concentrations of volatile organics, semivolatile organics, and petroleum hydrocarbons in soil borings 3 and 4. Both soil borings 3 and 4 are located near the dry well, as shown in Figure 3.31. Borings 1, 2, 5, and 6 have very low concentrations of organics which indicate that the soil contamination is probably limited to the area in and near the dry well.

The analytical results of the sediment samples identified some contamination in the ditch. Since all three sample locations showed high contamination, the extent of soil contamination in the ditch has not been determined.

Analysis of groundwater samples taken from the monitoring well at the site indicates low concentrations of benzene in the round 1 sample and duplicate, and low concentrations of benzene and ethyl benzene in the round 2 sample and duplicate. Several metals above background were also detected in these samples. Contamination of groundwater cannot be attributed specifically to the dry well at site 6 because of the presence of contamination associated with the removed underground storage tanks in the area of the site and the lack of a definitive indication of non-fuel-related contamination in the groundwater at this site.

3.10 SITE 7 – DRY WELL OFF CORROSION CONTROL BUILDING (BLDG. 23)

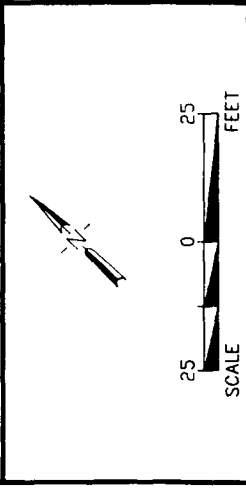
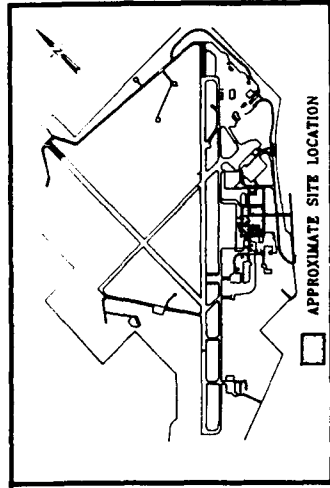
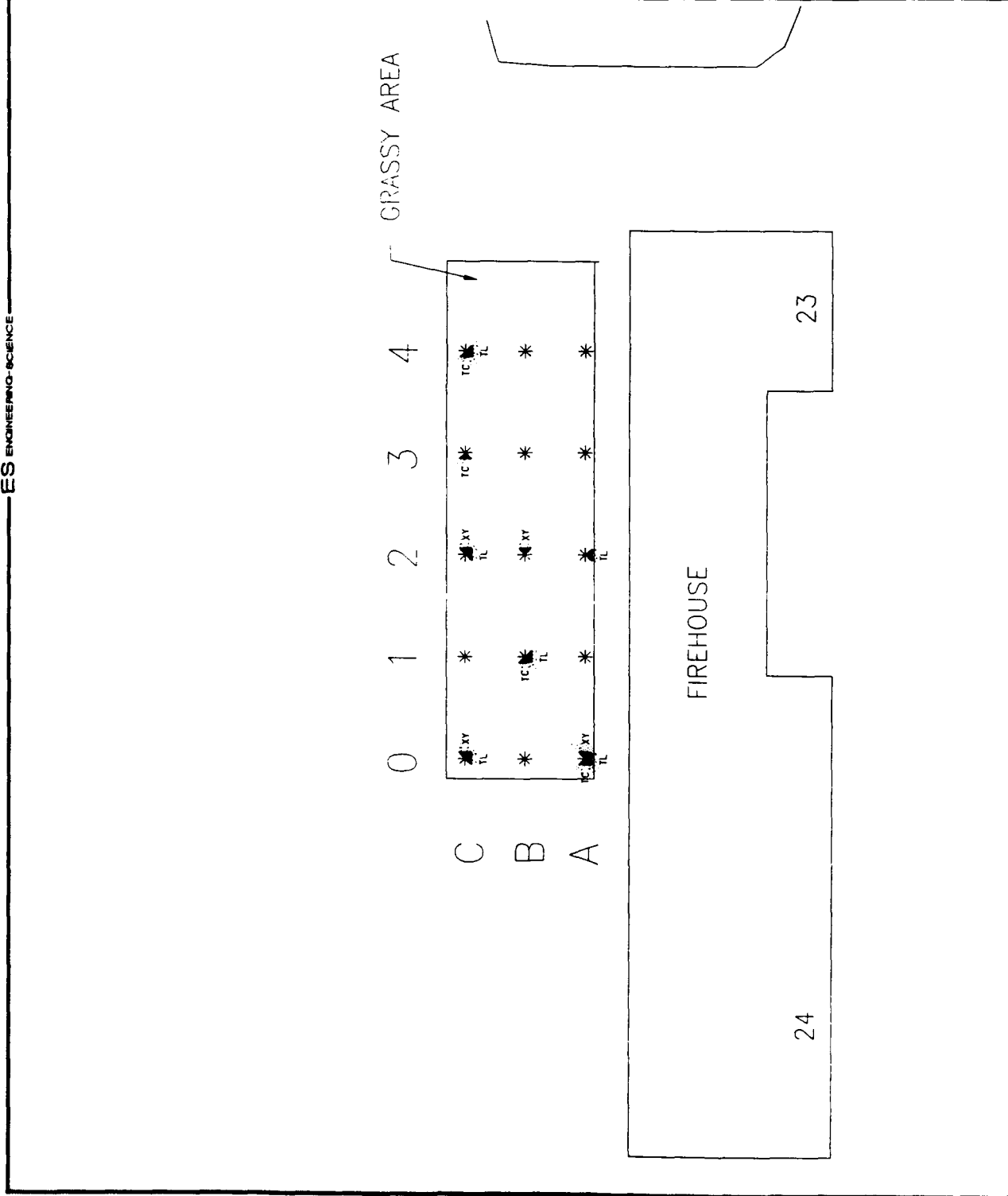
3.10.1 Screening Activity Results

Soil Gas

The results of the soil gas survey are summarized in Figure 3.34 and Table 3.43. The samples were taken on a 100-foot by 30-foot grid. The spacing between the points was 25 feet in the long direction and 15 feet in the short direction. There were few organics identified. These were 1,2-DCE, TCE, toluene, and o-xylene. The highest concentrations of these compounds tended to be near the entrance to the firehouse (sample points A0 and B1), and in the grass area.

Geophysics

A GPR survey was conducted to determine the presence and location of an abandoned dry well. Figure 3.35 shows the GPR grid and area investigated.



- LEGEND**
- ★ BENZENE DETECTED
 - ★ TCE DETECTED
 - ★ TOLUENE DETECTED
 - ★ O-XYLENE DETECTED
 - SOV GRID POINT

FIGURE 3.34
RESULTS OF
SOIL GAS SURVEY
SITE 7
DRY WELL OFF CORROSION
CONTROL BUILDING

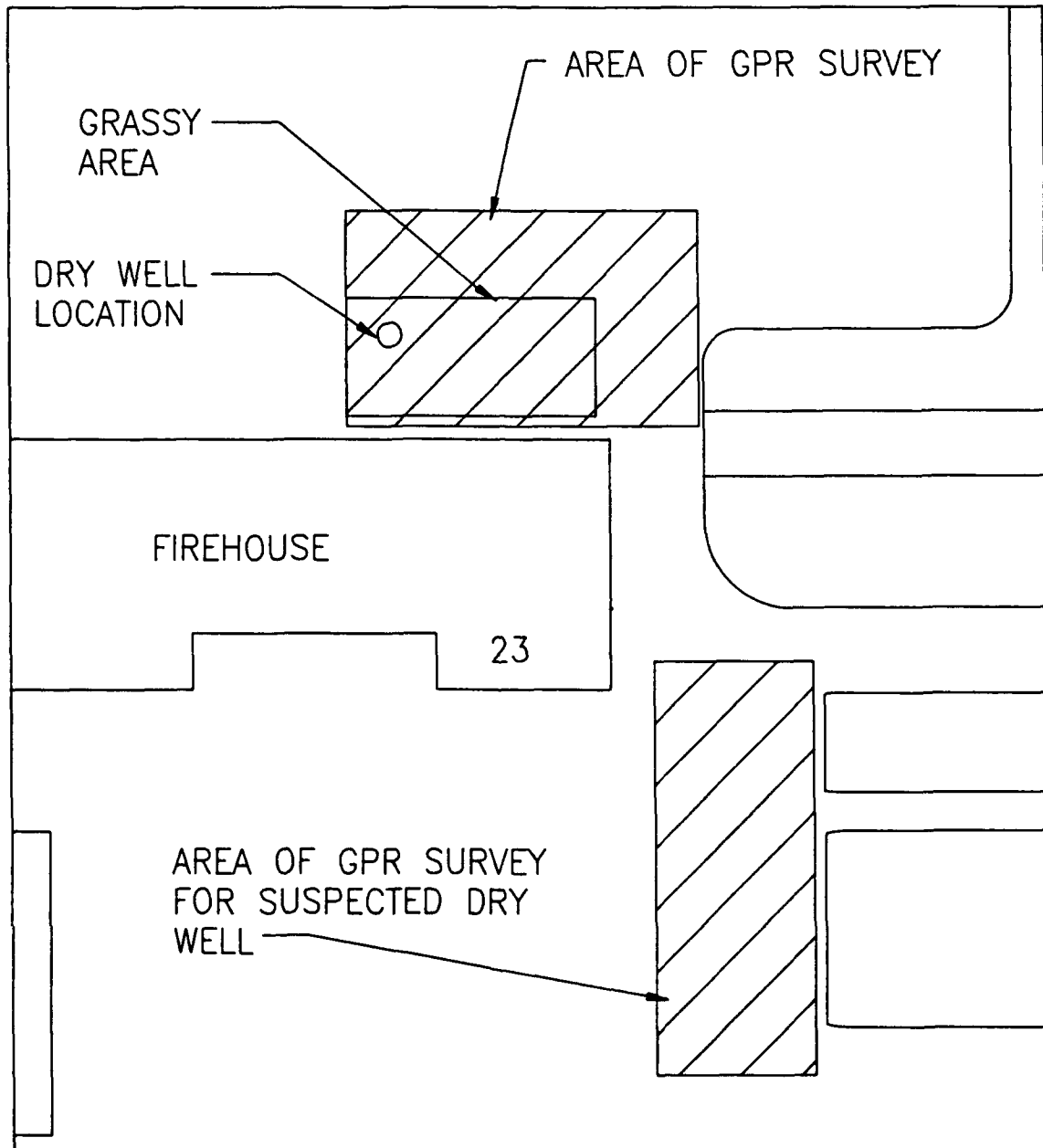
Table 3.43 Organic Constituents Detected in Soil Gas Survey
Site 7: Dry Well Off Corrosion Control Building
 (ppb by volume, GC)

Sample ID	Grid Coordinates		1,2-DCE	TCE	Toluene	o-Xylene
A0	0	0	58	130	135	147
A1	0	-25	ND	ND	ND	ND
A2	0	-50	ND	ND	16	ND
A3	0	-75	ND	ND	ND	ND
A4	0	-100	ND	ND	ND	ND
B0	15	0	ND	ND	ND	ND
B1	15	-25	ND	1,100	318	ND
B2	15	-50	ND	ND	ND	290
B3	15	-75	ND	ND	ND	ND
B4	15	-100	ND	ND	ND	ND
C0	30	0	ND	ND	88	207
C1	30	-25	ND	ND	ND	ND
C2	30	-50	ND	ND	19	37
C3	30	-75	ND	13	ND	ND
C4	30	-100	ND	6	15	ND

520SA/AU/23409/T3-43

ND = not detected

FIGURE 3.35
SITE 7
GPR SURVEY



The survey indicated the presence of a subsurface object or structure at the reported location of the dry well. A portion of the survey record showing the GPR response is presented in Figure 3.36. From this record it appears that the dry well is still in place.

Soil Borings

Description. Four soil borings were drilled and sampled at site 7. Figure 3.37 shows the locations of the soil borings for site 7. The boring depths ranged from 3 to 7 feet below grade. Staining of the sand and gravel was observed in borings SB3 and SB4. Strong petroleum odors were observed in SB3.

Field HNU. Each of the soil samples collected at the site was screened with HNU. The total organic vapor readings were non-detect except for SB3, in which the readings were as high as 350 ppm in the soil.

Field GC. The results of the field GC screening are summarized in Table 3.44. Other than TCE and o-xylene, which were also found in the blanks, no organics were found in borings 1, 2, and 4. Boring 3 samples contained moderate to high concentrations of benzene, toluene, and m/p-xylene, as evidenced by the off-scale results for sample C6.

Piezometer Levels

Six piezometers were installed around sites 4 through 8 collectively. Groundwater elevations indicate groundwater flow below the base buildings to the west. The downgradient monitor well for site 7 was located just west of the site. Groundwater elevations for each of the piezometers are discussed in section 3.7.3.

Piezometer Screening

The piezometers used at site 7 were the same as those used for site 4. The results of the headspace screening are described in section 3.7.

Monitoring Well Observations

Each monitoring well installed was logged during drilling for lithology and other observations that may indicate contamination. MANG-7-MW1 was placed downgradient of the area suspected of contamination and no observations during drilling indicated the presence of gross contamination in the borehole for the well at site 7.

3.10.2 Confirmation and Delineation Activities

Five soil samples and two groundwater samples were collected at site 7 for chemical analyses.

Soil Sampling

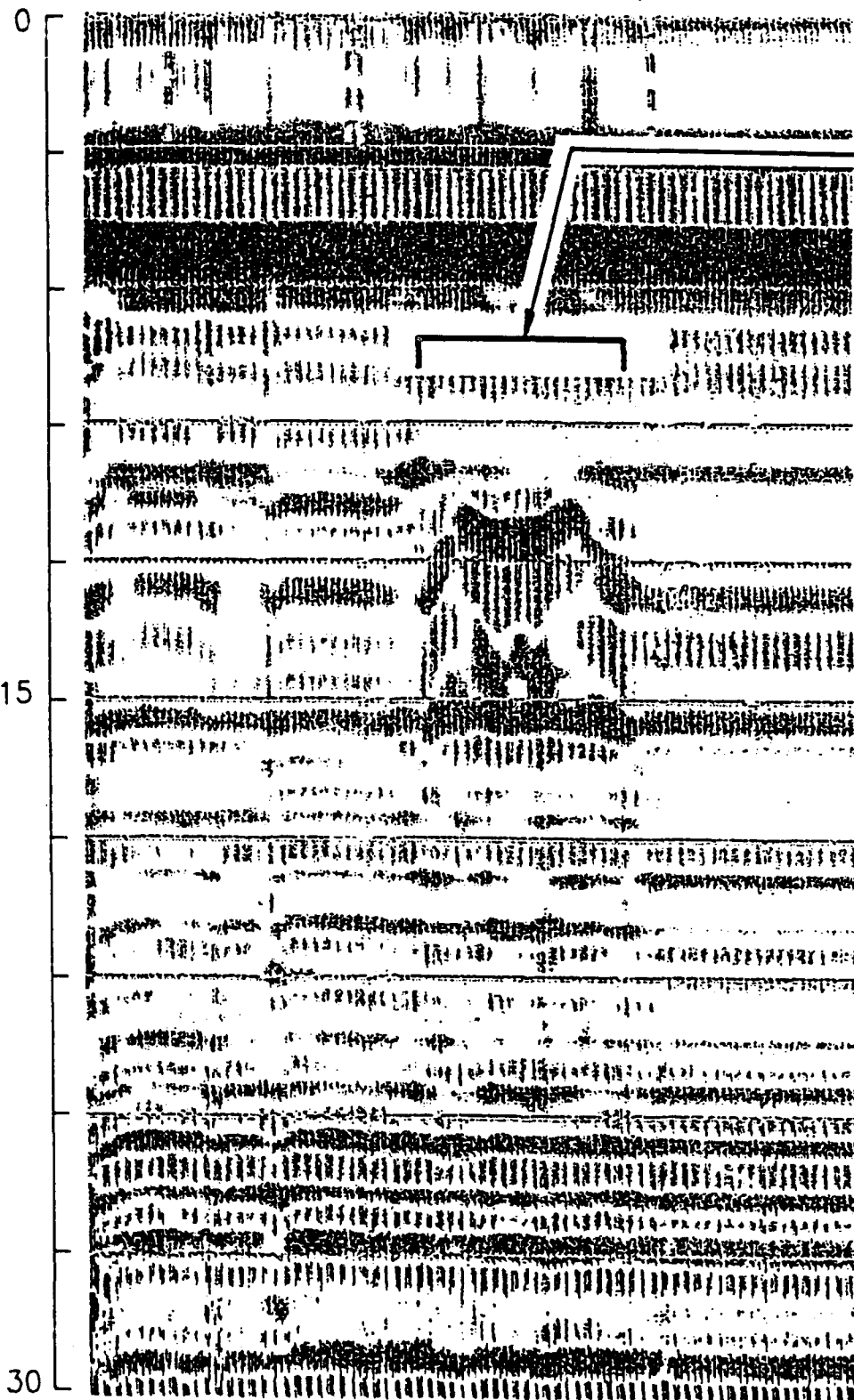
Several volatile organics, semivolatile organics, petroleum hydrocarbons, and metals were detected in the analyses run on the soil samples. The organic compounds and the metals detected and their respective concentrations are shown on Table 3.45, and selected analytes are shown on Figure 3.38.

FIGURE 3.36 GPR RECORD OF SITE 7 DRY WELL LOCATION

HORIZONTAL DISTANCE, FEET

0 5

TWO-WAY TRAVELTIME, NANoseconds



AREA OF
SUBSURFACE
SOIL
DISTURBANCE

3-105

120th FIG International Airport, Great Falls, Montana

GRASSY
AREA

7-MW1

7-SB1

7-SB4

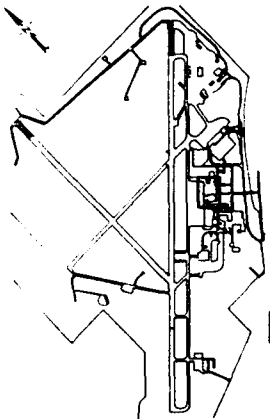
7-SB2
7-SB3

FIREHOUSE

BLDG. 23

BLDG. 24

17



APPROXIMATE SITE LOCATION



LEGEND

7-SB1 SOIL BORING
LOCATION AND
NUMBER

7-MW1 MONITOR WELL
LOCATION AND
NUMBER

FIGURE 3.37
LOCATIONS OF
SOIL BORINGS
SITE 7
DRY WELL OFF CORROSION
CONTROL BUILDING

**Table 3.44 Organic Constituents Detected in Soil Sample with Field GC Screen
Site 7: Dry Well Off Corrosion Control Building**

Soil Boring	Sleeve	CLP Sample ID	Constituent
SB-1	A6	MANG-7-SB1-1.5	TCE*
	B7		TCE*
SB-2	A4	MANG-7-SB2-1	TCE*
	B7		None
SB-3	A5	MANG-7-SB3-3.5	Benzene
			TCE*
			Toluene
	B5	MANG-7-SB3-5.5	Benzene
			Toluene
			m/p-Xylene
SB-4	C6	MANG-7-SB3-5.5	**
	D7		Toluene
		MANG-7-SB4-5	o-Xylene*
			m/p-Xylene
	A5		TCE*
	B5		TCE*
	C8		o-Xylene*
			TCE*

* This compound was also present in an associated blank.

** The peaks on the GC chromatogram were off scale.

Table 3.45 Chemical Constituents Detected in Soil
Site 7: Dry Well Off Corrosion Control Building
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-7 SB1-1.5	MANG-7 SB2-1	MANG-7 SB3-3.5	MANG-7 SB3-5.5	MANG-7 SB4-5	Health (2) Criteria
Volatile organics (µg/kg):							
Acetone	ND-157	ND	ND	ND	ND	J	8E06
Benzene	ND	ND	ND	2,600 J	ND	ND	2.4E04
Toluene	ND-9	ND	ND	76,000	140,000	ND	1.6E07
Ethyl benzene	ND	ND	ND	13,000	24,000	ND	8E06
m/p-Xylene (3)	ND	ND	ND	78,000	110,000	ND	1.6E08
o-Xylene	ND	ND	ND	41,000	49,000	ND	1.6E08
BNA organics (µg/kg):							
Naphthalene	ND	ND	ND	22,000	13,000	ND	3.2E05
2-Methylnaphthalene	ND	ND	ND	42,000	27,000	ND	--
Di-n-butylphthalate	ND	ND	ND	ND	ND	140 J	8E06
bis(2-Ethylhexyl)phthalate	ND	ND	ND	5,400	2,800 J	ND	5E04
Metals (mg/kg):							
Arsenic	1.9-9.9	2.7	4.5	4.6	5.8	6.2	80
Barium	ND-1,231	250	178	257	253	11	5,600
Chromium	8.7-22.7	9.7	16.5	15.7	12.3	7.9	8E04
Copper	3.3-19.7	19	15.3	17 *	17 *	17.1 *	--
Lead	3.4-13.0	8 N	10.7 N	443	167	9.9	500
Nickel	3.6-17.6	ND	10.1	10.5	7.8	ND	1,600
Selenium	ND-0.66	ND	ND	0.6 B	0.42 BW	0.37 B	240
Zinc	21.6-61.3	30.4 *	43.2 *	158 *	116 *	39.6 *	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	34	17	19,000	14,000	44	--

320SA\AU23409\T3-45.WK1

(1) Background range is the average +/- two standard deviations.

(2) Based upon soil ingestion, see section 4.

(3) Meta- and para-xylene coelute and are not distinguishable by this method.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

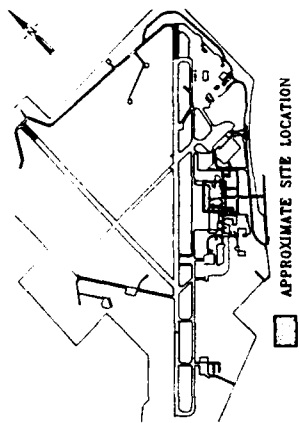
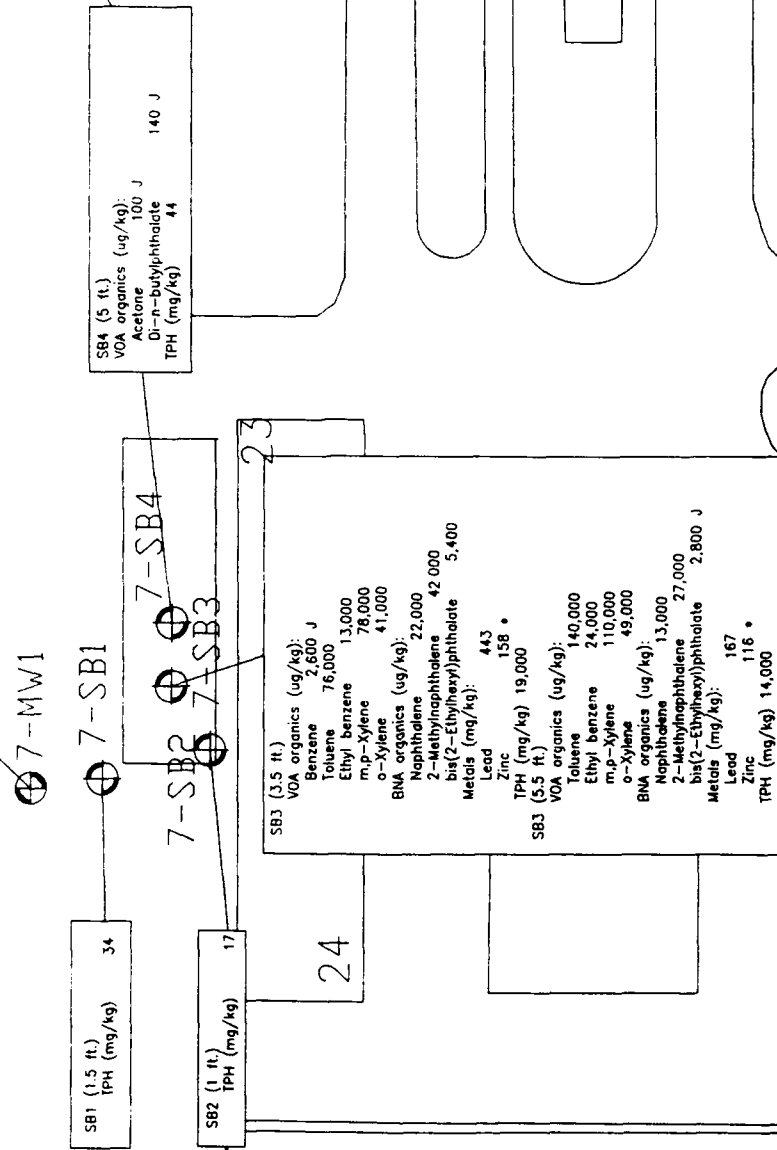
B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

* Duplicate analysis not within control limits set by lab QA/QC.

W Postdigestion spike for furnace AA analysis out of control limits (85 to 115%), while sample absorbance is less than 50% of spike absorbance.

MW1 (SITE 7)	ROUND 1	ROUND 2
GC Volatile organics (ug/l):		
Benzene	11	4.1
Ethyl benzene	160	27.5
Xylenes (total)	500	240
CLP semivolatile organics (ug/L):		
Naphthalene	24	ND
2-Methylnaphthalene	11 J	ND
Metals (ug/L):		
Barium	95	145 B
Zinc	30 J	14 BU



LEGEND

⊕ 7-SB1 SOIL BORING LOCATION AND NUMBER

⊕ 7-MW1 MONITOR WELL LOCATION AND NUMBER

NOTE: SEE ANALYTICAL SUMMARY TABLES FOR LABORATORY QUALIFIERS

FIGURE 3.38
SELECTED ANALYTES DETECTED
IN SOIL AND GROUNDWATER
SITE 7
DRY WELL OFF CORROSION
CONTROL BUILDING

The volatile organics found in the soil samples collected at site 7 include acetone (up to 100 $\mu\text{g/kg}$), benzene (up to 2,600 $\mu\text{g/kg}$), toluene (up to 140,000 $\mu\text{g/kg}$), ethyl benzene (up to 24,000 $\mu\text{g/kg}$), m/p-xylene (up to 110,000 $\mu\text{g/kg}$), and o-xylene (up to 49,000 $\mu\text{g/kg}$). Acetone is a common laboratory and sampling contaminant.

Semivolatile organics were detected in the soil sample collected at MANG-7-SB3-3.5 and SB3-5.5. These compounds include naphthalene (up to 22,000 $\mu\text{g/kg}$), 2-methylnaphthalene (up to 42,000 $\mu\text{g/kg}$) and bis(2-ethylhexyl)phthalate (up to 5,400 $\mu\text{g/kg}$). Phthalates are common laboratory and sampling contaminants.

The TPH analyses indicated some contamination at the site. The total petroleum hydrocarbon concentrations ranged up to 19,000 mg/kg.

The majority of metals concentrations detected at site 7 were below the background levels presented in Table 3.2. The metals detected in the soil above background levels were lead and zinc.

Groundwater Sampling

The results of the analyses of the groundwater samples collected from well MANG-7-MW1 reveal some volatile and semivolatile organic compounds, no petroleum hydrocarbons, and several metals. These analytical results are presented in Table 3.46, and selected analytes are shown in Figure 3.38.

Volatile organics detected in the groundwater from both rounds of sampling at site 7 are benzene (up to 11 $\mu\text{g/L}$), ethyl benzene (up to 160 $\mu\text{g/L}$), and xylenes (up to 500 $\mu\text{g/L}$). The semivolatile organics detected are naphthalene (up to 24 $\mu\text{g/L}$), 2-methylnaphthalene (up to 11 $\mu\text{g/L}$), and 2,4-dimethylphenol (up to 2 $\mu\text{g/L}$).

Metals and their respective concentrations detected in groundwater at site 7 are arsenic (up to 1.5 $\mu\text{g/L}$), barium (up to 145 $\mu\text{g/L}$), lead (up to 4.7 $\mu\text{g/L}$), and zinc (up to 30 $\mu\text{g/L}$).

Comparison of Screening Results with CLP Results

There was good correlation between the soil gas survey and the CLP data. The soil gas survey indicated high organic concentrations near SB3, and little organic contamination elsewhere. This was confirmed by the CLP data, since only SB3 had high concentrations of organic contaminants.

The field headspace readings of soil samples collected for laboratory analysis at site 7 ranged from 0 ppm to 350 ppm. These readings compare well with the analytical results from the CLP laboratory.

The field GC data from soil boring 3 indicated that benzene, toluene, and xylenes were detected. There is good correlation between the GC screening and the CLP analytical results for soil boring 3 since both indicate high concentrations of volatile organics. Trichloroethene was identified in the GC screening but was not confirmed with the CLP analysis.

**Table 3.46 Chemical Constituents Detected in Groundwater
Site 7: Dry Well Off Corrosion Control Building
(CLP Laboratory Analysis)**

Chemical	Round 1 MANG-7 MW1	Round 2 MANG-7 MW1	Background		ARARs
			Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics ($\mu\text{g/L}$):					
Benzene	11	4.1	ND	ND	5
Ethyl benzene	160	27.5	ND	ND	700
Xylenes (total)	500	240	ND	ND	10,000
CLP semivolatile organics ($\mu\text{g/L}$):					
Naphthalene	24	ND	ND	ND	--
2-Methylnaphthalene	11 J	ND	ND	ND	--
2,4-Dimethylphenol	ND	2 J	ND	ND	--
Metals ($\mu\text{g/L}$):					
Arsenic	1.5 JB	ND	1.1 JB	ND	50
Barium	95 JB	145 B	56 JB	62.2 B	1,000
Lead	4.7 J	4.3 JN	4.9 J	4.3 JN	50
Zinc	30 J*	14 JB	15 JB*	9.8 JB	5,000
Total petroleum hydrocarbons (mg/L)	ND	ND	1	ND	NA

320SA\AU23409\T3-46.WK1

NA = not applicable.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

Organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

***** Duplicate analysis not within control limits set by lab QA/QC.

J The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.

3.10.3 Geologic and Hydrogeologic Investigation Results

The results of geologic and hydrogeologic investigation of sites 4 through 8 were evaluated as a group because the sites are close together and share subsurface characteristics. This information is presented in the first portion of section 3.7.3. Geologic and hydrogeologic information specific to site 7 is discussed below.

During the construction of MANG-7-MW1, a shallow water-bearing zone was encountered at a depth interval of 5 to 15 feet bgl. The zone is believed to be associated with the zone encountered at site 6. The hole was cored to 20 feet bgl and allowed to sit for approximately 1 hour. After the waiting period, a depth to water of 17.5 feet bgl was measured. An HNU measurement of the borehole yielded a reading of 3 ppm. The hole was then reamed to 20 feet bgl, and a 6-inch-diameter, black steel surface casing was grouted into place. The casing was allowed to sit for 24 hours after placement of the grout to observe the integrity of the seal. After the 24-hour waiting period, water was not observed inside the casing, confirming that the zone had been sealed.

The source of the shallow water is undetermined, but is suspected to come from the numerous water leaks that have historically occurred on the base.

3.10.4 Conclusions

The results of screening activities at this site indicate significant contamination in the area near the entrance to the fire house (building 23). Significant soil contamination is indicated in data from both HNU screening and field GC screening of samples from soil boring SB3, which is located adjacent to the dry well.

Site 7 is a dry well located in front of the building 23, as described in section 1.3.1. The analytical results show some contamination at the site. The sample collected at soil boring 3 shows high concentrations of organics. Soil boring 3 is located adjacent to the dry well, as shown on Figure 3.37. The compounds detected are those commonly associated with fuels. Since the concentrations are significantly lower in the other soil borings, the soil contamination is apparently limited to the area near the dry well.

Analysis of groundwater samples taken from the monitoring well at the site indicates significant levels of benzene, ethyl benzene, and total xylene in both round 1 and round 2 samples, along with levels above background for some metals. Some semivolatile organics were detected in the round 1 sample, but the round 2 sample failed to confirm the presence of semivolatiles in groundwater at the site. As with site 6, contamination of groundwater cannot be definitely attributed to the dry well at site 7 because of the presence of contamination associated with removed underground storage tank upgradient of site 7 and the lack of a definitive indication of non-fuel-related contamination in the groundwater at this site.

3.11 SITE 8 - DRY WELL OFF COMPOSITE MAINTENANCE BUILDING (BLDG. 32)

3.11.1 Screening Activity Results

Soil Gas

The results of the soil gas survey are summarized in Figure 3.39 and Table 3.47. The samples were collected on a 60-foot by 150-foot grid. The distances between grid points were 20 feet perpendicular and 25 feet parallel to building 30. The soil gas survey detected a row of high organic contamination between buildings 30 and 32 (sample points A4 and A5). Compounds identified in the soil gas were 1,1-DCE, 1,2-DCE, TCE, benzene, toluene, and o-xylene. Several of these points resulted in chromatograms which were off scale.

Geophysics

A GPR survey was conducted to determine the presence and location of an abandoned dry well. Figure 3.40 shows the GPR grid and area investigated.

The survey indicated the presence of an area of disturbed soil beneath the asphalt. From the size and character of the disturbed area, it appears that the dry well had been removed and backfilled. Figure 3.41 presents a portion of the survey record showing the GPR response in the vicinity of the dry well location.

Soil Borings

Description. Five soil borings plus one duplicate were drilled and sampled at site 8. Figure 3.42 shows the locations of the soil borings for site 8. The boring depths ranged from 3 to 5 feet below grade. Staining of the soil was observed in borings 1, 2, and 4 at the surface and at 4 feet below grade in boring 2.

Field HNU. Each of the soil samples collected at the site were screened with an HNU. The total organic vapor readings ranged from 0 to 30 ppm, with the highest readings in borings SB1 duplicate, 4, and 5.

Field GC. The results of the field GC screening are summarized in Table 3.48. The only boring to show high concentrations of organics was SB1. Compounds identified as present in the soil were benzene, toluene, ethyl benzene, and m/p-xylene.

Piezometer Levels

Six piezometers were installed around sites 4 through 8 collectively. Groundwater elevations indicate groundwater flow below the site to the west-northwest. The downgradient monitor well for site 8 was located just west of the site on the west side of the engine shop. Groundwater elevations for each of the piezometers are discussed in section 3.7.3.

Piezometer Screening

The piezometers used at site 8 were the same as those used for site 4. The results of the headspace screening are described in section 3.7.

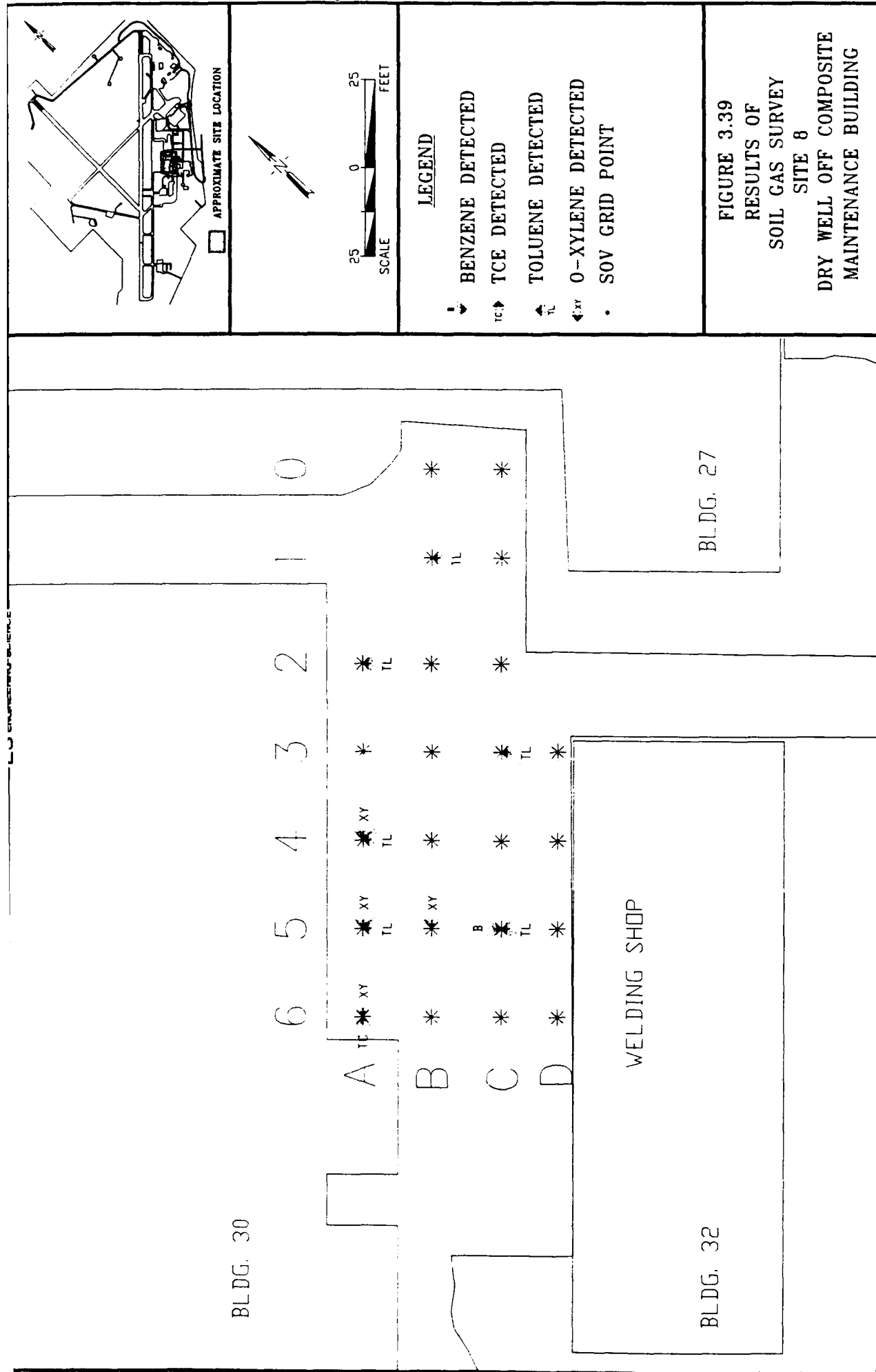


Table 3.47 Organic Constituents Detected in Soil Gas Survey
Site 8: Dry Well Off Composite Maintenance Building (Bldg. 32)
(ppb by volume)

Sample ID	Grid Coordinates		1,1-DCE	1,2-DCE	Benzene	TCE	Toluene	o-Xylene
A2	0	-50	0	0	0	0	8	0
A3	0	-75	0	0	0	0	0	0
A4	0	-100	23	140	0	0	240	620
A5	0	-125	12,000	160,000	0	0	***	680,000
A6	0	-150	0	23	0	21	0	71
B0	20	0	0	0	0	0	0	0
B1	20	-25	0	0	0	0	44	0
B2	20	-50	0	0	0	0	0	0
B3	20	-75	0	0	0	0	0	0
B5	20	-125	0	0	0	0	0	2,000
C0	40	0	0	0	0	0	0	0
C1	40	-25	0	0	0	0	0	0
C2	40	-50	0	0	0	0	0	0
C3	40	-75	0	0	0	0	9	0
C4	40	-100	0	0	0	0	0	0
C5	40	-125	0	0	130	0	***	0
C6	40	-150	0	0	0	0	0	0
D3	60	-75	0	0	0	0	0	0
D4	60	-100	0	0	0	0	0	0
D5	60	-125	0	0	0	0	0	0
D6	60	-150	0	0	0	0	0	0

3208A\AU23409\T3-47.WRI

ND= not detected

***Too high to quantify

FIGURE 3.40
SITE 8
GPR SURVEY

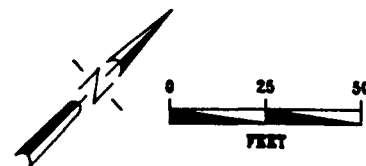
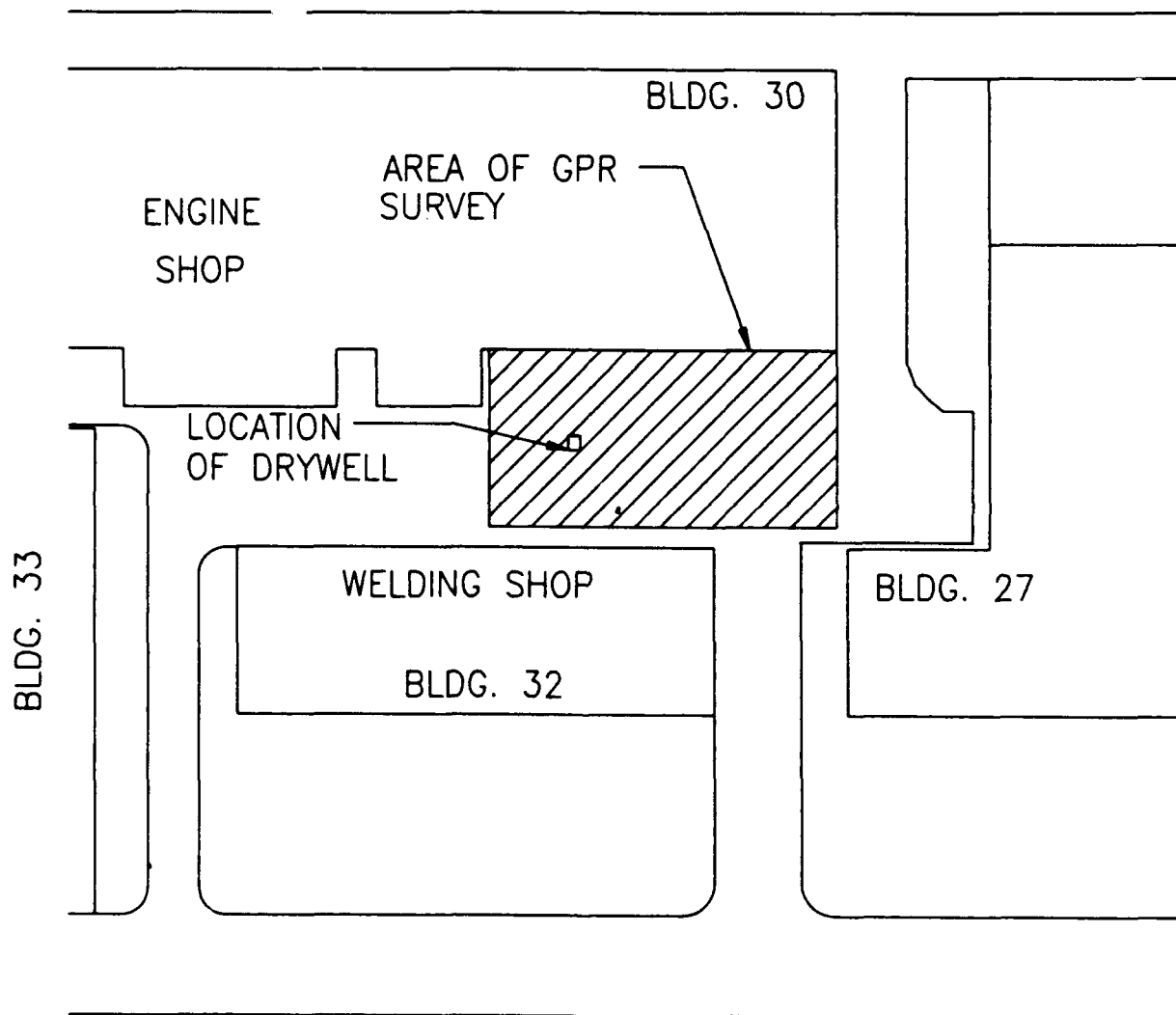
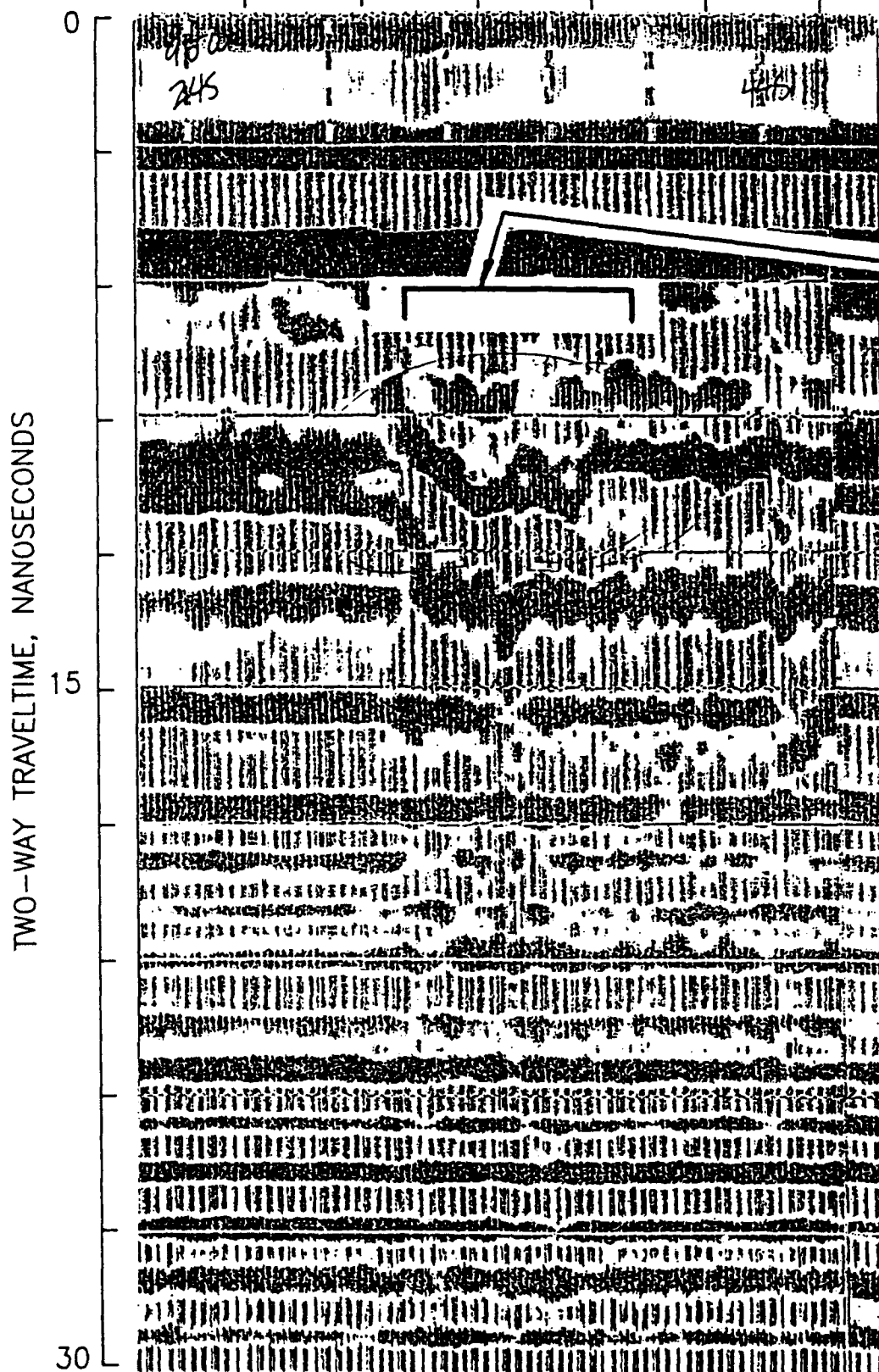
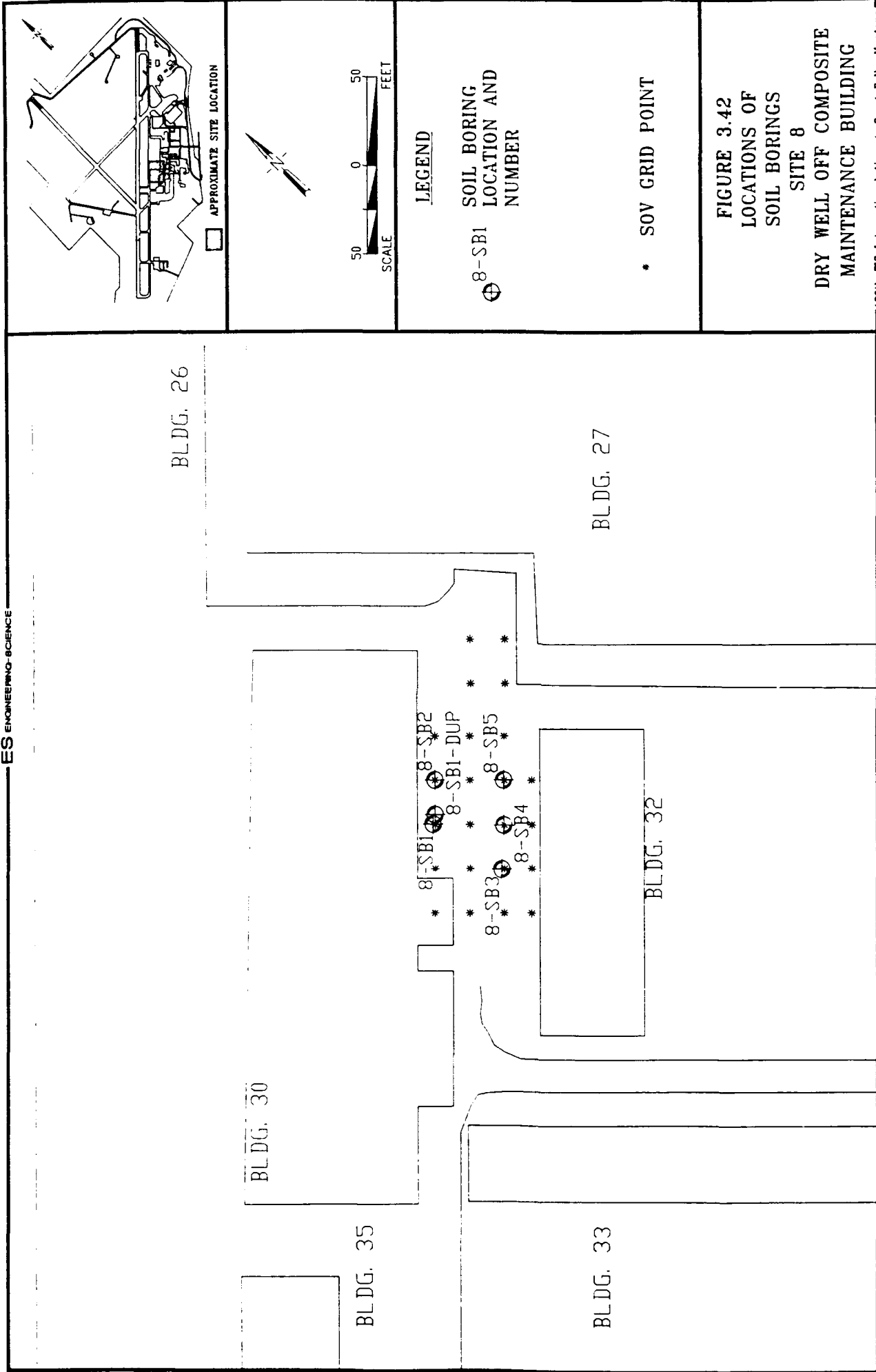


FIGURE 3.41
GPR RECORD OF SITE 8
DRY WELL LOCATION

HORIZONTAL DISTANCE, FEET
(GRID LOCATION ALONG 95 WEST GRID LINE)
24 28 32 36 40 44





SB-8A

Table 3.48 Organic Constituents Detected in Soil Sample with Field GC Screen
Site 8: Dry Well Off Composite Maintenance Building (Bldg. 32)

Soil Boring	Sleeve	CLP Sample ID	Constituent
SB-1	A5	MANG-8-SB1-1.5	Benzene Toluene Ethyl benzene o-Xylene*
	B8		Benzene Toluene Ethyl benzene o-Xylene m/p-Xylene
SB-1 dup	A5		Benzene Toluene m/p-Xylene*
	B8		Benzene Toluene Ethyl benzene o-Xylene*
SB-2	A4	MANG-8-SB2-3	TCE* o-Xylene
	B5 C7		TCE* None
SB-3	A4	MANG-8-SB3-3	TCE* o-Xylene*
	B5 C7		TCE* TCE*
SB-4	A5	MANG-8-SB4-1.5	TCE* o-Xylene*
	B6		TCE* o-Xylene*
	C7	MANG-8-SB4-5.5	TCE*
SB-5	A4	MANG-8-SB5-1	TCE*
	B5		TCE*
	C7	MANG-8-SB5-5.5	TCE* o-Xylene*

* This compound was also present in an associated blank.

Monitoring Well Observations

Each monitoring well installed was logged during drilling for lithology and other observations that may indicate contamination. MANG-8-MW1 was placed downgradient of the area suspected of contamination, and no observations during drilling indicated the presence of gross contamination in the borehole for the well at site 8.

3.11.2 Confirmation and Delineation Activities

Eight soil samples and two groundwater samples were collected at site 8 for chemical analyses.

Soil Sampling

Several volatile organics, semivolatile organics, petroleum hydrocarbons, and metals were detected in the analyses run on the soil samples. The organic compounds and the metals detected and their respective concentrations are shown in Table 3.49 and selected analytes are shown on Figure 3.43.

The volatile organics that were found in the soil sample collected at the site include acetone (up to 95 $\mu\text{g/kg}$), ethyl benzene (up to 8 $\mu\text{g/kg}$), toluene (up to 46 $\mu\text{g/kg}$), m/p-xylene (up to 14 $\mu\text{g/kg}$), and o-xylene (up to 10 $\mu\text{g/kg}$), trichloroethene (up to 260 $\mu\text{g/kg}$), chlorobenzene (up to 35 $\mu\text{g/kg}$), 1,2/1,4-dichlorobenzene (up to 180 $\mu\text{g/kg}$), and trans-1,2-dichloroethene (up to 8 $\mu\text{g/kg}$). Acetone is a common laboratory and sampling contaminant.

The analysis for semivolatile organics revealed only one compound. The sample collected at MANG-8-SB4-1.5 contained 1,2-dichlorobenzene at a concentration of 240 $\mu\text{g/kg}$.

The TPH analyses indicated some contamination at the site. Total petroleum hydrocarbon concentrations range up to 140 mg/kg.

The majority of the metals concentrations detected at site 8 were below the background levels presented in Table 3.2. The metals that were detected in the soil above background levels include arsenic, copper, and lead.

Groundwater Sampling

The results of the analyses of the groundwater from well MANG-8-MW1 reveal the presence of some volatile organic and semivolatile organic compounds, some petroleum hydrocarbons, and several metals. The results of the chemical analyses of the groundwater from MANG-8-MW1 are presented in Table 3.50, and selected analytes are shown in Figure 3.43.

Volatile organics detected in the groundwater during two rounds of sampling at site 8 are chloroform (up to 2.3 $\mu\text{g/L}$), 1,1-dichloroethane (up to 5 $\mu\text{g/L}$), 1,2-dichloroethene (up to 160 $\mu\text{g/L}$), 1,1,1-trichloroethane, tetrachloroethene (up to 4.5 $\mu\text{g/L}$), and trichloroethene (up to 18.4 $\mu\text{g/L}$). Chloroform, 1,1-dichloroethane, and 1,1,1-trichloroethane were not detected in round one samples. The only semivolatile organic detected in the groundwater at site 8 was bis(2-ethyl-hexyl)phthalate. Phthalates are common laboratory and sampling contaminants.

Table 3.49 Chemical Constituents Detected in Soil
Site 8: Dry Well Off Composite Maintenance Building (Bldg. 32)
(CLP Laboratory Analysis)

Chemical	Background (1)	MANG-8 SB1-1.5	MANG-8 SB2-3	MANG-8 SB3-3	MANG-8 SB4-1.5	MANG-8 SB4-5.5	MANG-8 SB5-1	MANG-8 SB5-5.5	MANG-8 SB6-1.5	Health (2) Criteria
Volatile organics (µg/kg):										
Acetone	ND-157	95 J	140	ND	ND	120	ND	24 J	56 J	8E06
trans-1,2-Dichloroethene	ND	ND	ND	ND	ND	ND	ND	ND	8	1.6E06
Trichloroethene	ND	ND	ND	4 J	260	ND	ND	ND	ND	6.4E04
Toluene	ND-9	29	ND	ND	6	ND	ND	ND	46	1.6E07
Chlorobenzene	ND	ND	ND	ND	35	ND	ND	ND	ND	1.6E06
Ethyl benzene	ND	ND	ND	ND	ND	ND	ND	ND	8	8E06
m/p-Xylene (3)	ND	11	ND	ND	ND	ND	ND	ND	14	1.6E08
o-Xylene	ND	10	ND	ND	ND	ND	ND	ND	9	1.6E08
1,2/1,4-Dichlorobenzene	ND	ND	ND	ND	180	ND	ND	ND	ND	2.4E04
BNA organics (µg/kg):										
1,2-Dichlorobenzene	ND	ND	ND	ND	240 J	ND	ND	ND	ND	7.2E06
Metals (mg/kg):										
Arsenic	1.9-9.9	6.3	7.1	22.2	7.4	3.2	3.2	3.5	7.3	80
Barium	ND-1,231	182	302	119	223	151	73.4	88.5	187	5,600
Chromium	8.7-22.7	9.4	12.5	10.5	14	15.6	8.9	12.6	14.6	8E04
Copper	3.3-19.7	12.6	17.2	6	19.8	7.4	5.2	6.3	14.2	--
Lead	3.4-13.0	11.4 N	13.7 N	12.3 N	14.9 N	7.5 N	7.4 N	8.9 N	12.9 N	500
Nickel	3.6-17.6	7.5 B	8.5	ND	ND	7.8	ND	ND	7.6 B	1,600
Selenium	ND-0.66	ND	ND	0.32 B	ND	0.35 B	ND	ND	ND	240
Zinc	21.6-61.3	39.2 *	46.3 *	20.2 *	48.3 *	37.7 *	26 *	42.9 *	45.4 *	1.6E04
Total petroleum hydrocarbons (mg/kg)	ND	140	26	ND	ND	ND	ND	ND	22	--

3208A1D2549T3-49 WK1

(1) Background range is the average +/- two standard deviations.

(2) Based upon soil ingestion, see section 4.

(3) Meta- and para-xylene coelute and are not distinguishable by this method.

ND = not detected.

Data qualifiers follow the data. The qualifiers are:

VOA and BNA organics:

J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit.

Metals:

B Reported value is less than reporting limit but greater than the instrument detection limit.

N Spiked sample recovery not within control limits set by lab QA/QC.

* Duplicate analysis not within control limits set by lab QA/QC.

Table 3.50 Chemical Constituents Detected in Groundwater
Site 8: Dry Well Off Composite Maintenance Building (Bldg. 32)
(CLP Laboratory Analysis)

Chemical	Round 1 MANG-8 MW1	Round 2 MANG-8 MW1	Background		ARARs (1)
			Round 1 MANG-BG MW1	Round 2 MANG-BG MW1	
GC volatile organics ($\mu\text{g/L}$):					
Chloroform	ND	2.3 J	ND	ND	100
1,1-Dichloroethane	ND	5	ND	ND	
1,2-Dichloroethene	48.0	160	ND	ND	70
1,1,1-Trichloroethane	ND	6.1	ND	ND	
Tetrachloroethene	2.8	4.5	ND	ND	5
Trichloroethene	3.5	18.4	ND	ND	5
CLP semivolatile organics ($\mu\text{g/L}$):					
bis(2-Ethylhexyl)phthalate	7 J	ND	ND	ND	4
Metals ($\mu\text{g/L}$):					
Arsenic	ND	ND	1.1 JB	ND	50
Barium	70 JB	51.2 B	56 JB	62.2 B	1,000
Lead	5.8 J	4.3 JN	4.9 J	4.3 JN	50
Zinc	11 JB*	9.4 JB	15 JB*	9.8 JB	5,000
Total petroleum hydrocarbons (mg/L)	3	ND	1	ND	NA

320SAVAU23409/T3-50.WKI

(1) ARARs are proposed only. These are MCLs where available, otherwise WQC.

NA = not applicable.

ND = not detected.

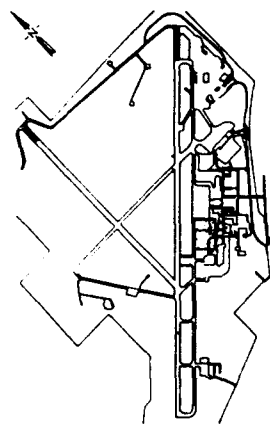
Data qualifiers follow the data. The qualifiers are:

Organics:

- J The value reported is an estimated concentration. This is used when the compound is detected at an amount below the reporting limit. For chloroform on sample MANG-8-MW1 (round 2) the compound was detected at less than 5 times the amount detected in an associated blank.

Metals:

- B Reported value is less than reporting limit but greater than the instrument detection limit.
- N Spiked sample recovery not within control limits set by lab QA/QC.
- * Duplicate analysis not within control limits set by lab QA/QC.
- J The value reported is an estimated concentration. This is used when the compound is detected at less than 10 times the amount in an associated preparation blank, or less than 5 times the amount in an associated field blank.



APPROXIMATE SITE LOCATION



LEGEND

⊕ 8-SB1
SOIL BORING
LOCATION AND
NUMBER

⊕ 8-MW1
MONITOR WELL
LOCATION AND
NUMBER

* SOV GRID POINT

FIGURE 3.43

SELECTED ANALYTES DETECTED
IN SOIL AND GROUNDWATER
SITE 8
DRY WELL OFF COMPOSITE
MAINTENANCE BUILDING

120th FIG International Airport, Great Falls, Montana
3-123

MW1 (SITE 8)	
GC volatile organics (ug/L):	
1,1-Dichloroethene	5
1,2-Dichloroethene	160
1,1,1-Trichloroethene	6.1
Tetrachloroethene	4.5
Trichloroethene	18.4
CLP semivolatile organics (ug/L):	
bis (2-Ethylhexyl)phthalate	ND
TPH (mg/L):	
	ND

BLDG. 26

8-MW1

BLDG. 30

SB1 (1.5 ft.)	
VOA organics (ug/kg):	
Acetone	95 J
Toluene	29
m,p-Xylene	1
o-Xylene	10
Metals (mg/kg):	
Lead	114 N
TPH (mg/kg)	140

BLDG. 35

SB2 (3 ft.)	
VOA organics (ug/kg):	
Acetone	36 J
Metals (mg/kg):	
Lead	12.9 N
TPH (mg/kg)	26

SB1DUP (1.5 ft.)	
VOA organics (ug/kg):	
Acetone	56 J
trans-1,2-Dichloroethene	8
Toluene	46
Ethylbenzene	8
m,p-Xylene	14
o-Xylene	9

BLDG. 33

SB3 (3 ft.)	
VOA organics (ug/kg):	
Trichloroethene	4 J
Metals (mg/kg):	
Arsenic	22.2

BLDG. 27

SB4 (1.5 ft.)	
VOA organics (ug/kg):	
Trichloroethene	260
Toluene	6
Chlorobenzene	35
1,2/1,4-Dichlorobenzene	180
BVA organics (ug/kg):	
1,2-Dichlorobenzene	240 J
Metals (mg/kg):	
Copper	19.8
Lead	14.9 N
SB4 (5.5 ft.)	
VOA organics (ug/kg):	
Acetone	120

BLDG. 32

SB5 (5.5 ft.)	
VOA organics (ug/kg):	
Acetone	24 J

Metals detected in groundwater during both rounds of sampling at site 8 are barium (up to 70 $\mu\text{g/L}$), lead (up to 5.8 $\mu\text{g/L}$), and zinc (up to 11 $\mu\text{g/L}$).

Comparison of Screening Results with CLP Results

The CLP data compared well with the soil gas survey. The soil gas survey indicated that the highest organic concentrations were located in the vicinity of soil borings 1, 4, and 6. These borings were the only samples to show significant organics in the CLP analyses.

The field headspace readings of soil samples collected for laboratory analysis at site 8 ranged from 0 ppm to 25 ppm. These readings compare moderately well with the analytical results from the CLP laboratory.

The field GC data indicated that benzene, toluene, trichloroethene, and xylenes were detected. The CLP analysis of the same samples showed concentrations of acetone, toluene, trichloroethene, xylenes, chlorobenzene, and 1,2/1,4-dichlorobenzene were present. This suggests that there is some correlation between the field GC data and the CLP data.

3.11.3 Geologic and Hydrogeologic Investigation Results

The results of geologic and hydrogeologic investigation of sites 4 through 8 were evaluated as a group because the sites are close together and share subsurface characteristics. This information is presented in the first portion of section 3.7.3. Geologic and hydrogeologic information specific to site 8 is discussed below.

The shallow water-bearing zone encountered during monitoring well construction at sites 4, 5, 6, and 7 was not encountered at site 8. The hole was drilled to 19 feet bgl and allowed to sit for approximately 1 hour, after which time no water had accumulated in the hole.

3.11.4 Conclusions

The results of screening activities indicate significant contamination at site 8. Compounds identified include both fuel components and solvents.

Site 8 is the location of another dry well, as described in section 1.3.1. Small amounts of waste oil, hydraulic fluids, fuels, and paint strippers and thinners were deposited in the dry well. The samples collected from soil borings 1, 4, and 6 contained the highest levels of contamination. The compounds that were detected are those which would have been disposed of in the dry well (i.e., solvents and fuels). Since borings 1, 4, and 6 are located near the dry well (see Figure 3.5), it appears that the soil contamination is limited to the area near the dry well. The analytical results of the samples from the other soil borings indicate no contamination.

Analysis of groundwater samples taken from the monitoring well at the site reveals significant levels of volatile organics. In addition, trace levels of semivolatile organics and TPH are indicated in the round 1 sample, but not confirmed in the second round of sampling. Some metals were also detected in samples from the monitoring well at site 8 in concentrations greater than the background samples. The compounds detected in groundwater are those which would have been disposed of in the dry well (i.e., solvents and fuels).

3.12 INVESTIGATION DERIVED MATERIALS

Materials generated during SI activities includes cuttings from piezometer and monitoring well construction, soil from soil borings, and water from piezometer and monitoring well development and purging. These materials were generated, contained, stored, sampled and analyzed as described in section 2 of this report.

The results of analyses of samples taken from these materials indicate that neither the soil and cuttings nor the development and purge water contain significant concentrations of waste constituents. TCLP test results for all material samples for all constituents detected were below the maximum concentrations for the toxicity characteristic. Methylene chloride (a common laboratory contaminant) was detected in one soil sample and duplicate in concentrations approximately the same as that found in the associated blank. Neither the soils nor the water meet the definition of a hazardous waste.

Total petroleum hydrocarbon (TPH) analysis was conducted on two samples collected from the development and purge water holding tank. The analyses indicate that concentrations of petroleum hydrocarbons (150 mg/L and 77 mg/L) are in excess of the allowable concentrations of oil and grease (50 mg/l) for disposal in the municipal sanitary sewer. A third sample was taken from a valve near the bottom of the purge water holding tank. Analysis of this sample indicates no detectable TPH concentration. This suggests that the TPH detected in the first two samples is present primarily in a floating layer and that the TPH could be effectively reduced using an oil-water separator.

SECTION 4

PRELIMINARY RISK EVALUATION

4.1 INTRODUCTION

The potential risks to human health and the environment based on the information presented in previous sections are assessed in this preliminary risk evaluation. The preliminary risk evaluation for the 120th Fighter Interceptor Group (FIG) Air Base was performed using data collected during the site investigation (SI). Data were collected on the site history (section 1); demographics, land use and climate; and the results of the investigative program, including contaminant concentrations and geologic and hydrogeologic information (sections 2 and 3). The objectives of the preliminary risk evaluation are to provide qualitative information on the potential risks to human and environmental receptors due to the release or threat of release of hazardous substances from the eight sites; to aid in identifying additional data needed to complete a quantitative risk assessment during the remedial investigation (RI); and to provide information for the determination that no further action is required if no risks to human and environmental receptors are identified.

The results of the medium-specific investigations described in the previous sections were used to identify chemicals of concern, chemical concentrations, general release characteristics, the affected environmental media, and exposed or potentially exposed human or environmental receptors. The initial objectives of the preliminary risk evaluation for each site were to:

- Select chemicals of potential concern.
- Review the factors that affect migration of selected chemicals through the affected media, and identify and evaluate potential migration pathways.
- Evaluate the potential toxicities associated with exposure of human or environmental receptors to the selected chemicals against appropriate protective criteria.
- Identify potential risks to human or environmental receptors that may be affected by the migration of contaminants along identified pathways.

Because the SI is a screening phase of investigation, the purpose of which is to confirm or deny the presence of contamination, the potential for data gaps exists. Therefore, detailed calculations to quantify risk to human health and the environment from the sites were not performed. Rather, a qualitative approach was taken in which all potential receptors and exposure pathways were evaluated, and the

potential importance of each exposure pathway was ascertained based on a comparison with standards or criteria and an evaluation of the likelihood of pathway completion. This evaluation was based on existing site information concerning migration pathways, the location and types of contaminants present, and the locations of current and possible future receptors. Conservative assumptions were employed to ensure that potential exposure pathways were not excluded from consideration.

The preliminary evaluation assumes that no remediation is performed at the site. This is referred to as the *no-action alternative*. This assumption is made to determine the need for remediation.

4.2 PRELIMINARY HUMAN HEALTH EVALUATION

4.2.1 Selection of Chemicals of Concern

Data used in the selection of chemicals of concern for this preliminary human health evaluation were compiled from the site investigation (SI) field work performed at the 120th FIG Base by ES. Compounds detected during the investigations are summarized in the site-specific discussions in sections 3.4 through 3.11. Compounds which were not detected in any samples were eliminated from further evaluation.

Thirty-four compounds were identified as chemicals of potential concern in this evaluation. They are:

Acetone	Copper	Nickel
Arsenic	1,2-Dichlorobenzene	Phenanthrene
Barium	1,4-Dichlorobenzene	Pyrene
Benzene	1,2-Dichloroethene	Selenium
Benzo(b)fluoranthene	Diethylphthalate	Tetrachloroethene
Bis(2-ethylhexyl)phthalate	Di-n-butylphthalate	Toluene
2-Butanone	Ethylbenzene	Total petroleum hydrocarbons
Butylbenzylphthalate	Fluoranthene	Trichloroethene
Cadmium	Lead	Xylenes
Chlorobenzene	Mercury	Zinc
Chloroform	2-Methylnaphthalene	
Chromium	Naphthalene	

Analytical data were reviewed by medium to characterize contamination at each of the eight sites at the base. Not all chemicals were detected at all sites or in all sampled media. The maximum concentrations detected for each chemical indicate the magnitude of chemical contamination in the analyzed samples. The maximum concentration values are used in subsequent sections to estimate the potential for adverse health affects.

Naphthalene, 2-methylnaphthalene, benzo(b)fluoranthene, fluoranthene, phenanthrene, and pyrene are members of the diverse polycyclic aromatic hydrocarbon (PAH) class of compounds. These compounds were detected only in soils and sediments at the base. It is important to note that PAHs may be present in the

environment both from natural and anthropogenic sources. Although total petroleum hydrocarbons (TPH) cover many compounds, this risk evaluation focuses on the gasoline and fuel oil components of TPH.

Many of the inorganic compounds selected as chemicals of potential concern may be present at naturally occurring background concentrations. Maximum detected concentrations of inorganic compounds at each site were compared with background concentrations (Table 3.2, section 3) and each compound was retained as a chemical of potential concern only if it exceeded the average detected background concentration by greater than 10 percent. This represents a conservative approach in identifying chemicals of potential concern, since this approach will include some chemicals which are found at levels greater than 10 percent above average detected background concentrations, but which are below the upper bound for background concentrations (defined as two standard deviations above the average detected concentration). Cadmium and mercury were retained where detected as chemicals of concern because background concentrations for these inorganics were not evaluated.

Acetone and toluene were each detected once in soil background samples. However, both of these compounds are common laboratory contaminants and may not be representative of site-related contamination. All concentrations of these contaminants detected in site-related soil samples were more than 10 times above the average background soil concentrations and were therefore retained as contaminants of concern.

Toxicity data exist for each of chromium's (Cr) two common valence states, Cr(III) and Cr(VI). Because Cr(VI) is quite soluble and is not sorbed to any significant degree by clays or hydrous metal oxides, it was assumed that all chromium detected in water was in the Cr(VI) state. Because the Cr(III) state forms an insoluble precipitate with hydroxide ions in water, all chromium detected in soils and sediments was assumed to be in the Cr(III) state.

4.2.2 Exposure Assessment

4.2.2.1 Environmental Fate and Transport

An evaluation of the environmental fate and transport of the selected chemicals of concern for the base can help determine the potential for migration in the environment and the potential for human exposure to the contaminants. The environmental fate and transport of contaminants depend on the chemical and physical properties of the compounds, the environmental transformation processes affecting them, and the media through which they migrate. In this section the physical and chemical properties of the chemicals of concern are presented, and the relevance of these properties to environmental fate and transport is discussed. In addition, mechanisms of chemical migration into air, groundwater, and surface water, and processes of biotransformation and bioaccumulation are discussed in relation to the environmental fate and transport of the chemicals of concern. Additional information on environmental fate and transport can be found in the toxicity profiles for the selected chemicals of concern (section 4.2.2.2).

Physical and chemical properties of the chemicals of concern will affect the extent to which they may migrate through the environment. Table 4.1 summarizes several of these properties for many of the selected chemicals of concern.

The water solubility of a substance is a critical property affecting environmental fate. Highly soluble chemicals can be rapidly leached from wastes and soils and are generally mobile in groundwater. Solubilities can range from less than 1 milligram per liter (mg/L) to totally miscible, with most common organic chemicals falling between 1 mg/L and 1,000,000 mg/L (Lyman et al., 1982). The solubility of chemicals which are not readily soluble in water may become enhanced in the presence of organic solvents (e.g., toluene) which themselves are more soluble in water.

Volatilization of a compound will depend on its vapor pressure, water solubility, and air diffusion coefficient. Highly water-soluble compounds generally have lower volatilization rates from water unless they also have high vapor pressures. Vapor pressure, a relative measure of the volatility of chemicals in their pure state, ranges from roughly 0.001 to 760 millimeters of mercury (mm Hg) for liquids. The Henry's Law Constant, which combines vapor pressure with solubility, is more appropriate than vapor pressure alone for estimating releases from water to air for compounds having Henry's Law Constants. Compounds with Henry's Law Constants greater than 10^{-3} atmospheres cubic meters per mole ($\text{atm}\cdot\text{m}^3/\text{mole}$) can be expected to readily volatilize from water. Those with values ranging from 10^{-3} to 10^{-5} $\text{atm}\cdot\text{m}^3/\text{mole}$ are associated with possibly significant but not facile volatilization, while compounds with values less than 10^{-5} $\text{atm}\cdot\text{m}^3/\text{mole}$ will only volatilize from water to a limited extent (Lyman et al., 1982).

The organic carbon partition coefficient (K_{oc}) reflects the propensity of a compound to sorb to organic matter found in soil. The normal range of K_{oc} values is 1 to 10^7 milliliters per gram (mL/g), with higher values indicating greater sorption potential. Chemicals which have a strong tendency to sorb to organic matter (i.e., chemicals with high K_{oc} s) will move more slowly in the subsurface environment than chemicals with low K_{oc} s.

Chemicals of concern were classified into several categories according to their similarity in chemical structure and/or physicochemical properties (factors which influence mobility in the environment). The organic chemical categories and the chemicals of concern within each category, as well as the inorganics, are listed below:

- Inorganic compounds: Arsenic, barium, cadmium, chromium, copper, lead, mercury, nickel, selenium, and zinc
- Volatile organic compounds: Acetone, benzene, 2-butanone, chlorobenzene, chloroform, 1,2-dichloroethene, ethyl benzene, tetrachloroethene, toluene, trichloroethene, and xylenes
- Semivolatile organic compounds: bis(2-Ethylhexyl)phthalate, butylbenzylphthalate, diethylphthalate, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and di-n-butylphthalate

Table 4.1 Relevant Physical and Chemical Properties of Potential Chemicals of Concern
120th FIG, International Airport, Great Falls, Montana

Chemical	CAS Number	Water Solubility (mg/L) ^c	Vapor Pressure ^b (mm Hg) ^d	Henry's Law Constant (atm-m ³ /mole) ^e	KOC (mL/g) ^f	BCF (L/kg) ^g
Inorganics						
Arsenic	7440-38-2	--	0.0E+00	--	--	44
Barium	7740-39-3	--	--	--	--	--
Cadmium	7740-43-9	--	0.0E+00	--	--	81
Chromium	7440-47-3	--	0.0E+00	--	--	16
Copper	7440-50-8	--	0.0E+00	--	--	200
Lead	7439-92-1	--	0.0E+00	--	--	49
Mercury	7439-97-6	--	2.0E-03	--	--	5500
Nickel	7440-02-0	--	0.0E+00	--	--	47
Selenium	7782-49-2	--	0.0E+00	--	--	16
Zinc	7440-66-6	--	0.0E+00	--	--	47
Organics						
Acetone	67-64-1	1E+06	2.7E+02	2.06E-05	2.2	--
Benzene	71-43-2	1.75E+03	9.52E+01	5.59E-03	83	5.2
Bis(2-ethylhexyl)phthalate	117-81-7	0.4	--	--	--	--
2-Butanone	78-93-3	2.68E+05	7.75E+01	2.74E-05	4.5	0
Butylbenzylphthalate	85-68-7	2.9E+00	--	--	--	--
Chlorobenzene	108-90-7	4.66E+02	1.17E+01	3.72E-03	330	10
Chloroform	67-66-3	8.2E+03	1.51E+02	2.87E-03	31	3.75
Di-n-butylphthalate	84-74-2	1.30E+01	1.00E-05	2.82E-07	170,000	--
1,2-Dichlorobenzene	95-50-1	1.0E+02	1.00E+00	1.93E-03	1700	56
1,4-Dichlorobenzene	106-46-7	7.9E+01	1.18E+00	2.89E-03	1700	56
1,2-Dichloroethene (cis)	540-59-0	3.5E+03	2.08E+02	7.58E-03	49	1.6
1,2-Dichloroethene (trans)	540-59-0	6.3E+03	3.24E+02	6.56E-03	59	1.6
Diethylphthalate	84-66-2	8.96E+02	3.5E-03	1.14E-06	142	117

Table 4.1, continued

Chemical	CAS Number	Water Solubility (mg/L) ^c	Vapor Pressure ^b (mm/Hg) ^d	Henry's Law Constant (atm-m ³ /mole) ^e	KOC (mL/g) ^f	BCF (L/kg) ^g
Organics, continued						
Ethyl benzene	100-41-4	1.52E+02	7E+00	6.43E-03	1100	37.5
Tetrachloroethene	127-18-4	1.5E+02	1.78E+01	2.59E-02	364	31
Toluene	108-88-3	5.35E+02	2.81E+01	6.37E-03	300	10.7
Trichloroethene	79-01-6	1.10E+03	5.79E+01	9.1E-03	126	10.6
Xylenes	1330-20-7	1.98E+02	1E+01	7.04E-03	240	--
Polycyclic aromatic hydrocarbons						
Benzo(b)fluoranthene	205-99-2	1.4E-02	5.0E-07	1.19E-05	550,000	--
Fluoranthene	206-44-0	2.06E-01	5.0E-06	6.46E-06	38,000	1,150
2-Methylnaphthalene	91-57-6	2.54E+01	--	8.5E+03	--	--
Naphthalene	91-20-3	3.17E+01	2.3E-01	1.15E-03	1.3E+03	--
Phenanthrene	85-01-8	1.0E+00	6.8E-04	1.59E-04	14,000	2,630
Pyrene	129-00-0	1.32E-01	2.5E-06	5.04E-06	38,000	--

a CAS = Chemical Abstract Service.

b Values listed are for 25°C unless otherwise noted.

c mg/L = milligrams per liter.

d mmHg = millimeters of mercury.

e atm-m³/mole = atmospheres - meters cubed per mole.

f KOC = organic carbon partition coefficient; mL/g = milliliters per gram.

g BCF = bioconcentration factor; L/Kg = liters per kilogram.

h Value is in torr at 20 degrees Celsius.

i Values are listed for the beta isomer.

j Value is in torr at 25 degrees Celsius.

Note: -- = no value available.

Source: U.S. Environmental Protection Agency, 1986.

- PAHs: Benzo(b)fluoranthene, fluoranthene, 2-methylnaphthalene, naphthalene, phenanthrene, and pyrene
- Other: TPH.

4.2.2.2 Toxicity Profiles For the Chemicals of Concern

Inorganic Compounds

Arsenic. Arsenic is a naturally occurring metalloid which may be present in the environment in a number of different valence states. It may be a constituent of both organic and inorganic compounds. Arsenic is widely used in industry as an alloying agent and in ore-concentrating processes. Inorganic arsenic was a commonly used insecticide in the pre-World War II era, but it was replaced with synthetic pesticides after World War II. Organic arsenic is still used as a post emergent herbicide.

Arsenic is generally extremely mobile in aquatic environments, and it cycles through air, water, and soils. Its precise fate in a particular environment depends on the complex interactions of a number of factors: oxidation potential (Eh); pH; the presence and concentrations of metal sulfide and sulfide ions, phosphorus minerals, and iron; temperature; salinity; and the distribution and composition of the biota. Of these factors, Eh and pH have been shown to be most critical. Sediments and soils often act as a sink for arsenic through its adsorption onto clays, iron oxides, aluminum hydroxide, and organic materials.

Arsenic has been associated with skin, lung, liver, and bladder cancers in humans. Acute arsenic poisoning can cause nausea, vomiting, and diarrhea. In severe cases, arsenic poisoning may produce shock followed by coma and death. Chronic arsenic poisoning may cause disturbances of the digestive system, liver damage, disturbances of the blood, kidneys, or nervous system, and keratosis and hyperpigmentation.

Arsenic is toxic to aquatic animal species and induces its toxic effects via enzyme inhibition. In aquatic species, arsenic has induced death following acute exposures, and has caused death and deformity following chronic exposure. Arsenic can bioaccumulate in aquatic vertebrates and invertebrates, but bioconcentration occurs to a greater extent in invertebrates. From a human health risk assessment standpoint, it is a well-known fact that organic arsenic is the predominant form found in fish. Thus, the cancer potency factor for inorganic arsenic is inappropriate for use in evaluating the human health risk posed by arsenic in fish and shellfish.

According to the recent final Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profile for arsenic, fish and shellfish often accumulate rather high tissue levels of arsenic. Depending on the species, most of this accumulation exists in the form of arsenobetaine or arsenocholine. Available data indicate that these organic derivatives have low toxicity, and ingestion of arsenic in this form is not generally considered to be of human health concern (Agency for Toxic Substances and Disease Registry, 1989).

Furthermore, methylation of inorganic arsenic (such as occurs in the human body) is viewed as a detoxification pathway. It is important to note a recent report

on ingested arsenic by the Drinking Water Subcommittee of the U.S. Environmental Protection Agency (EPA) Science Advisory Board (SAB). The report concludes that daily ingestion of 200 to 250 micrograms (μg) of arsenic probably will not cause skin cancer in humans, the most likely form of cancer that may be induced by ingested arsenic (U.S. Environmental Protection Agency/Science Advisory Board, 1989). This is based on an EPA group A weight-of-evidence classification. The subcommittee noted an important study which found that humans detoxify low levels of ingested arsenic. Arsenic has been classified as a group A respiratory tract and oral carcinogen by EPA.

Barium. Barium is a relatively common, naturally occurring trace metal which occurs in the +2 valence state in natural waters. Barium is associated with potassium in felsic igneous rocks and with lead-zinc sulfide ores. Barium sulfate is used in medicine as an opaque contrast medium for gastrointestinal radiography. Barium is produced commercially from the mining of barite.

Barium is not a known carcinogen, although soluble barium salts (i.e., chloride and sulfide salts) are poisonous when ingested. Exposure to barium sulfide, oxide, and carbonate compounds usually causes irritation of the eyes, throat, nose, and skin. Adverse effects in humans following oral exposure to soluble barium compounds include gastroenteritis, muscular paralysis, hypertension, ventricular fibrillation, and central nervous system damage. Inhalation of barium compounds may cause fetotoxicity.

Barium is considered to have intermediate environmental mobility, probably limited by the solubility of barite in a particular environment. Barium may be relatively strongly sorbed onto certain clays, limiting its mobility. It is not known to biomagnify. The soluble form may be toxic to certain species. In most natural waters there is sufficient sulfate or carbonate to precipitate the barium present in the water, rendering it an insoluble nontoxic compound. Therefore, EPA has not established criteria for the protection of aquatic life.

Cadmium. Cadmium is a transitional metal which occurs widely in nature, generally in association with lead or zinc ores. Elemental cadmium is insoluble in water, but many cadmium compounds are quite soluble. The general populace is widely exposed to low levels of cadmium in drinking water, food, and industrial settings.

Cadmium is relatively mobile in the environment compared to most other heavy metals. Cadmium is less mobile in alkaline than in acidic waters, and pH is a major factor influencing mobility. Sorption processes affect cadmium less than most other heavy metals. However, the mobility of cadmium can be reduced by sorption onto clays, hydrous iron, aluminum and manganese oxides, and organic materials. Volatilization is not an important process in aqueous environments.

There is no evidence that cadmium is an essential mineral. Mammals have no effective mechanism for the elimination of ingested cadmium; therefore, with time, cadmium tends to accumulate in the liver and kidneys. It tends to be very persistent in the kidney and can cause renal tubular damage. Toxic effects include decreased growth rates, anemia, infertility, fetus abnormalities, abortions, kidney disease,

intestinal disease, and hypertension. Cadmium compounds, when inhaled, have been associated with pulmonary cancer in humans. Cadmium is classified by EPA as a Group B1 probable human carcinogen. Inhalation of cadmium dust or fumes affects the respiratory tract and kidneys. Exposure to high concentrations may result in pulmonary edema and death. Ingestion of cadmium can result in gastrointestinal poisoning.

Chromium. Cr is a transition element, occurring in nature principally as the trivalent ion Cr(III), although valence states ranging from -2 to +6 have been reported in the literature. Cr exists in primarily two oxidation forms, Cr(III) and Cr(VI). The hexavalent form, Cr(VI), is quite soluble, existing in solution as a complex anion, and is not sorbed to any significant degree by clays or hydrous metal oxides. It is, however, sorbed strongly to activated carbon. Cr(VI) is a moderately strong oxidizing agent and reacts with reducing materials to form Cr(III). Cr(III) reacts with aqueous hydroxide ions to form insoluble chromium hydroxide [Cr(OH)₃]. Most of the hydroxide form precipitates to the benthic zone in natural waters directly or by sorption to other particulates.

Following oral exposure, human absorption of Cr(III) is low, and absorption of Cr(VI) is high. Cr is an essential micronutrient and is not toxic in trace quantities. High levels of soluble Cr(IV) and Cr(III) can produce kidney and liver damage following acute oral exposure; organs affected by chronic oral exposure have not been identified. Chronic inhalation exposure may cause respiratory-system damage in humans. Further, epidemiological studies of worker populations have clearly established that inhaled Cr(VI) is a human carcinogen; the respiratory passages and lungs are the target organs. Inhalation of Cr(III) or ingestion of Cr(VI) or Cr(III) has not been associated with carcinogenicity in humans.

Cr has a low tendency to bioaccumulate in freshwater or marine aquatic organisms, although some passage of chromium through the food chain has been demonstrated (Bodek et al., 1988). Cr has a low inherent toxicity to fish and animals, moderate toxicity to plants, and low potential for translocation from root to shoot, or for biomagnification in the food chain (Bodek et al., 1988).

In aquatic systems, plants and polychaete worms appear to be the most sensitive groups tested. The toxicity of Cr(VI) to aquatic species appears to increase as pH or hardness decreases. Bioaccumulation has been found to vary among species; concentrations are normally highest at lower trophic levels and lowest in the top predators, indicating that biomagnification does not occur. Cr(III) has not been classified by EPA as a carcinogen. However, Cr(VI) has been classified as a group A lung carcinogen by EPA.

Copper. Copper is a reddish-colored metal widely used as a structural material when high electrical and thermal conductivity is required. Copper salts are used as fungicides and in ceramics and electroplating, and have a wide variety of other industrial uses.

Elemental copper has little or no toxicity to humans, and EPA has not classified its carcinogenicity. Copper is an essential dietary element. Ingestion of copper salts by humans can cause salivation, gastrointestinal irritation, nausea, vomiting, gastric

pain, hemorrhagic gastritis, and diarrhea. Dermal exposure to copper salts can produce skin irritation and eczema. Inhalation of dusts and mists of copper salts may result in irritation of the mucous membranes and pharynx, as well as ulceration and perforation of the nasal septum.

Copper has a low potential for biomagnification in the food chain, low inherent toxicity to terrestrial animals, and a high inherent toxicity to fish and plants. Toxicity of copper to aquatic life is enhanced at low water alkalinity. Although copper is highly toxic to fish and freshwater algae, mammals and birds have physiological barriers to copper absorption and are more resistant to copper toxicity than more primitive animals.

Lead. Elemental lead is heavy, ductile, and bluish white in color. It is widely used in industry because of its softness, resistance to corrosion and radiation, and high density. Lead is also used as a paint pigment, in solders, and in storage batteries.

The concentration and mobility of lead is controlled primarily by sorption. The tendency for lead to form complexes with naturally occurring organic materials increases its adsorptive affinity for clays and other minerals surfaces. At low pH values, sorption and precipitation are not nearly as effective in removing lead from solution; therefore lead is much more mobile in acidic waters than at higher pH values. In alkaline and circumneutral waters, removal of lead by sorption and precipitation may occur relatively quickly. Bioaccumulation may also be an important fate process.

Lead is stored in bone, kidneys, and the liver. The major adverse effects in humans include alterations in the hematopoietic and nervous systems. The toxic effects are generally related to the concentration of this metal in blood. Toxic blood concentrations in children and in sensitive adults can cause severe, irreversible brain damage, encephalopathy, and possible death. Physiological and biochemical effects that occur even at low levels include enzyme inhibition, elevated erythrocyte protoporphyrin, interferences with vitamin D metabolism, cognitive dysfunction in infants, electrophysiological dysfunction, and reduced childhood growth. Lead has been classified as a group B2 carcinogen by EPA.

Lead is generally considered a highly toxic contaminant because it is not an essential nutrient to either plants or animals. Lead bioaccumulates in animal tissues, but has a low potential for biomagnification in the food chain. The solubility of lead is dependent on water hardness, and lead is considered twenty to one hundred times more toxic in soft water. In aquatic environments, most lead is found in bottom sediments and is therefore a concern more in benthic organisms than in planktonic or pelagic forms. Toxicity of lead in water is dependent on pH, organic materials, and the presence/absence of other metals.

The primary mechanism of acute toxicity of lead to freshwater organisms is unknown. Invertebrate species appear more sensitive than vertebrate species. Lead inhibits plant growth and reduces photosynthesis, mitosis, and water absorption.

Mercury. Mercury is a silvery, liquid, metallic element. It is used in barometers, thermometers, hydrometers, pyrometers, mercury arc lamps producing ultraviolet rays, switches, fluorescent lamps, mercury boilers, extracting gold and silver ores, making amalgams, and dentistry.

In the environment, mercury readily bioaccumulates. It is strongly sorbed to inorganic and organic particulates. Precipitation of mercury sulfide can result when mercury-laden sediments are deposited in reducing zones. Mercury in sediments can be remobilized through biomethylation. Volatilization of dimethyl mercury may occur in the environment.

In humans, elemental and inorganic mercury are absorbed following inhalation exposure or contact with skin and the gastrointestinal tract. Spilled and heated elemental mercury is particularly hazardous. Occupational exposure of workers to elemental mercury vapors has been associated with mental disturbances, tremors, and gingivitis. The central nervous system is a major target for organic mercury compounds. Adverse effects in humans from exposure to organic mercury compounds have included destruction of cortical cerebral neurons, damage to Purkinje cells, and lesions of the cerebellum. Clinical symptoms following exposure to organic mercury compounds have included paresthesia, loss of sensation in extremities, ataxia, and hearing and visual impairment. A primary target organ for inorganic compounds is the kidney. Human exposure to inorganic mercury compounds has been associated with anuria, polyuria, proteinuria, and renal lesions.

In birds and mammals, mercury can adversely affect reproduction, growth and development, behavior, blood chemistry, coordination, vision, hearing, and metabolism. Symptoms of mercury poisoning in birds include muscular incoordination, hyperactivity, and withdrawal. Mercury toxicity in birds depends on the form of the element, route of exposure, and age of the animal. Organic forms of mercury, such as methylmercury, are more toxic than inorganic mercury.

In mammals, organomercury compounds are more toxic than the inorganic form. Larger mammals such as the mule deer appear to be more resistant than smaller animals such as cats, dogs, pigs, monkeys, and river otters. This may be related to differences in metabolism and detoxification rates. Mercury is not known to be readily taken up by plants. Symptoms of toxicity to plants include stunting of seedling growth and root development, and an inhibition of photosynthesis causing yield reductions.

Nickel. Nickel is a naturally occurring element. The largest use of nickel is in the manufacturing of coinage, stainless steels, and nickel-chrome resistance wire. Nickel is also used in money metal alloy.

Nickel appears to be a relatively mobile heavy metal. Although sorption and precipitation processes do not appear to be as effective in removing nickel from liquids as they are with many of the other heavy metals, sorption processes can scavenge nickel from solution. Nickel has an affinity for organic materials and hydrous iron and manganese oxides. The latter materials are probably the dominant control of the mobility of nickel in an aquatic environment. Although nickel is bioaccumu-

lated, the concentration ratios reported for most freshwater organisms indicate that this is not a dominant fate process.

In humans, exposure to nickel may cause dermatitis in sensitive individuals. Ingestion of soluble nickel salts causes nausea, vomiting, diarrhea, and reduced body and organ weight. Inhalation of dust or fumes may cause irritation to the eyes, nose, or throat; leave a metallic taste in the mouth; or result in metal-fume fever. Certain nickel compounds have been classified by EPA as group A human carcinogens via inhalation. These compounds are nickel refinery dust and nickel subsulfides.

Nickel has a low toxicity to aquatic life and a low potential to biomagnify in the food chain. Toxicity of nickel to aquatic life varies and is determined by water hardness, pH, the organism, and the chemical form of nickel. In general, nickel's toxicity is increased five to ten times in soft water compared to hard water. Vascular plants are known to accumulate nickel, but they also have been shown to have a high nickel tolerance.

Selenium. Selenium is a naturally occurring metalloid which may be present in several valence states in the environment. Selenium is associated with sulfide deposits and may be particularly enriched in certain sedimentary deposits. This element is produced as a by-product of copper refining.

Selenium may become mobile in the soil-water system under certain conditions. In aerobic conditions, it may be present in selenite or selenate, both of which are very soluble. Under reducing conditions relatively insoluble metal selenides may also form, limiting mobility. Lack of mobility may be enhanced by sorption on hydrous metal oxides, clays, and organic materials. In reducing conditions, hydrogen selenide can also form, remobilizing sorbed selenium. Mobility is considered to be relatively low in normal acid soils. Biotransformation (methylation) of selenium, or formation of volatile hydrogen selenide by inorganic means under reducing conditions, may cause some volatilization of selenium.

In humans, selenium compounds are readily absorbed from the gastrointestinal tract following oral exposure. Selenium is absorbed by inhalation to some extent. Selenium is an essential element and therefore is nontoxic at doses necessary for normal health and nutrition. However, overexposure to selenium has been associated with adverse health effects. Chronic oral exposure to selenium has been associated with alopecia, dermatitis, discoloration of the skin, loss of fingernails, muscular dysfunction, convulsions, paralysis, amyotrophic lateral sclerosis, nervousness, depression, digestive disturbances, and increased incidences of dental caries. Headaches and respiratory irritation have been noted in humans following inhalation exposure. Selenium is not known to be a carcinogen. However, certain forms of selenium, such as hydrogen selenide, are considered toxic.

Selenium is generally considered moderately to highly toxic depending on the receptor biotic group. It is highly toxic to aquatic life and terrestrial animals and poses a serious hazard to cattle in semi-arid regions. Selenium bioaccumulates to high levels in vascular plants without adverse effects. Selenium is an essential trace element for animals, but not for plants. Selenium does not appear to biomagnify in the food chain. The metabolism and degradation of selenium is influenced by other

heavy metals, agricultural chemicals, microorganisms, and physical and chemical factors. Selenium deficiency in animals is considered to be as detrimental as selenium poisoning.

Zinc. Zinc is a common trace metal generally associated with base metal and precious metal deposits. Zinc is used commercially in the manufacture of batteries, for galvanizing, and as an alloying agent. Zinc and zinc compounds are essential trace nutrients for humans, and are commonly used in such products as antidandruff shampoos and astringents.

Zinc is one of the most mobile of the heavy metals in natural surface water systems, but is only moderately mobile in natural soil-water systems. In soil-groundwater systems, zinc can be adsorbed onto hydrous iron and manganese oxides (30 to 60 percent), clay minerals (20 to 45 percent), and organic materials (5 percent in sediments) (Bodek et al., 1988), thereby reducing its mobility. Eh and pH appear to be important factors in transportation fate, with solubility decreasing in reducing environments. Volatilization is not an important process in the fate of zinc.

The toxicity of zinc to humans is considered to be very low. Zinc has not been classified as a carcinogen by EPA. Small amounts of zinc are necessary for normal human growth and development. Ingestion of zinc salts can cause fevers, nausea, vomiting, stomach cramps, diarrhea, and anemia. Exposure to zinc chloride fumes can cause damage to the respiratory tract and nasal tract.

Zinc bioaccumulates and is moderately toxic to aquatic life and vegetation at high doses, but is also an essential element. The toxicity of zinc is strongly influenced by water hardness, pH, temperature, and dissolved oxygen. Zinc toxicity increases with water softness, increase in temperature, reduction in dissolved oxygen, and increase in pH. For aquatic life, zinc is most toxic at a pH of 8.0.

Organic Compounds

Acetone. Acetone is a colorless liquid with a fragrant, mint-like odor. It is used as a solvent for fats, oils, waxes, resins, rubber, plastics, lacquers, varnishes, and rubber cement. It is used in the manufacture of various organic compounds and as a component of paint and varnish removers.

In humans, it is a skin and eye irritant. In high concentrations, it acts as a narcotic. When inhaled for a prolonged period, it can cause headaches. It is permitted for human consumption when used as a food additive. Chronic oral exposure may result in increased liver and kidney weight, and nephrotoxicity. Acetone is not classified for carcinogenicity by EPA.

Benzene. Benzene is a colorless aromatic hydrocarbon with a characteristic odor. Benzene was widely used in the past as a solvent and as an octane-raising additive in gasoline. Currently, benzene is used primarily in the chemical industry as a starting or intermediate material for the synthesis of many other organic compounds.

Benzene has been shown to be mobile in the soil-groundwater system. It is relatively soluble in groundwater and may be transported through sandy soils and soils

of low organic content. The amount of benzene sorbed to the soil increases with increasing organic content. Benzene is highly volatile, and volatilization in surficial soils is probably an important transport mechanism. However, sorption of benzene vapors onto soil particles may slow vapor-phase transport. Data on the biodegradation of benzene are inconclusive. There is some evidence of gradual biodegradation at low concentrations by aquatic organisms, but the compound is considered fairly resistant to biodegradation. The rate of biodegradation may be enhanced in the presence other hydrocarbons.

Benzene is readily absorbed following oral and inhalation exposure. The toxic effects of benzene in humans following exposure by inhalation is the same as that for laboratory animals, and includes central nervous system effects, hematological effects, and immune system depression. In humans, acute exposures to high concentrations of benzene vapors has been associated with dizziness, nausea, vomiting, headache, drowsiness, narcosis, coma, and death. Chronic exposure to benzene vapors can produce reduced leukocyte, platelet, and red blood cell levels.

Chronic exposure to benzene is associated with leukemia and bone marrow damage. In addition, the compound is a central nervous system depressant at high concentrations, and may cause acute narcotic reactions. Benzene has been classified a group A human carcinogen by EPA.

2-Butanone. 2-Butanone is also known as methyl ethyl ketone. It is a colorless liquid with an acetone-like odor. 2-Butanone is used primarily as a solvent. In the coating industry, it is used to manufacture gums, resins, and nitrocellulose. It is also used to make cements, adhesives, printing ink, cleaning fluids, smokeless powders, and wax.

2-Butanone is fairly mobile in soil-groundwater systems. The relative mobility of 2-butanone is governed by the extent to which it is sorbed onto soil particles. In general, the amount of 2-butanone sorbed onto the soil increases with soil organic-matter content, decreasing temperature, and salinity. Its mobility decreases with increasing dissolved organic matter in the soil water. Volatilization and hydrolysis are not expected to be important transport processes in removing 2-butanone from soil-groundwater systems. Bioaccumulation is also expected not to be an important process in the fate of 2-butanone.

After initial exposure to 2-butanone, usually the eyes, nose, and throat become irritated. At high concentrations, the central nervous system is depressed. Narcosis and congestion of the lungs, liver, and kidneys have also been observed at high concentrations. Chronic exposure has been reported to cause dermatitis. EPA has classified 2-butanone as a class D carcinogen.

Chlorobenzene. Chlorobenzene is a colorless liquid used as a solvent and degreasing agent. It has been used as a feedstock in the production of phenol, nitrobenzenes, DDT, and aniline. Chlorobenzene is a carrier agent in pesticide products.

It is not possible to determine the predominantly aquatic fate of chlorobenzene. There is some experimental evidence indicating that volatilized chlorobenzene will

undergo atmospheric photo-oxidation in the presence of nitric oxide. The extent to which such photo-oxidation will occur at chlorobenzene concentrations prevalent in the atmospheric environment, in the presence of nitric oxide as well as other free radical initiators, is unknown. Information concerning the biodegradation potential of chlorobenzene indicates that this compound, being very persistent, will probably eventually biodegrade, but not at a substantial rate unless the microorganisms present are already growing on another hydrocarbon source.

Short-term human exposure may result in dizziness, drowsiness, headache, nausea, and vomiting. It may also cause irritation of the eyes, nose, and skin. Long-term exposure may result in liver and kidney damage. Chlorobenzene has not been classified by EPA as to its carcinogenicity.

Chloroform. Chloroform, a trihalomethane, is predominantly used as a feed-stock for the manufacture of chlorodifluoromethane. It is also used as an extraction solvent in the pharmaceutical industry and as an industrial solvent in pesticides, textiles, and dyes.

Chloroform may be relatively mobile in the soil-groundwater system at low concentrations (dissolved in water and sorbed on soil) or as a separate organic phase (resulting from a spill of significant quantities of the chemical). The degree of chloroform sorption onto soil particles, which affects the mobility of the compound in the soil-groundwater system, is influenced by soil organic matter content, temperature, soil water salinity, and the dissolved organic matter content of the soil water. The properties of chloroform suggest that it is generally weakly adsorbed to soil. Because of its high vapor pressure, volatilization is a major transport process for removal of chloroform from natural systems. Oxidation, hydrolysis, and in most cases biodegradation do not appear to be important fate process for chloroform.

Chloroform is a probable human carcinogen (EPA group B2). Chronic chloroform poisoning may cause liver and kidney damage. Exposure may also cause central nervous system depression and heart damage. Short-term exposure also affects the liver, kidney, and central nervous system.

Chloroform has a low potential for bioaccumulation and biomagnification. Toxicity of chloroform varies by the sex and species of organism.

Dichlorobenzene. The major use of 1,2-dichlorobenzene is in organic synthesis, primarily in the manufacture of 3,4-dichloroaniline. It is also used as a process solvent in the manufacture of toluene diisocyanate. Other applications include cleaning and polishing formulations, motor oil additive formulations, paints, rust preventatives, degreasing of leather hides and woolen pelts, and use as a carrier solvent for wood preservatives and repellents. Minor uses include the manufacture and application of dyes, odor control, and pesticide manufacture. Most of the 1,4-dichlorobenzene produced in the United States is used as an air deodorant and moth repellent.

Dichlorobenzene is expected to have limited mobility in soils with 1 to 2 percent organic content, although some migration is expected in sandy soils or other low

organic content soils. This compound will persist in the soil-groundwater system. Volatilization from aqueous solutions is rapid, but volatilization from soils is expected to be much less significant; biodegradation in soils is not expected to be important. Dichlorobenzene that has been released from the soil into the air will eventually undergo photochemical oxidation.

The primary pathway of concern from a soil-water system is the migration of dichlorobenzene into groundwater drinking water supplies. Inhalation resulting from volatilization from surface soils may also be important.

The 1,2- isomer of dichlorobenzene appears to have a low toxicity to humans. The only adverse effects from short-term inhalation exposure are irritation of the eyes and throat. The principal toxic effects from acute and long-term exposure are central nervous system depression, blood dyscrasias, and lung, kidney, and liver damage. EPA classifies 1,2-dichlorobenzene as a group D carcinogen.

The 1,4- isomer appears to be less toxic than the 1,2- isomer of dichlorobenzene. This may be because its binding to liver proteins is not as pronounced. The toxic effects of 1,4-dichlorobenzene are primarily on the liver and central nervous system.

Total 1,2-dichloroethene (1,2-DCE). The halogenated organic compound 1,2-DCE gradually decomposes in the presence of air, light, and moisture to form hydrochloric acid. It is used as a solvent for fats, phenol, and camphor.

The primary exposure pathway of concern from a soil-water system is the migration of the cis- and trans-1,2-DCE isomers into groundwater drinking water supplies. In soil-groundwater systems, cis- and trans-1,2-DCE are expected to be highly mobile. Volatilization may be important for 1,2-DCE isomers near the surface or in the soil-air compartment. Transformation processes such as hydrolysis or biodegradation are not expected to be significant in natural soils.

Inhalation or ingestion of 1,2-DCE will produce nausea, vomiting, dizziness, and narcosis. The liquid can act as a primary irritant, producing dermatitis and irritation of mucous membranes. Long-term oral exposure to cis-1,2-DCE may cause anemia, whereas long-term oral exposure to trans-1,2-DCE may affect the liver. Neither the cis- or the trans- isomers of 1,2-DCE have been classified by EPA as to their carcinogenicity.

Ethyl benzene. Ethyl benzene is a colorless aromatic liquid. It is used in industry as a resin solvent and in the conversion to styrene monomer. When released into water, ethyl benzene evaporates rapidly. Microorganisms usually degrade most ethyl benzene in water; however, some is sorbed by the sediment and some is bioconcentrated in fish.

In humans, short-term inhalation exposure to ethyl benzene can cause sleepiness, fatigue, headache, and mild eye and respiratory irritation. Chronic oral exposure may result in hepatotoxicity and nephrotoxicity. Ethyl benzene has not been classified by EPA as to its carcinogenicity.

Petroleum hydrocarbons. Petroleum hydrocarbons, a group of organic compounds, are thick, dark yellow to brown or green-black liquids which consist of a mixture of hydrocarbons from C_2H_2 and up. They are used as a source of gasoline, petro ether, petrolatum, fuel and lubricating oils, butane, and isopropyl alcohol. The two petroleum hydrocarbons of primary concern in this risk evaluation are gasoline and fuel oil.

Hydrocarbon-containing petroleum residues are decomposed in soil systems. Hydrocarbons degrade to carbon dioxide and water via several intermediates (organic acids, ketones, aldehydes, alcohols, and other hydrocarbon derivatives). Nonvolatile components of oils tend to stay tightly bound in soil, while volatile fractions may escape into the atmosphere.

Gasoline is an aspiration hazard, defats the skin, and has been shown to cause kidney tumors in laboratory animals. It contains benzene and toluene, which may be absorbed through the skin. Benzene is a cancer hazard that affects the blood. Primary routes of exposure are inhalation and skin contact. Eye contact with liquid gasoline may cause burning, tearing, redness, and transient corneal damage. Prolonged or repeated dermal contact may cause burning, redness, drying and cracking of the skin, and dermatitis. Exposure to mist or excessive vapor concentration may cause irritation of the nose, throat, and upper respiratory tract. Severe exposures may result in unconsciousness, coma, and death. Ingestion of gasoline may cause signs of central nervous system depression, headache, nausea, drowsiness, and dizziness.

Fuel oil is a combustible liquid and a skin irritant. Breathing oil mists may irritate the nose and throat. Chronic exposure to oil mists may lead to the development of lipoid pneumonia. Similarly refined and processed petroleum residual materials have been shown to cause skin cancer and liver damage in laboratory animals through prolonged skin contact. There is no direct evidence that fuel oil causes skin cancer or liver damage in humans.

Phthalate esters. Phthalate esters are present in the environment from anthropogenic and perhaps natural sources. As a group, they are widely distributed in the environment. They have been found in well and drinking water, oil, soil, air, plants, fish, food, animals, and humans. Phthalate ester contamination in surface water residues has been correlated with drainage from industrial or heavily polluted areas. Phthalate esters occurring at the 120th FIG Base are bis(2-ethylhexyl)phthalate, di-n-butylphthalate, diethylphthalate, and butylbenzylphthalate. Information on the uses and toxicity of most individual phthalate esters is readily available, while that on their environmental fate is less well studied. Toxicity data are presented for each of the four phthalate esters detected, and the environmental fate of phthalate esters as a group is discussed in the following paragraphs.

Bis(2-ethylhexyl)phthalate is a common laboratory contaminant. It is used in vacuum pumps and is a possible human carcinogen. When heated to decomposition, it emits acrid smoke.

Di-n-butylphthalate is an ubiquitous pollutant due to its widespread use primarily as a plasticizer. It is also used as an insect repellent and as a component of leather varnishes and mixed lacquers.

Diethylphthalate is a clear, colorless, odorless liquid. It is used as a solvent, a plasticizer, a wetting agent, a camphor substitute, an alcohol denaturant, and a mosquito repellent, and in cellulose acetate, insecticide sprays, plastics, and perfumes.

Butylbenzylphthalate (BBP) is used as a plasticizer in the manufacture of polyvinyl and cellulosic resins. Most BBP releases are due to the manufacture of polyvinyl chloride. BBP is used primarily in flooring materials.

A variety of organisms can accumulate phthalate esters, and these chemicals have been known to concentrate in animal and human tissues and organs. Under aerobic conditions microbial systems can degrade phthalate esters, but under anaerobic conditions, bis-(2-ethylhexyl)phthalate in particular ceases to degrade. In determining the environmental fate of phthalate esters, bioaccumulation, biotransformation, and biodegradation are probably the most important processes.

In humans, bis(2-ethylhexyl)phthalate is readily absorbed following oral or inhalation exposure. It has been classified as a group B2 probable human carcinogen by EPA. Chronic oral exposure to bis(2-ethylhexyl)phthalate may affect the liver.

Diethylphthalate is irritating to mucous membranes and, in high concentrations, is a narcotic. It is an experimental teratogen and an eye irritant. It is classified as a group D carcinogen by EPA.

Di-n-butylphthalate has been reported to cause increased miscarriages, menstrual disorders, reduced gestation, and accelerated delivery rates in workers exposed to the chemical. Ingestion is reported to have caused severe keratitis, corneal epithelium, and transitory toxic nephritis. Chronic exposure to di-n-butylphthalate may lead to death. Di-n-butylphthalate has not been classified as to its carcinogenicity by EPA.

Ingestion of butylbenzylphthalate by laboratory animals causes body weight gain and may also affect reproductive organs, liver, and kidneys. Butylbenzylphthalate has been classified as a group B2 probable human carcinogen by EPA.

Polycyclic aromatic hydrocarbons. PAHs are a class of chemical compounds characterized by a basic structure of two or more fused aromatic (benzene) rings. The compounds are fused by pairs of carbon atoms, resulting in a molecule with a carbon atom lying in a single plane with hydrogen atoms. The lowest-molecular-weight member of this group is naphthalene, with two fused rings. The highest-molecular-weight member is graphite. PAH compounds can be divided into two groups by their chemical, physical, and biological properties: the lower-molecular-weight (two- to three-ring) compounds, and the higher-molecular-weight (four- to seven-ring) compounds. The PAHs associated with sites at the 120th FIG Base include naphthalene (two-ring), 2-methylnaphthalene (2-ring), phenanthrene (three-

ring), pyrene (four-ring), fluoranthene (four-ring), and benzo(b)fluoranthene (four-ring).

The physical properties of PAHs typically vary with increasing molecular weight. Vapor pressure and solubility decrease almost logarithmically with increasing molecular weight. Resistance to reduction and oxidation typically decreases with increasing molecular weight. These trends help to explain why the lower-ring-numbered and higher-ring-numbered compounds differ substantially in their behavior and distribution in the environment.

In the case of PAH compounds, the lower-ring-numbered compounds have K_{oc} values in the 10^3 to 10^4 range. The higher-ring-numbered compounds have K_{oc} values from 10^5 to 10^6 . K_{oc} values for PAHs are very high, indicating little tendency for mobility.

PAHs have been noted to be ubiquitous in the environment. In the past, PAH compounds were typically thought to result only from high-temperature pyrolysis of organic materials. Although this is the principal means of PAH generation, additional sources of PAHs have more recently been shown to be low-temperature transformation of sedimentary organic material to form fossil fuels and direct biosynthesis by microbes and plants. Anthropogenic sources also increase the loading of PAHs into the environment. These sources are industrial activities such as coke and coal gas production, gas production from petroleum, oil refining, and preparation of acetylene from natural gas. Other sources include incineration of domestic and industrial wastes, power generation from fossil fuels, and automobile exhaust.

Biodegradation is thought to be the primary fate of PAHs in the environment. Some PAH compounds have been noted to be highly toxic, carcinogenic, mutagenic, and/or teratogenic to many species. PAHs have demonstrated toxicity via the oral and dermal routes, indicating that they are capable of passage across epithelial membranes. Additionally, research indicates that they are easily absorbed through the lungs. They tend to concentrate initially in the liver and kidneys until they are excreted. They eventually move to organs containing or surrounded by fat (e.g., mammary glands and adrenals).

PAH compounds vary substantially in their acute toxicity to aquatic animals. In general, toxicity to aquatic species will increase with increasing molecular weight. However, the higher-ring-numbered PAHs have low acute toxicity, apparently due to their low solubilities. In most cases, crustaceans are the most sensitive species, polychaete worms are intermediate in sensitivity, and fish are the most resistant. Acute toxicity levels in water are several orders of magnitude higher than levels found in even the most polluted marine and freshwaters. Sediment levels typically approach concentrations similar to the acutely toxic level; however, being bound to the sediment renders PAHs considerably less toxic.

Tetrachloroethene (PCE). PCE is a colorless liquid with a pleasant, ethereal odor. It is used in the synthesis of spiro compounds and as an aromatizing agent. PCE is ubiquitous in the environment. Volatilization is the major transport process for PCE. Photodissociation, oxidation, hydrolysis, biodegradation, and adsorption

do not appear to be important processes in determining the fate of PCE in the environment.

PCE has been classified as a group B2 probable human carcinogen by EPA. The liver is a target organ both in inhalation and oral exposures. Inhalation exposure may also cause leukemia. Some bioaccumulation may occur, but there is no evidence of biomagnification.

Toluene. Toluene is a monocyclic, aromatic, colorless liquid. It is used in manufacturing benzoic acid, benzaldehyde, explosives, dyes, and many other organic compounds. Toluene functions as a solvent in products such as wood furniture cleaners.

From the available data, it appears that volatilization is the major route of toluene removal from aquatic environments. Once volatilized, atmospheric photodestruction of toluene probably subordinates all other fates. Toluene will be adsorbed by sediments and suspended solids, but the degree to which this adsorption will interfere with volatilization is unknown. Toluene does not bioaccumulate in the environment.

Toluene in low levels may irritate both the skin and eye and may cause impairment of coordination and reaction time when inhaled at low levels. Higher levels of exposure may produce additional symptoms such as headaches, nausea, and loss of appetite. Acute poisoning is rare, but chronic poisoning occasionally results in anemia and leucopenia.

Trichloroethene (TCE). TCE is a halogenated organic compound very commonly used in industry, primarily as a solvent. Other uses are dry cleaning, fumigation, paint dilution, aerospace operations, and textile processing.

TCE is relatively mobile in the soil-groundwater system, particularly where soils have a low organic content. It is moderately soluble in water but can be sorbed onto soils with sufficiently high organic content. Transport mechanisms include volatilization in near-surface soils and migration in groundwater. Most TCE released onto surface soils will volatilize. TCE can be biodegraded into cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE, and vinyl chloride.

TCE has been classified as a group B2 probable human carcinogen by EPA. The target organ depends on the route of exposure. Inhalation exposure results in lung tumors; oral ingestion causes liver tumors. Chronic exposure to TCE may affect the central nervous system and cause minor liver-function impairments. Short-term, high-level concentrations of TCE may cause depression of the central nervous system, kidney and liver damage, cardiovascular damage, and death due to ventricular fibrillation. Short-term, low-level exposure may cause irritation of the eyes, nose, throat, and skin. TCE may bioaccumulate in organisms, but it does not appear to biomagnify in the food chain.

Xylenes. Xylenes are mixtures of the ortho-, meta-, and para-dimethyl benzenes, with the meta- form usually the principal component. Xylenes may also contain 6 to 10 percent impurities such as benzene, ethyl benzene, trimethylbenzene, toluene, phenol, thiophene, pyridene, and nonaromatic hydrocarbons.

Xylenes are widely used as fuel components and as solvents for inks, rubbers, gums, resins, adhesives, lacquers, paints, and insecticides. Xylenes are commonly used in the chemical industry as intermediates. Specifically, ortho-xylene is used in the manufacture of phthalic anhydride, which is a basic building block for plasticizers. Meta-xylene is an intermediate in the preparation of isophthalic acid, which is the base of unsaturated polyester resins. Commercially, para-xylene is the most important isomer, and most of it is converted to terephthalic acid or dimethylterephthalate and used to make fibers, films, and resins.

The primary exposure pathway of concern from soil-groundwater systems is the migration of xylenes into groundwater used for drinking water supplies. Inhalation resulting from volatilization from surface soils may also be important. Xylenes are relatively mobile in soil-water systems, especially in the aqueous phase. Volatilization is also possible. The chemical is resistant to hydrolysis but is probably biodegradable. Xylenes may persist for months to years.

The three xylene isomers have similar toxicological properties and are discussed together. Approximately 60 percent of an inhaled dose is absorbed, and absorption of orally administered xylene is nearly complete. Dermal absorption is reported to be minor following exposure to xylene vapor, but may be significant following contact with the liquid. Liquid xylene and high vapor concentrations are irritating to the eyes, and the vapor may cause transient, reversible damage to the cornea. Aspiration of liquid into the lungs may cause chemical pneumonitis, pulmonary edema, and hemorrhage. The effects of chronic exposure resemble those from acute exposure, but are more severe.

In humans, acute inhalation exposure to relatively high concentrations of xylenes adversely affects the central nervous system and lungs, and can irritate mucous membranes. Symptoms include dizziness, drowsiness, nausea, vomiting, abdominal pain, loss of appetite, weight loss, pulmonary edema, and unconsciousness, as well as reversible effects on the liver and kidneys. Xylenes have not been classified by EPA as to their carcinogenicity.

4.2.2.3 Mechanisms of Migration

The media into which chemicals migrate can affect the types of exposures that could occur. For example, a very volatile chemical is likely to be released into air, and thus inhalation exposures may occur. Mechanisms of chemical migration are discussed below to help identify potential exposure pathways.

There are several mechanisms by which chemicals may migrate from source locations at the 120th FIG Base. Contaminated soil, sediment, groundwater, and surface water can act as sources of contaminant migration. Migration of contaminants into the air can occur via fugitive dust emissions and volatilization. Migration into groundwater can occur by percolation of rainfall with subsequent leaching and transport. Migration into surface water can occur from precipitation run off. The migration of organic chemicals may be altered by biotransformations which may enhance or inhibit transport. The movement of inorganic compounds depends on physical-chemical processes such as pH, ionic charge, and adsorption.

4.2.2.4 Exposure Pathways

Potential pathways of exposure to chemicals of concern at all eight sites at the Base have been summarized in Table 4.2. Demographic and land use information presented in section 1 was used in developing exposure pathways. EPA requires that hypothetical future use of a site as well as current use be considered. Therefore, Table 4.2 presents current-use and future-use pathways.

Current-use pathways include exposure to air, groundwater, surface water, soils, and sediments to base personnel and non-base personnel. All current-use pathways have little or no probability of completion. The possibility of air contamination is based on the presence of volatiles that were detected in surface soils at several sites. However, since soil concentrations are low and since some of the sites may be partially paved or vegetated, contaminant release via volatilization and fugitive dust generation is likely to be very low.

There is no permanent surface water body on the 120th FIG Base. However, sites 2 and 6 contain drainage ditches that collect run off during heavy precipitation. Contact with run off waters by base personnel is unlikely. No contact with groundwater is anticipated because the base's potable water is supplied by the City of Great Falls. Contact with contaminated soils and sediments is possible but unlikely for base personnel, and is not anticipated for non-base personnel because access to the base is restricted by fences and security personnel.

Future-use pathways resulting from a change in land use could include exposure to contaminated air, groundwater, surface water, soils, and sediments by hypothetical residents, non-base personnel, downstream water users, and future hypothetical construction workers. Exposure to subsurface soils is possible for all receptors if these soils are exposed via excavation. The probability of future-use pathway completions is higher than for current use, primarily because the base may be developed for other uses at some point in the future. No timeframe for future development was considered for the PRE. Current contaminant concentrations were used for risk evaluation.

4.2.3 Toxicity Assessment

The objective of the toxicity assessment is to weigh available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals and to provide, where possible, an estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. The types of toxicity information considered in this assessment are the slope factor for evaluation of carcinogenic potential, and the reference dose (RfD) for evaluation of noncarcinogenic effects.

4.2.3.1 Health Criteria for Carcinogenic Effects

For chemicals that exhibit carcinogenic effects, most authorities recognize that one or more molecular events can evoke changes in a single cell or a small number of cells that can lead to tumor formation. This is the nonthreshold theory of carcinogenesis which purports that any level of exposure to a carcinogen can result in some finite possibility of generating the disease. Generally, regulatory agencies

Table 4.2 Matrix of Potential Exposure Pathways
120th FIG, International Airport, Great Falls, Montana

Transport Medium	Release Source and Mechanism	Primary Exposure Point	Potential Receptors	Primary Exposure Route	Probability of Pathway Completion
Current use					
Air	Affected soils/fugitive dust generation, volatilization	Montana ANGB and areas downwind	Base personnel, Non-base personnel	Inhalation, dermal	Moderate: Volatiles were detected in surface soils and sediments near occupied buildings.
Groundwater	Affected soils, ground water/site leaching	None: No current groundwater use	Base personnel	Ingestion, inhalation, dermal	None: Base served by city water.
Surface water	Affected soils, ground-water/seepage of groundwater, surface runoff	Surface runoff	Base personnel	Ingestion, dermal	Low: Surface runoff occurs only after a heavy rainfall. Workers unlikely to intentionally walk through drainage ditches.
			Non-base personnel	Ingestion, dermal	None: Access to the site is restricted.
Soils/sediments	Affected soils, sediments, surface water and ground-water/site leaching, runoff, tracking	Surface soils and sediments	Base personnel	Ingestion, dermal	Low: Incidental contact with soils or sediment would be infrequent.
			Non-base personnel	Ingestion, dermal	None: Access to the site is restricted.
		Subsurface soils	Construction workers	Ingestion, dermal	Likely if construction or excavation takes place.

Table 4.2, continued

Transport Medium	Release Source and Mechanism	Primary Exposure Point	Potential Receptors	Primary Exposure Route	Probability of Pathway Completion
Future use					
Air	Affected soils/fugitive dust generation, volatilization	Montana ANGB and areas downwind	Base personnel, Non-base personnel, construction workers	Inhalation, dermal	Moderate: Volatiles were detected in surface and subsurface soils and sediments.
Groundwater	Affected soils, ground water/site leaching	Hypothetical future onsite wells	Residents	Ingestion, inhalation, dermal	Low: Would not be likely to occur unless the base is sold.
4-24 Surface water	Affected soils, outfalls, groundwater/Surface runoff, ground-water seepage	Surface runoff	Residents, non-base personnel	Ingestion, inhalation, dermal	Low: Surface runoffs occurs only after a heavy rainfall. Unlikely that base would be developed or become unrestricted.
	Surface runoff	Surface water entering downstream drinking water source	Downstream water users	Ingestion, inhalation, dermal	Low: Unlikely that runoff would enter drinking water source unless dramatic change in climate or drainage patterns occurred.

Table 4.2, continued

Transport Medium	Release Source and Mechanism	Primary Exposure Point	Potential Receptors	Primary Exposure Route	Probability of Pathway Completion
Soil/ sediment	Affected soils, sediments, surface water and ground water/site leaching, runoff, tracking	Surface soils and sediments at the site	Residents	Ingestion, dermal	Likely if residence(s) are developed on base.
			Non - base personnel	Ingestion, dermal	Likely if base access restrictions are removed.
		Subsurface soils on site	Construction workers	Ingestion, dermal	Likely if construction takes place, if possible.
			Residents, non - base personnel workers	Ingestion, dermal	Likely if subsurface soils are exposed through excavation.

assume the nonthreshold hypothesis for carcinogens in the absence of information concerning the mechanisms of action for the chemical (U.S. Environmental Protection Agency, 1989b).

EPA's Carcinogen Assessment Group (CAG) has developed slope factors (i.e., dose-response values) for estimating excess lifetime cancer risks associated with various levels of lifetime exposure to potential human carcinogens. Risks estimated using slope factors are considered unlikely to underestimate actual risks, but they may overestimate actual risks. Excess lifetime cancer risks are generally expressed in scientific notation and are probabilities. An excess lifetime cancer risk of 1×10^{-6} (one in one million), for example, represents the probability that an individual will develop cancer as a result of exposure to a carcinogenic chemical over a 70-year lifetime under specified exposure conditions. EPA has suggested developing remedial alternatives for cleanup of Superfund sites using total excess lifetime cancer risks ranging from 1×10^{-4} (one-in-ten-thousand) to 1×10^{-6} (one-in-one-million).

In practice, slope factors are derived from the results of human epidemiology studies or chronic animal bioassays. The data from animal studies are fitted to the linearized multistage model, and a dose-response curve is obtained. The 95th-percentile upper-confidence-limit slope of the dose-response curve is subjected to various adjustments, and an interspecies scaling factor is applied to conservatively derive the slope factor for humans. Thus, the actual risks associated with exposure to a potential carcinogen quantitatively evaluated based on animal data are not likely to exceed the risks estimated using these slope factors, but they may be much lower. Dose-response data derived from human epidemiological studies are fitted to dose-time-response curves on an ad hoc basis. These models provide rough but plausible estimates of the upper limits on lifetime risk. Slope factors based on human epidemiological data are also derived using very conservative assumptions and, as such, they too are considered unlikely to underestimate risks. In summary, while the actual risks associated with exposures to potential carcinogens are unlikely to be higher than the risks calculated using a slope factor, they could be considerably lower.

In addition, there are varying degrees of confidence in the weight of evidence for carcinogenicity of a given chemical. EPA has proposed a system for characterizing the overall weight of evidence for a chemical's carcinogenicity based on the availability of animal, human, and other supportive data (U.S. Environmental Protection Agency, 1989b). The weight-of-evidence classification is an attempt to determine the likelihood that an agent is a human carcinogen, and thus qualitatively affects the estimation of potential health risks. Three major factors are considered in characterizing the overall weight of evidence for carcinogenicity: (1) the quality of evidence from human studies and (2) the quality of evidence from animal studies, which are combined into a characterization of the overall weight of evidence for human carcinogenicity; and (3) other supportive information which is assessed to determine whether the overall weight of evidence should be modified. EPA's final classification of the overall weight of evidence includes the following five categories:

- **Group A, human carcinogen:** This category indicates that there is sufficient evidence from epidemiological studies to support a casual association between an agent and cancer.
- **Group B, probable human carcinogen:** This category generally indicates that there is at least limited evidence from epidemiological studies of carcinogenicity to humans (group B1), or that, in the absence of adequate data on humans, there is sufficient evidence of carcinogenicity in animals (group B2).
- **Group C, possible human carcinogen:** This category indicates that there is limited evidence of carcinogenicity in animals in the absence of data on humans.
- **Group D, not classified:** This category indicates that the evidence for carcinogenicity in animals is inadequate.
- **Group E, no evidence of carcinogenicity to humans:** This category indicates that there is no evidence for carcinogenicity in at least two adequate animal tests in different species, or both in epidemiological and in animal studies.

Slope factors are developed based on epidemiological or animal bioassay data for a specific route of exposure, either oral or inhalation. For some chemicals, sufficient data are available to develop route-specific slope factors for inhalation and ingestion. For chemicals with only one route-specific slope factor but for which carcinogenic effects may also occur via another route, the available value may be used to evaluate risks associated with both potential routes of exposure.

Several of the chemicals of concern at the 120th FIG Base have been classified as potential carcinogens by EPA, and each of these has also been assigned a carcinogenicity weight-of-evidence category (Table 4.3). Some of these chemicals are:

Group A, human carcinogens:

Arsenic
Benzene
Cr(VI)

Group B, probable human carcinogens:

Benzo(b)fluoranthene	Butylbenzylphthalate
Bis(2-ethylhexyl)phthalate	PCE
Cadmium	TCE
Lead	Chloroform
1,2-Dichlorobenzene	1,4-Dichlorobenzene

Group C, possible human carcinogens:

None

Potential carcinogenic effects and slope factors for chemicals of concern identified at the base are presented in Table 4.3.

Table 4.3 Toxicity Values: Potential Carcinogenic Effects
for Chemicals of Potential Concern at 120th FIG, International Airport
Great Falls, Montana

Chemical	Slope factor 1/(mg/kg-day)		Weight-of-Evidence Classification a/		Type of Cancer	
	Inhalation	Oral	Inhalation	Oral	Inhalation	Oral
Inorganics						
Arsenic	5.00E+01	NA	b/	A	Respiratory tract	Skin
Barium	See Table 4.4	ND				
Cadmium	6.1E+00	ND				
Chromium III	ND c/	ND	NA d/	NA	Respiratory tract	NA
Chromium VI	4.1E+01	ND	A	ND	Lung	NA
Copper	See Table 4.4					
Lead	ND	ND	B2	B2	Possible liver and kidney tumors	Possible liver and kidney tumors
Mercury	See Table 4.4					
Nickel (refinery dust)	8.40E-01	ND	A	ND	Respiratory tract	NA
Selenium	No information, See Table 4.4					
Zinc	No information, See Table 4.4					
Organics						
Acetone	See Table 4.4					
Benzene	2.9E-02	2.9E-02	A	A	Leukemia	Leukemia
Bis(2-ethylhexyl)phthalate	ND	1.4 E-02	B2	B2	NA	Liver
2-Butanone	NA	NA	D	D	NA	NA
Butylbenzylphthalate	See Table 4.4					
Chlorobenzene	See Table 4.4					
Chloroform	8.1E-02	6.1E-03	B2	B2	Liver	Kidney
1,2-Dichlorobenzene	See Table 4.4					
1,4-Dichlorobenzene	ND	2.4E-02	B2	B2	NA	Liver
Diethylphthalate	See Table 4.4					
Di-n-butylphthalate	See Table 4.4					
cis-1,2 Dichloroethene	See Table 4.4					
trans-1,2-Dichloroethene	See Table 4.4					

Table 4.3, continued

Chemical	Slope factor 1/(mg/kg-day)		Weight-of-Evidence Classification a/		Type of Cancer	
	Inhalation	Oral	Inhalation	Oral	Inhalation	Oral
Organics, continued						
Ethyl benzene	See Table 4.4					
Tetrachloroethene	3.30E-03	5.10E-02	B2	B2	Leukemia, liver	Liver
Toluene	See Table 4.4		D	D		
Trichloroethene	1.7E-02 d/	1.1E-02 d/	B2	B2	Lung	Liver
Xylenes	See Table 4.4					
Polycyclic aromatic hydrocarbons						
Benzo(b)fluoranthene	ND	ND	B2	B2	NA	NA
Fluoranthene	See Table 4.4					
2-Methylnaphthalene	No information					
Naphthalene	See Table 4.4					
Phenanthrene	No information	--				
Pyrene	See Table 4.4					

a/ A=Human carcinogen; B=Probable human carcinogen (B1-limited evidence of carcinogenicity in humans; B2-sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans); C=Possible human carcinogen.

b/ NA=Not applicable or not available

d/ ND=Not determined

d/ Based on metabolized dose assuming a 54 percent absorption.

Source: U.S. Environmental Protection Agency, 1990a and 1990b.

4.2.3.2 Health Criteria for Noncarcinogenic Effects

For chemicals that exhibit noncarcinogenic (e.g., systemic) effects, many authorities consider organisms to have repair and detoxification capabilities that must be exceeded by some critical concentration (threshold) before the health effect is manifested. For example, an organ can have a large number of cells, ALL performing the same or similar functions, which must be significantly depleted before the effect on the organ is seen. This threshold view holds that a range of exposures from just above zero to some finite value can be tolerated by the organism without an appreciable risk of adverse effects.

Health criteria for chemicals exhibiting noncarcinogenic effects for use in risk assessment are generally developed using EPA RfDs (reference doses) developed by the RfD/Reference Concentrations Work Group and included in the Integrated Risk Information System (IRIS) (U.S. Environmental Protection Agency, 1990b). For those chemicals for which EPA has not derived verified RfDs, health criteria used in a risk assessment may be derived from information provided in EPA documents. In general, the RfD is an estimate of an average daily exposure to an individual (including sensitive individuals) below which there will be no appreciable risk of adverse health effects. The RfD is derived using conservative safety factors (e.g., to adjust from animals to humans and to protect sensitive subpopulations) to ensure that the potential for adverse noncarcinogenic effects is not underestimated. The purpose of the RfD is to set a benchmark with which the sum of other doses (e.g., those projected from human exposure to various environmental conditions) might be compared. Doses that are significantly higher than the RfD may indicate an inadequate margin of safety for exposure to that substance and the possibility of an adverse health effect.

EPA has developed RfDs for many of the chemicals of concern selected for the 120th FIG Base. The chemicals of concern may affect different target organs in the body. Some of the chemicals of concern that may have noncarcinogenic effects following long-term exposure, and the target organs that are most sensitive to these chemicals, are as follows:

Chemicals that may adversely affect the liver:

Bis(2-ethylhexyl)phthalate	PCE
Cr (III)	TCE
Ethyl benzene	1,4-Dichlorobenzene
Lead	1,2-DCE

Chemicals that may adversely affect the liver and kidney

Cadmium	Chloroform
Ethyl benzene	Acetone
Mercury	Butylbenzylphthalate
Fluoranthene	Chlorobenzene

Chemicals that may adversely affect the central nervous system

Lead
Toluene
TCE

Chemicals that may adversely affect the kidneys

Pyrene
Mercury

Chemicals that may adversely affect other systems:

Arsenic may cause keratosis.
Barium may cause cardiovascular effects.
Cr(III) may cause reductions in organ weight.
Copper may cause local gastrointestinal irritation.
2-Butanone may cause fetotoxicity.
Di-n-butylphthalate may cause mortality.
Diethylphthalate may cause reduced terminal body weight.
Naphthalene may cause ocular and internal lesions.
Nickel may cause reduced body and organ weight.
Selenium may cause dermatitis and gastrointestinal disturbances.
Total xylenes may cause reproductive effects.
Zinc may cause anemia.

Potential noncarcinogenic effects and RfDs of chemicals of concern identified at the base are shown on Table 4.4.

No RfDs or slope factors are available for the dermal route of exposure. In some cases, however, noncarcinogenic or carcinogenic risks associated with dermal exposure can be evaluated using an oral RfD or an oral slope factor. Exposures via the dermal route generally are calculated and expressed as *absorbed doses*. These absorbed doses are compared to an oral toxicity value that is also expressed as an absorbed dose. This comparison is only appropriate for chemicals causing effects through a systemic action. At this time, toxicity information expressed as an absorbed dose is not available for chemicals of concern identified at the base.

4.2.4 Risk Screening

4.2.4.1 Human Health Criteria

In this section concentrations of chemicals of concern are compared with appropriate criteria to provide a rough estimation of whether the contaminants pose a risk. The method is intended as a preliminary screening tool rather than a detailed evaluation of risks posed by contaminants at the site. For clarity, each of the eight sites is evaluated separately.

Maximum concentrations of chemicals at each of the eight sites at the 120th FIG Air Base were compared with health criteria. Health criteria may consist of applicable or relevant and appropriate requirements (ARARs), EPA-established exposure-limit criteria (e.g., slope factors and RfDs), or other standards, guidelines, and toxic threshold values.

Maximum chemical concentrations were first compared to ARARs. Section 121 of the Superfund Amendments and Reauthorization Act (SARA) establishes cleanup criteria for Superfund sites. This section of the statute sets forth the need for appropriate remedial actions, consistent with the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), that achieve a cost-effective

Table 4.4 Toxicity Values: Potential Noncarcinogenic Effects
for Potential Chemicals of Concern at
120th FIG, International Airport, Great Falls, Montana

Chemical	Chronic RID (mg/kg-day)		Critical Effect	
	Inhalation	Oral	Inhalation	Oral
Inorganics:				
Arsenic	ND/1E-04	1.00E-03	Cancer b/ Fetotoxicity	Keratinosis and hyperpigmentation; cancer b/ Increased blood pressure
Barium	ND	7E-02	Cancer b/ NA c/	Renal damage
Cadmium	ND	5E-04	Cancer b/ NA	Hepatotoxicity
Chromium III	ND	1.00E+00	Cancer b/ NA	Not defined
Chromium VI	ND	5E-03	Cancer b/ NA	Local GI irritation d/ CNS effects e/; cancer b/
Copper	ND	ND	CNS e/; cancer b/ Neurotoxicity	Kidney effects
Lead	3E-04	3E-04	Cancer b/	Reduced body and organ weight
Mercury	ND	2.00E-02		
Nickel	No information			
Selenium	ND	2.0E-1	NA	Anemia
Zinc				
Organics:				
Acetone	ND	1E-01	NA	Increased liver and kidney weight, nephrotoxicity
Benzene	See Table 4.3			
Bis(2-ethylhexyl)phthalate	ND	2E-02	NA	Increased relative liver weight, cancer b/ Fetotoxicity
2-Butanone	9E-02	5E-02	CNS e/	Effects on body weight gain, testes, liver, kidney
Butylbenzylphthalate	ND	2E-01	NA	Liver and kidney effects
Chlorobenzene	5E-03	2E-02	NA	Liver lesions
Chloroform	ND	1E-02	NA	Decreased hematocrit and hemoglobin
Cis - 1,2-Dichloroethene	ND	1E-02	NA	Increased serum alkaline phosphatase
Trans - 1,2-Dichloroethene	ND	2.00E-02	NA	Liver effects/cancer b/
1,2-Dichlorobenzene	4E-02	9E-02	Decreased body Weight gain	
1,4-Dichlorobenzene	7E-01	ND	Liver and kidney effects	ND
Diethylphthalate	ND	8E-01	NA	Reduced terminal body weight
Di-n-butylphthalate	ND	1E-01	NA	Mortality
Ethyl benzene	ND	1E-01	NA	Hepatotoxicity and nephrotoxicity
Tetrachloroethene	ND	1.00E-02	cancer b/ CNS e/; eye and nose irritation	Hepatotoxicity, cancer b/ CNS e/
Toluene	2E+00	2E-01		
Trichloroethene	Pending	Pending		CNS e/
Xylenes	3E-1	2E+00	CNS e/; nose and throat irritation	Hyperactivity, decreased body weight and increased mortality at higher dosage

Table 4.4, continued

Chemical	Chronic RfD (mg/kg-day)		Critical Effect	
	Inhalation	Oral	Inhalation	Oral
Polycyclic aromatic hydrocarbons:				
Benzo(b)fluoranthene	See Table 4.3	ND	NA	Nephropathy, liver weight changes, Hematological changes; cancer b/
Fluoranthene	ND	4E-02	NA	
2-Methylnaphthalene	No information	ND	NA	Ocular and internal lesions
Naphthalene	See Table 4.3	ND	NA	Renal effects
Phenanthrene	ND	3E-02	NA	
Pyrene	ND	3E-02	NA	

a/ ND = not determined

b/ See Table 4.3

c/ NA = not applicable or not available

d/ GI = gastrointestinal

e/ CNS = Central Nervous System

Source: U.S. Environmental Protection Agency, 1990a and 1990b.

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response. Subsection (d) of section 121 generally requires that remedial actions attain a level of standard of control at least equivalent to ARARs promulgated under federal or state laws. *Applicable standards* are those cleanup or control standards and other substantive environmental protection requirements, criteria, or limitations, promulgated under federal or state law which specifically address a hazardous substance, pollutant, contaminant, remedial action location, or other circumstance at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site. *Relevant or appropriate standards* are those cleanup or control standards, and other substantive environmental protection requirements, criteria, or limitations, promulgated under federal or state law that, while not *applicable*, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site. EPA has identified three categories of ARARs:

- Chemical-specific
- Location-specific (e.g., wetland limitations or historical sites)
- Action-specific (e.g., performance and design standards).

In performing this preliminary risk evaluation, chemical-specific ARARs were considered. Potential federal ARARs are presented in Table 4.5.

At the present time, EPA considers drinking water maximum contaminant levels (MCLs), federal ambient water quality criteria (WQC), national ambient air quality standards (NAAQS), and promulgated state environmental standards to be ARARs. WQC may be considered ARARs for groundwater only if they reflect current scientific information and there are no federal MCLs or state ARARs.

Since ARARs are not available for all chemicals in all media of concern, it was necessary in some instances to develop health-based criteria which could be used in a manner similar to ARARs. EPA reference toxicity information (RfDs and carcinogenic slope factors) was used, when available, to develop these criteria. This toxicity information was obtained from U.S. EPA's IRIS (integrated risk information system) database (online, EPA, 1990b).

In all cases, health criteria were based on exposure scenarios which would yield the lowest possible concentrations in a given medium of concern. For chemicals which produce both carcinogenic and noncarcinogenic effects by a given route of exposure, the lowest value is used as the health criterion (usually the value based on carcinogenic effects).

For carcinogenic chemicals, the following equation was used to calculate health criteria:

$$C_i = (R/q_1^*) \times (W/I)$$

where

C_i = the criterion concentration for the constituent of interest

R = the specified risk level (e.g., 10^{-6} for class A and class B carcinogens, 10^{-5} for class C carcinogens)

**Table 4.5 Potential Federal Applicable or Relevant
and Appropriate Requirements for Chemicals of Potential Concern
120th FIG, International Airport, Great Falls, Montana**

Chemicals	Federal ARARs (mg/L unless otherwise noted)	
	SDWA MCLs a/	WQC Drinking Water b/
Organics		
1,2-Dichloroethene	0.07/0.1 c/	0(0.00094) d/
1,2-Dichlorobenzene	0.6 e/	0.470 f/
1,4-Dichlorobenzene	0.075	0.470 f/
2-Butanone	—	—
2-Methylnaphthalene	—	—
Acetone	—	—
Benzene	0.005	0(0.00067) d/
Benzo(b)fluoranthene	0.0002 e/	0(0.0000031) d/ g/
Bis(2-ethylhexyl)phthalate	0.004 e/ h/	—
Butylbenzylphthalate	0.1 e/	—
Chlorobenzene	0.1 e/	0.488
Chloroform	0.1 i/	0(0.00019) d/
Diethylphthalate	0.004 e/ h/	434
Di-n-butylphthalate	0.004 e/ h/	44
Ethylbenzene	0.7 e/	2.4
Fluoranthene	—	0.188
Naphthalene	—	—
Phenanthrene	—	0(0.0000031) d/ g/
Pyrene	—	0(0.0000031) d/ g/
Tetrachloroethene	0.005 e/	0.(0.00088) d/
Toluene	2 e/	15
Total petroleum hydrocarbons	—	—
Trichloroethene	0.005	0(0.0028) d/
Xylenes	10 e/	—
Inorganics		
Arsenic	0.05	0(0.000025) d/
Barium	1.0/5 e/	—
Cadmium	0.01/0.005 e/	0.01
Chromium	0.05/0.1 e/	0.05(VI)/179(III)
Copper	1.3 e/	—
Lead	0.05/0.005 e/	0.05
Mercury	0.002	0.010
Nickel	0.1 e/	0.0154
Selenium	0.01/0.05 e/	0.01
Zinc	—	5 j/

a/ SDWA MCLs = Safe Drinking Water Act Maximum Contaminant Levels, 40 CFR Part 141 (USEPA, 1989a and 1990c).

b/ WQC Drinking Water = Water Quality Criteria adjusted for drinking water, 40 CFR Part 131 (USEPA, 1986b).

c/ Proposed value for cis/trans isomers, respectively.

d/ The value for carcinogens is zero. The number in parentheses corresponds to a E-06 risk.

e/ Proposed value.

f/ Value is for all dichlorobenzene isomers.

g/ Value for total polycyclic aromatic hydrocarbons.

h/ Value for total phthalate esters. (Proposed value for butylbenzyl phthalate is 0.1).

i/ Value is for total trihalomethanes.

j/ Value for organoleptic (i.e., taste and odor) effects.

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q1* = the carcinogenic slope factor in (mg/kg/day)⁻¹ developed by the EPA Office of Health and Environmental Assessment, or EPA's Carcinogen Risk Assessment Verification Endeavor (CRAVE) work group

W = the assumed weight of the exposed individual

I = the intake amount averaged over a 70-year lifespan.

For carcinogenic substances in both surface and subsurface soils, maximum exposure is anticipated to occur for adults in the hypothetical residential setting. Although the "child" soil ingestion rate is higher than the adult value, the adult exposure scenario yields a more protective (lower) concentration since exposures for carcinogens are averaged over a 70-year lifespan. Thus, health criteria for carcinogens in soil were developed by assuming that a 70-kg adult (W) ingests 0.1 gram of soil per day (I). When groundwater or surface water was the medium of concern, the carcinogen criteria for water were used unless MCLs existed. The slope factors (SF) used in the development of these criteria are given in Table 4.3. The assumed I for water ingestion is 2 liters per day (L/day) for a 70-kg person. Criteria for the inhalation pathway were not calculated because no air monitoring data were collected. No toxicity data are currently available to address the dermal route of exposure.

For chemicals which produce noncarcinogenic health effects, health criteria were developed on the basis of maximum exposures via the following equation:

$$C_i = (RfD) \times (W/I)$$

where

C_i = criterion concentration for constituent of interest

RfD = reference dose developed by EPA

W = the assumed weight of the exposed individual

I = the intake amount for a given, chronic time period.

For soils, maximum exposure to noncarcinogens is anticipated to occur via the child ingestion scenario where a 16 kg child (W) ingests 0.2 grams of soil per day (I) for 5 years. This exposure scenario yields lower values than the adult soil ingestion scenario used above because exposures to noncarcinogens are not averaged over a 70-year lifespan. Health criteria for groundwater were based on adult ingestion (I - 2 L/day) and body weight (W - 70 kg). The RfDs used in the calculation of these criteria are given in Table 4.4.

4.2.4.2 Qualitative Assessment of Site-Specific Risks

A qualitative assessment of human health risks was made for each of the eight sites at the 120th FIG Base. The following paragraphs describe the results of the assessment by medium for each site.

Site 1: Current Fire Training Area

The chemicals of concern for each medium at site 1, their maximum concentration and their associated human health criteria are compared in Tables 4.6 through 4.8. A discussion by medium of potential human health risks is presented in the following paragraphs.

Groundwater. All chemicals detected in groundwater at site 1 were retained as chemicals of concern and are compared with human health criteria in Table 4.6. No criteria were exceeded, indicating a low potential for adverse human health effects.

Soils. Soils data at site 1 were divided into surface soils (less than 2 feet deep) and subsurface soils (greater than 2 feet deep). Exposure to surface soils is currently possible for base personnel. Exposure to surface and subsurface soils is hypothetically possible for future residents, construction workers, base personnel, and non-base personnel.

In subsurface soils, six organic compounds and four metals were determined to be chemicals of concern. The metals chromium, lead, nickel, and zinc were eliminated after comparison with background concentrations. Criterion values were available for all chemicals of concern with the exception of copper. No criteria were exceeded (Table 4.7). Although there are insufficient quantitative data on copper from which to derive an RfD, copper is not reported to be toxic to humans except in persons with inherited metabolic disorders (Carson et al., 1987).

All detected chemicals in surface soil were retained as chemicals of concern at site 1. Human health criteria are available for all the chemicals except for PAHs, TPH, and copper. As shown in Table 4.8, no criteria were exceeded. Although TPH cannot be directly evaluated, components of TPH may be detected in volatile organic compound (VOC) and base/neutral/acid (BNA) organics analyses. No human health risks were identified for the components of TPH included in the VOCs and BNA organics analytes in this sampling event.

Based on available data and criteria, ingestion of soils at site 1 does not appear to present a potential public health risk. However, VOCs detected in surface soils may pose a potential public health risk from inhalation of contaminants. Air quality data were not collected; therefore, this pathway cannot be evaluated.

Site 2: Drainage Ditch Off Old Power Check Pad

The chemicals of concern for each medium, their maximum concentrations, and their associated human health criteria are compared in Tables 4.9 through 4.12. A discussion by medium of the potential human health risks is presented in the following paragraphs.

Groundwater. Selenium, zinc, and TPH were determined to be the chemicals of concern in groundwater at site 2. Barium and lead were eliminated based on a comparison with background concentrations.

In groundwater, selenium slightly exceeded its MCL of 0.01 mg/L (Table 4.9). Selenium is not associated with any identified sources of contaminants and probably derives from the soil, where it occurs naturally. In addition, due to reconsideration

**Table 4.6 Comparison of Groundwater Contaminant
Concentrations with Health Criteria for Site 1
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/L) b/	Criterion Type Used a/	Criterion Value (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
Groundwater Ingestion	Chloroform	1.10E-03	MCL c/	1.00E-01	NO
Inorganics					
	Barium	1.38E-01	MCL	1.00E+00	NO
	Lead	6.40E-03	MCL	5.00E-02	NO
	Selenium	4.20E-03	MCL	1.00E-02	NO
	Zinc	9.52E-01	RfD	7.00E+00	NO

a/ RfD = reference dose; MCL = maximum contaminant level.

b/ mg/L = milligram per liter.

c/ MCL is for trihalomethanes (total).

320SA\AU23405\T4-6.WK1

**Table 4.7 Comparison of Subsurface Soil Contaminant
Concentrations with Health Criteria for Site 1
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion?
Subsurface soil ingestion:					
Organics					
	Acetone	9.00E-02	RfD	8.00E+03	NO
	2-Butanone	1.40E-02	RfD	4.00E+03	NO
	Ethyl benzene	1.60E-02	RfD	8.00E+03	NO
	Toluene	9.20E-02	RfD	1.60E+04	NO
	m,p-Xylene	5.40E-02	RfD	1.60E+05 c/	NO
	o-Xylene	4.00E-02	RfD	1.60E+05 c/	NO
Inorganics					
	Arsenic	1.33E+01	RfD	8.00E+01	NO
	Barium	5.48E+02	RfD	5.60E+03	NO
	Copper	1.81E+01	-	-	-
	Selenium	4.20E-01	RfD	2.40E+02 d/	NO

3205A\AU23405\T4-7.WK1

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ Value is for total xylenes.

d/ Value is for selenious acid.

Table 4.8 Comparison of Surface Soil Contaminant
Concentrations with Health Criteria for Site 1
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface soil ingestion:					
Organics					
	Acetone	2.20E-01	RfD	8.00E+03	NO
	Diethylphthalate	2.70E-01	RfD	6.40E+04	NO
	Ethylbenzene	2.20E+01	RfD	8.00E+03	NO
	Fluoranthene	4.90E+00	RfD	3.20E+03	NO
	2-Methylnaphthalene	1.30E+01	-	-	-
	Phenanthrene	9.50E+00	-	-	-
	Pyrene	1.40E+01	RfD	2.40E+03	NO
	Toluene	8.80E+00	RfD	1.60E+04	NO
	TPH c/	1.20E+05	-	-	-
	m,p-Xylene	1.50E+02	RfD	1.60E+05 d/	NO
	o-Xylene	7.70E+01	RfD	1.60E+05 d/	NO
Inorganics					
	Arsenic	1.77E+01	RfD	8.00E+01	NO
	Barium	7.63E+02	RfD	5.60E+03	NO
	Cadmium	4.00E+00	RfD	4.00E+01	NO
	Chromium	1.95E+00	RfD	8.00E+04 e/	NO
	Copper	2.23E+01	-	-	-
	Lead	1.39E+00	f/	5.00E+02	NO
	Mercury	1.60E-01	RfD	2.40E+01	NO
	Nickel	1.77E+01	RfD	1.60E+03	NO
	Selenium	4.50E-01	RfD	2.40E+02 g/	NO
	Zinc	6.29E+00	RfD	1.60E+04	NO

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ TPH= total petroleum hydrocarbons.

d/ Value is for total xylenes.

e/ Value is for chromium III.

f/ OSWER, 1989.

g/ Value is for selenious acid.

3208A/AU23405YT4-8.WK1

**Table 4.9 Comparison of Groundwater Contaminant
Concentrations with Health Criteria for Site 2
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/L) b/	Criterion Type Used a/	Criterion Value (mg/L)	Release Concentrations Exceed Criterion ?
Groundwater ingestion:					
Organics	TPH c/	7.00E+00	-	-	-
Inorganics	Selenium	1.42E-02	MCL	1.00E-02	YES
	Zinc	3.70E-02	RfD	7.00E+00	NO

a/ RfD = reference dose; MCL = maximum contaminant level.

b/ mg/L = milligram per liter.

c/ TPH = total petroleum hydrocarbons.

3208A/AU/23405/T4-9.WK1

**Table 4.10 Comparison of Subsurface Soil Contaminant
Concentrations with Health Criteria for Site 2
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Subsurface soil ingestion:					
Inorganics	Cadmium	3.80E-01	RfD	4.00E+01	NO
	Copper	1.48E+01	-	-	-
	Lead	1.20E+01	c/	5.00E+02	NO
	Mercury	5.50E-02	RfD	2.40E+01	NO

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ OSWER, 1989.

3208A\AU23405\T4-10.WRI

**Table 4.11 Comparison of Surface Soil Contaminant
Concentrations with Health Criteria for Site 2
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface soil ingestion:					
Organics	Acetone	1.70E-01	RfD	8.00E+03	NO
	bis(2-Ethylhexyl)phthalate	2.00E+00	SF	5.00E+01	NO
	Butylbenzylphthalate	1.40E+00	RfD	1.60E+04	NO
	di-n-butylphthalate	4.90E+00	RfD	8.00E+03	NO
	TPH c/	4.60E+01	-	-	-
Inorganics	Arsenic	8.70E+00	RfD	8.00E+01	NO
	Barium	2.31E+02	RfD	5.60E+03	NO
	Copper	2.96E+01	-	-	-
	Lead	1.77E+01	d/	5.00E+02	NO
	Nickel	1.94E+01	RfD	1.60E+03	NO
	Selenium	5.00E-01	RfD	2.40E+02 e/	NO
	Zinc	8.23E+01	RfD	1.60E+04	NO

a/ RfD = reference dose; SF = slope factor.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ OSWER, 1989.

e/ Value is for selenious acid.

3205A/AU23405/T4-11.W/KI

**Table 4.12 Comparison of Sediment Contaminant
Concentrations with Health Criteria for Site 2
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Sediments ingestion:					
Organics	bis(2-Ethylhexyl)phthalate	2.00E+00	SF	5.00E+01	NO
	Benzo(b)fluoranthene	1.70E+00	-	-	-
	TPH c/	5.90E+02	-	-	-
Inorganics	Arsenic	1.03E+01	RfD	8.00E+01	NO
	Cadmium	2.42E+01	RfD	4.00E+01	NO
	Chromium	6.49E+01	RfD	8.00E+04 d/	NO
	Copper	6.69E+01	-	-	-
	Lead	1.31E+02	e/	5.00E+02	NO
	Mercury	1.90E-01	RfD	2.40E+01	NO
	Nickel	3.75E+01	RfD	1.60E+03	NO
	Selenium	1.10E+00	RfD	2.40E+02 f/	NO
	Zinc	5.55E+02	RfD	1.60E+04	NO

a/ RfD = reference dose; SF = slope factor.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Value is for chromium III.

e/ OSWER, 1989.

f/ Value is for selenious acid.

320SAIAU23405/T4-12.WR

of selenium toxicity, an MCL of 50 $\mu\text{g/L}$ has been proposed for selenium. If the proposed MCL were used to evaluate groundwater for site 2, selenium would not be a problem. Recent human studies on the toxicity of selenium strongly suggest that the proposed MCL would be protective (Iris, 1991). TPH cannot be directly evaluated; however components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the TPH components included in the VOCs and BNA organics analyses in this sampling event. Based on available data and criteria, ingestion of groundwater at site 2 probably does not pose a potential public health concern.

Soils. In subsurface soils, cadmium, copper, lead, and mercury were determined to be the chemicals of concern. Criterion values are available for cadmium, lead, and mercury. As shown in Table 4.10, no criteria were exceeded.

In surface soils, five organics and seven inorganics were retained as chemicals of concern. Chromium was eliminated because its detected concentration approximated background. Criterion values are available for all the chemicals of concern with the exceptions of TPH and copper. No criterion values were exceeded (Table 4.11).

Because no criteria were exceeded in either surface or subsurface soils, ingestion of soils at site 2 probably does not pose a potential public health risk. However, VOCs detected in surface soils may pose a potential public health concern from inhalation of contaminants. Air quality data were not collected, and therefore this pathway cannot be evaluated.

Sediments. All detected chemicals were retained as chemicals of concern with the exception of barium, which was eliminated after comparison with background concentrations (Table 4.12). Bis(2-ethylhexyl)phthalate was the only organic chemical which could be compared to a criterion. As shown in Table 4.12, bis(2-ethylhexyl)phthalate did not exceed its criterion value. Of the metals, only copper could not be evaluated. All other metals did not exceed their criteria. Based on available criteria, ingestion of sediments does not appear to pose a potential public health concern. However, VOCs were detected and may pose a potential public health concern through the inhalation pathway. Air quality data were not collected; therefore this pathway cannot be evaluated.

Site 3: North Disposal and Fire Training Pit

The chemicals of concern for each medium at site 3, their maximum concentrations, and their associated human health criteria are compared in Tables 4.13 through 4.15. A discussion by medium of the potential human health risks is presented in the following paragraphs.

Groundwater. Only TPH and zinc were retained as chemicals of concern at this site (Table 4.13). Barium and lead were eliminated based on comparison with background concentrations. Zinc did not exceed its criterion value. TPH cannot be directly evaluated; however, components of TPH may be detected in VOC and BNA organic analyses. No human health risks were identified for the TPH components included in the VOCs and BNA organics analyzed for in this sampling event.

Table 4.13 Comparison of Groundwater Contaminant
Concentrations with Health Criteria for Site 3
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/L) b/	Criterion Type Used a/	Criterion Value (mg/L)	Release Concentrations Exceed Criterion ?
Groundwater ingestion:					
Organics	TPH c/	2.00E+00	—	—	—
Inorganics	Zinc	6.60E-02	RfD	7.00E+00	NO

a/ RfD = reference dose.

b/ mg/L = milligram per liter.

c/ TPH = total petroleum hydrocarbons.

3205A\AU23405\T4-13.WK1

Table 4.14 Comparison of Subsurface Soil Contaminant
Concentrations with Health Criteria for Site 3
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Subsurface soil ingestion:					
Inorganics	Arsenic	9.20E+00	RfD	8.00E+01	NO
	Copper	1.33E+01	-	-	-
	Lead	9.70E+00	c/	5.00E+02	NO
	Nickel	1.50E+01	RfD	1.60E+03	NO

320SAIAU23405T4-14.W/KI

a/ RfD = reference dose.

b/ mg/kg = milligrams per kilogram.

c/ OSWER, 1989.

**Table 4.15 Comparison of Surface Soil Contaminant
Concentrations with Health Criteria for Site 3
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface soil ingestion:					
Organics	Acetone	2.50E-01	RfD	8.00E+03	NO
	Butylbenzylphthalate	2.00E-01	RfD	1.60E+04	NO
	Diethylphthalate	5.90E-01	RfD	6.40E+04	NO
	Toluene	7.00E-03	RfD	1.60E+04	NO
Inorganics	Arsenic	2.34E+01	RfD	8.00E+01	NO
	Barium	6.65E+02	RfD	5.60E+03	NO
	Chromium	2.99E+01	RfD	8.00E+04 c/	NO
	Copper	2.18E+01	-	-	-
	Lead	1.39E+01	d/	5.00E+02	NO
	Nickel	2.25E+01	RfD	1.60E+03	NO
	Selenium	4.60E-01	RfD	2.40E+02 e/	NO
	Zinc	7.11E+01	RfD	1.60E+04	NO

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ Value is for chromium III.

d/ OSWER, 1989.

e/ Value is for selenious acid.

320SAIAU23405/T4-15.WK1

Soils. Soils data at site 3 were divided into surface soils (less than 2 feet deep) and subsurface soils (greater than 2 feet deep) to evaluate different exposure pathways. Exposure to surface soils is currently possible for base personnel. Exposure to surface and subsurface soils is hypothetically possible for future residents, base personnel, construction workers, and non-base personnel.

Arsenic, copper, lead, and zinc were retained as chemicals of concern in subsurface soils (Table 4.14). Arsenic, lead, and nickel did not exceed their criteria. No criterion value is available for copper.

All detected chemicals were retained as chemicals of concern in surface soils. Criterion values were available for all the organics detected, and none were exceeded. Copper does not have a criterion, and all other metals concentrations were less than their respective criteria. Because no criteria were exceeded, ingestion of soils probably does not pose a public health concern. However, VOCs were detected in surface soils and may pose a potential public health concern from inhalation of contaminants. Air quality data were not collected, and therefore this pathway cannot be evaluated.

Site 4: Former Fire Training Area 1

The chemicals of concern for each medium, their maximum concentration and their associated human health criteria are compared in Tables 4.16 through 4.18. A discussion by medium of the potential human health risks is presented in the following paragraphs.

Groundwater. TPH, lead, selenium, and zinc were identified as chemicals of concern in groundwater at site 4. In groundwater, selenium slightly exceeded its MCL of 0.01 mg/L (Table 4.16). In addition, it should be noted that the proposed MCL for selenium (50 µg/L) is higher than the current MCL. If the proposed MCL were used as the criterion value, the maximum detected value for selenium in groundwater would not be problematic. Recent human studies on the toxicity of selenium strongly suggest that the proposed MCL would be protective (Iris, 1991). Selenium is not associated with any identified sources of contaminants and probably derives from the soils, where it occurs naturally. All other metals were below their criteria. A criterion value is not available for TPH. However, TPH components may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH included in the VOCs and BNA organics analyzed for in this sampling event.

Soil. Soils data at site 4 were divided into surface soils (less than 2 feet deep) and subsurface soils (greater than 2 feet deep), which correspond to likely exposure pathways. Exposure to surface soils is currently possible for base personnel. Exposure to surface and subsurface soils is hypothetically possible for future residents, base personnel, construction workers, and non-base personnel.

In subsurface soils, six organics and seven inorganics were identified as chemicals of concern. None of the chemicals of concern exceeded criteria (Table 4.17). However, criterion values are not available for copper and TPH. Although TPH cannot be directly evaluated, components of TPH may be detected in VOC and

Table 4.16 Comparison of Groundwater Contaminant Concentrations with Health Criteria for Site 4
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/L) b/	Criterion Type Used a/	Criterion Value (mg/L)	Release Concentrations Exceed Criterion?
Groundwater ingestion:					
Organics	TPH c/	3.00E+00	-	-	-
Inorganics	Barium	2.59E-01	MCL	1.00E+00	NO
	Lead	7.50E-03	MCL	5.00E-02	NO
	Selenium	1.08E-02	MCL	1.00E-02	YES
	Zinc	3.20E-02	RfD	7.00E+00	NO

a/ RfD = reference dose; MCL = maximum contaminant level.

b/ mg/L = milligram per liter.

c/ TPH = total petroleum hydrocarbons.

320SA1AU23405T4-16.WK1

**Table 4.17 Comparison of Subsurface Soil Contaminant
Concentrations with Health Criteria for Site 4
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Subsurface soil ingestion:					
Organics	Acetone	1.60E-01	RfD	8.00E+03	NO
	Butylbenzylphthalate	1.40E+00	RfD	1.60E+04	NO
	Diethylphthalate	1.70E+00	RfD	6.40E+04	NO
	bis(2-Ethylhexyl)phthalate	2.40E-01	SF	5.00E+01	NO
	Toluene	6.00E-03	RfD	1.60E+04	NO
	TPH c/	6.00E+02	-	-	-
Inorganics	Arsenic	7.90E+00	RfD	8.00E+01	NO
	Barium	1.19E+03	RfD	5.60E+03	NO
	Chromium	2.06E+01	RfD	8.00E+04 d/	NO
	Copper	3.49E+01	-	-	-
	Lead	1.54E+01	e/	5.00E+02	NO
	Nickel	1.21E+01	RfD	1.60E+03	NO
	Zinc	4.88E+01	RfD	1.60E+04	NO

a/ RfD = reference dose; SF = slope factor.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Value is for chromium III.

e/ OSWER, 1989.

320SA\AU23405\T4-17.WKI

**Table 4.18 Comparison of Surface Soil Contaminant
Concentrations with Health Criteria for Site 4
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface soil ingestion:					
Organics	TPH c/	1.50E+03	-	-	-
Inorganics	Arsenic	7.40E+00	RfD	8.00E+01	NO
	Copper	1.85E+01	-	-	-
	Lead	1.67E+01	d/	5.00E+02	NO
	Nickel	1.38E+01	RfD	1.60E+03	NO
	Zinc	4.84E+01	RfD	1.60E+04	NO

320SA/AU23405/T4-18.WKI

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ OSWER, 1989.

BNA organics analyses. No human health risks were identified for the components of TPH included in the VOCs and BNA organics analyses of this sampling event.

In surface soils, TPH, arsenic, copper, lead, nickel, and zinc were identified as chemicals of concern. As shown in Table 4.18, none of the chemicals of concern exceeded criteria. However, criterion values are not available for copper and TPH. Although TPH cannot be directly evaluated, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH included in the VOCs and BNA organics analysis of this sampling event.

Based on available criteria, ingestion of soils at site 4 probably does not pose a potential public health concern. However, VOCs were detected in subsurface soils and may pose a potential public health concern from inhalation of contaminants by future construction workers (Table 4.2).

Site 5: Former Fire Training Area 2

The chemicals of concern for each medium, their maximum concentrations, and their associated human health criteria are compared in Tables 4.19 through 4.21. A discussion by medium of the potential human health risks is presented in the following paragraphs.

Groundwater. TPH, selenium, and zinc were retained as chemicals of concern in groundwater at site 5. Selenium and zinc did not exceed criteria and probably do not pose a potential public health concern. A criterion value is not available for TPH. However, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH included as VOC and BNA organic analytes for in this sampling event.

Soils. Soils data at site 5 were divided into surface soils (less than 2 feet deep) and subsurface soils (greater than 2 feet deep). Exposure to surface soils is currently possible for base personnel. Exposure to surface and subsurface soils is hypothetically possible for future residents, base personnel, construction workers, and non-base personnel.

All detected organics and inorganics in subsurface soils were retained as chemicals of concern with the exceptions of barium and chromium, which were detected at concentrations comparable to background levels. Criteria are available for all the chemicals of concern except copper. No criterion values were exceeded (Table 4.20). Therefore, ingestion of subsurface soils probably does not pose a potential public health concern. However, the presence of VOCs in subsurface soils may pose a potential public health concern from inhalation of contaminants by future construction workers (Table 4.2).

In surface soils, TPH, arsenic, copper, lead, selenium, and zinc were determined to be the chemicals of concern (Table 4.21). Criteria are available for arsenic, lead, selenium, and zinc. None of the criteria were exceeded, indicating that these chemicals do not pose a potential health threat. A criterion value is not available for TPH. However, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH

**Table 4.19 Comparison of Groundwater Contaminant
Concentrations with Health Criteria for Site 5
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/L) b/	Criterion Type Used a/	Criterion Value (mg/L)	Release Concentrations Exceed Criterion ?
Groundwater ingestion:					
Organics	TPH c/	4.00E+00	-	-	-
Inorganics	Selenium	8.10E-03	MCL	1.00E-02	NO
	Zinc	5.10E-02	RfD	7.00E+00	NO

320SA\AU23405\T4-19.WK1

a/ RfD = reference dose; MCL = maximum contaminant level.

b/ mg/L = milligram per liter.

c/ TPH = total petroleum hydrocarbons.

Table 4.20 Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 5
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Subsurface soil ingestion:					
Organics	Acetone	1.40E-01	RfD	8.00E+03	NO
	Toluene	1.00E-02	RfD	1.60E+04	NO
Inorganics	Arsenic	2.25E+01	RfD	8.00E+01	NO
	Chromium	2.28E+01	RfD	8.00E+04 c/	NO
	Copper	3.16E+01	-	-	-
	Lead	1.27E+01	d/	5.00E+02	NO
	Nickel	1.61E+01	RfD	1.60E+03	NO
	Zinc	6.12E+01	RfD	1.60E+04	NO

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ Value is for chromium III.

d/ OSWER, 1989.

320SA\AU23405\T4-20.WIG

Table 4.21 Comparison of Surface Soil Contaminant Concentrations with Health Criteria for Site 5
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface soil ingestion:					
Organics	TPH c/	1.60E+02	-	-	-
Inorganics	Arsenic	7.00E+00	RfD	8.00E+01	NO
	Copper	3.10E+01	-	-	-
	Lead	9.50E+00	d/	5.00E+02	NO
	Selenium	2.90E-01	RfD	2.40E+02 e/	NO
	Zinc	4.70E+01	RfD	1.60E+04	NO

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ OSWER, 1989.

e/ Value is for selenious acid.

320SA\AU23405\T4-21.W\K1

included in the VOC and BNA organics analyzed for in this sampling event. Based on available data and criteria, ingestion of surface soils at site 5 probably does not pose a potential public health concern.

Site 6: Aerospace Ground Equipment Area

The chemicals of concern for each medium, their maximum concentration and their associated human health criteria are compared in Tables 4.22 to 4.25. A discussion by medium of potential human health risks is presented in the following paragraphs.

Groundwater. Two organics and six inorganics were detected and retained as chemicals of concern. Each chemical of concern is compared to its criterion value in Table 4.22. As shown in Table 4.22, bis(2-ethylhexyl)phthalate exceeded its criterion of 0.0025 mg/L. If groundwater were ever used as a source of drinking water, and if these levels of bis(2-ethylhexyl)phthalate were detected, potential adverse effects on human health could be observed.

Soils. Soil data at site 6 were divided into surface soils (less than 2 feet deep) and subsurface soils (greater than 2 feet deep) for analysis of exposure pathways. Exposure to surface and subsurface soils is hypothetically possible for future residents, base personnel, construction workers, and non-base personnel.

In subsurface soils, ten organics and five inorganics were determined to be chemicals of concern (Table 4.23). Arsenic, barium, and nickel were eliminated because they were detected at concentrations comparable to background levels. Criteria values are available for all chemicals of concern except 2-methylnaphthalene, copper, and TPH. No criterion values were exceeded (Table 4.23). Although TPH cannot be directly evaluated, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for components of TPH included in the VOCs and BNA organics analyzed for in this sampling event.

TPH, acetone, toluene, arsenic, cadmium, copper, lead, nickel, selenium, and zinc were identified as chemicals of concern in surface soils (Table 4.24). Criterion values are available for all the chemicals of concern with the exception of TPH and nickel. As shown in Table 4.24, no criteria were exceeded. No human health risks were identified for components of TPH included in the VOCs and BNA organics analyzed for in this sampling event.

Based on available data and human health criteria, ingestion of soils at site 6 probably does not pose a potential public health risk. However, VOCs were detected both in surface and subsurface soils and may pose a potential public health concern from inhalation of contaminants in the event that pavement and soils are disturbed. Air quality data were not collected; therefore this pathway cannot be evaluated.

Sediments. TPH and all detected inorganics with the exceptions of arsenic and barium, were determined to be chemicals of concern in sediments at site 6. Criterion values are available for all the inorganics except copper (Table 4.25). Except for lead, none of the inorganics exceeded their criteria, indicating a low potential

**Table 4.22 Comparison of Groundwater Contaminant
Concentrations with Health Criteria for Site 6
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/L) b/	Criterion Type Used a/	Criterion Value (mg/L)	Release Concentrations Exceed Criterion ?
Groundwater ingestion:					
Organics	Benzene	1.80E-03	MCL	5.00E-03	NO
	Bis(2-Ethylhexyl)phthalate	2.10E-02	SF	2.50E-03	YES
Inorganics	Arsenic	1.50E-03	MCL	5.00E-02	NO
	Barium	2.15E-01	MCL	1.00E+00	NO
	Copper	6.00E-03	MCL c/	1.00E+00	NO
	Lead	6.30E-03	MCL	5.00E-02	NO
	Mercury	1.90E-04	MCL	2.00E-03	NO
	Zinc	5.20E-02	RfD	7.00E+00	NO

a/ RfD = reference dose; SF = slope factor; MCL = maximum contaminant level.

b/ mg/L = milligram per liter.

c/ Value is a secondary level.

3208A/AU/23405/T4-22.WT1

**Table 4.23 Comparison of Subsurface Soil Contaminant
Concentrations with Health Criteria for Site 6
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Subsurface soil ingestion:					
Organics	Acetone	5.70E-01	RfD	8.00E+03	NO
	bis(2-Ethylhexyl)phthalate	1.30E-01	SF	5.00E+01	NO
	Ethyl benzene	1.60E+00	RfD	8.00E+03	NO
	2-Methylnaphthalene	2.70E+00	-	-	-
	Naphthalene	3.00E+00	RfD	3.20E+02	NO
	Toluene	1.70E+01	RfD	1.60E+04	NO
	TPH c/	8.10E+03	-	-	-
	Trichloroethene	4.00E+00	SF	6.40E+01	NO
	m,p-Xylene	7.90E+00	RfD	1.60E+05 d/	NO
	o-Xylene	2.60E+00	RfD	1.60E+05 d/	NO
Inorganics	Cadmium	4.10E-01	RfD	4.00E+01	NO
	Chromium	1.83E+01	RfD	8.00E+04 e/	NO
	Copper	1.44E+01	-	-	-
	Lead	5.23E+01	f/	5.00E+02	NO
	Selenium	3.50E-01	RfD	2.40E+02 g/	NO

a/ RfD = reference dose; SF = slope factor.

b/ mg/kg = milligram per kilogram.

d/ Value is for total vlenes.

e/ Value is for chromium III.

f/ OSWER, 1989.

g/ Value is for selenious acid.

320SA\AU23405\T4-23.W\K1

Table 4.24 Comparison of Surface Soil Contaminant
Concentrations with Health Criteria for Site 6
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface soil ingestion:					
Organics	Acetone	5.20E-01	RfD	8.00E+03	NO
	Toluene	7.00E-03	RfD	1.60E+04	NO
	TPH c/	1.30E+04	-	-	-
Inorganics	Arsenic	7.20E+00	RfD	8.00E+01	NO
	Cadmium	3.50E-01	RfD	4.00E+01	NO
	Copper	4.34E+01	-	-	-
	Lead	2.83E+01	d/	5.00E+02	NO
	Nickel	1.24E+01	RfD	1.60E+03	NO
	Selenium	3.70E-01	RfD	2.40E+02 e/	NO
	Zinc	6.08E+01	RfD	1.60E+04	NO

320SA\AU23405\T4-24.W\KJ

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ OSWER, 1989.

e/ Value is for selenious acid.

Table 4.25 Comparison of Sediment Contaminant
Concentrations with Health Criteria for Site 6
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Sediments ingestion:					
Ingestion					
Organics	TPH c/	3.00E+03	-	-	-
Inorganics	Cadmium	6.40E+00	RfD	4.00E+01	NO
	Chromium	5.88E+01	RfD	8.00E+04 d/	NO
	Copper	4.85E+01	-	-	-
	Lead	5.29E+02	e/	5.00E+02	YES
	Mercury	6.50E-02	RfD	2.40E+01	NO
	Nickel	1.89E+01	RfD	1.60E+03	NO
	Selenium	4.10E-01	RfD	2.40E+02 f/	NO
	Zinc	2.84E+02	RfD	1.60E+04	NO

a/ RfD = reference dose.

b/ milligram per kilogram

c/ TPH = total petroleum hydrocarbons.

d/ Value is for chromium III.

e/ OSWER, 1989.

f/ Value is for selenious acid.

320SA\AU23405\T4-25.WRI

public health risk. The maximum detected concentration of lead exceeded EPA's recommended target level for lead in soils (500 ppm). TPH cannot be directly evaluated; however, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH included as VOCs and BNA organic analytes in this sampling event.

Site 7: Dry Well Off Corrosion Control Building

The chemicals of concern for each medium, their maximum concentrations, and their associated human health criteria are compared in Tables 4.26 to 4.28. A discussion by medium of potential human health risks is presented in the following paragraphs.

Groundwater. Benzene, ethyl benzene, 2-methylnaphthalene, naphthalene, xylenes, arsenic, barium, and zinc all exceeded background concentrations by at least 10 percent, and were therefore retained as chemicals of concern in groundwater at site 7. All the chemicals of concern were compared with criteria except 2-methylnaphthalene (Table 4.26). Benzene exceeded its MCL of 0.005 mg/L. If groundwater were ever used as a source of drinking water, and if these levels of benzene were present, an increased probability of disease such as leukemia in the exposed population could be demonstrated.

Soils. Soils data at site 7 were divided into surface (less than 2 feet deep) and subsurface soils (greater than 2 feet deep). Exposure to surface soils is currently possible for base personnel. Exposure to surface and subsurface soils is hypothetically possible for future residents, construction workers, base personnel, and non-base personnel.

Eleven organics and four metals were retained as chemicals of concern in subsurface soils (Table 4.27). Arsenic, barium, chromium, and nickel were eliminated based on a comparison with background concentrations. Of the chemicals of concern, only 2-methylnaphthalene, TPH, and copper do not have criterion values. As shown in Table 4.27, none of the available criteria were exceeded. Although no criterion value is available for TPH, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH included as VOC and BNA organic analytes in this sampling event.

In surface soils at site 7, TPH, copper, and lead were determined to be the chemicals of concern (Table 4.28). Lead does not exceed its criterion, but no criteria are available for TPH or copper. Although no criterion value is available for TPH, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH included as VOC and BNA organics analytes in this sampling event.

Based on available data and criteria, ingestion of soils at site 6 probably does not pose a potential public health concern. However, VOCs were detected in subsurface soils and may pose a potential public health concern from inhalation of contaminants by future construction workers (Table 4.2).

Table 4.26 Comparison of Groundwater Contaminant
Concentrations with Health Criteria for Site 7
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/L) b/	Criterion Type Used a/	Criterion Value (mg/L)	Release Concentrations Exceed Criterion ?
Groundwater ingestion:					
Organics	Benzene	1.10E-02	MCL	5.00E-03	YES
	Ethylbenzene	1.60E-01	RfD	3.50E+00	NO
	2-Methylnaphthalen	1.10E-02	-	-	-
	Naphthalene	2.40E-02	RfD	1.40E-01	NO
	Xylenes (total)	5.00E-01	RfD	7.00E+01	NO
Inorganics	Arsenic	1.50E-03	MCL	5.00E-02	NO
	Barium	9.50E-02	MCL	1.00E+00	NO
	Zinc	3.00E-02	RfD	7.00E+00	NO

a/ RfD = reference dose.

b/ mg/L = milligram per liter.

320SA/AU/23405/T4-26.WR1

Table 4.27 Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 7
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Subsurface soil ingestion:					
Organics	Acetone	1.00E-01	RfD	8.00E+03	NO
	Benzene	2.60E+00	SF	2.40E+01	NO
	bis(2-Ethylhexyl)phthalate	5.40E+00	SF	5.00E+01	NO
	di-n-butylphthalate	1.40E-01	Rfd	8.00E+03	NO
	Ethyl benzene	2.40E+01	Rfd	8.00E+03	NO
	2-Methylnaphthalene	4.20E+01	-	-	-
	Naphthalene	2.20E+01	RfD	3.20E+02	NO
	Toluene	1.40E+02	RfD	1.60E+04	NO
	TPH c/	1.90E+04	-	-	-
	m,p-Xylene	1.10E+02	RfD	1.60E+05 d/	NO
	o-Xylene	4.90E+01	RfD	1.60E+05 d/	NO
Inorganics	Copper	1.71E+01	-	-	-
	Lead	4.43E+02	e/	5.00E+02	NO
	Selenium	6.00E-01	RfD	2.40E+02 f/	NO
	Zinc	1.58E+02	RfD	1.60E+04	NO

a/ Rfd = reference dose; SF = slope factor.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Value is for total xylene.

e/ OSWER, 1989.

f/ Value is for selenious acid.

320SAIAU23405/T4-27.W/KI

**Table 4.28 Comparison of Surface Soil Contaminant
Concentrations with Health Criteria for Site 7
120th FIG, International Airport, Great Falls, Montana**

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface soil ingestion:					
Organics	TPH c/	3.40E+01	-	-	-
Inorganics	Copper	1.90E+01	-	-	-
	Lead	1.07E+01	d/	5.00E+02	NO

a/ RfD = reference dose.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ OSWER, 1989.

320SA\AU23405\T4-28.WF1

Site 8: Dry Well Off Composite Maintenance Building

The chemicals of concern for each medium, their maximum concentrations, and their associated human health criteria are compared in Tables 4.29 to 4.31. A discussion by medium of potential human health risks is presented in the following paragraphs.

Groundwater. TPH, bis(2-ethylhexyl)phthalate, 1,2-DCE, PCE, TCE, barium, and lead were determined to be the chemicals of concern in groundwater at site 8. Of the chemicals of concern, only TPH does not have a criterion value. Although TPH cannot be directly evaluated, TPH components may be detected in VOC and BNA organics analyses. No human risks were identified for the components of TPH included as VOC and BNA organic analytes in this sampling event. As shown in Table 4.29, PCE and bis(2-ethylhexyl)phthalate exceeded their respective criteria of 0.00069 mg/L and 0.0025 mg/L. Therefore, groundwater ingestion at site 8 poses a potential human health threat.

Soils. Soils data at site 8 were divided into surface soils (less than 2 feet deep) and subsurface soils (greater than 2 feet deep) for analysis of exposure pathways. Exposure to surface soils is currently possible for base personnel. Exposure to surface and subsurface soils is hypothetically possible for future residents, construction workers, base personnel, and non-base personnel.

In subsurface soils, TPH, acetone, TCE, arsenic, copper, lead, selenium, and zinc were identified as chemicals of concern. Criteria are available for all the chemicals of concern with the exceptions of copper and TPH. As shown in Table 4.30, no criteria were exceeded. Although TPH cannot be directly evaluated, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH included as VOC and BNA organics analytes in this sampling event.

In surface soils eleven organics and four metals were determined to be chemicals of concern (Table 4.31). Barium and chromium were eliminated as chemicals of concern after a comparison with background concentrations. Copper and TPH are the only chemicals of concern that do not have criteria. As shown in Table 4.31, no available criteria were exceeded. Although TPH cannot be directly evaluated, components of TPH may be detected in VOC and BNA organics analyses. No human health risks were identified for the components of TPH included as VOC and BNA organic analytes in this sampling event.

Based on available data and criteria, ingestion of soils does not appear to pose a potential public health risk. However, VOCs were detected in both surface and subsurface soils, and may pose a potential health concern from inhalation of contaminants.

4.3 PRELIMINARY ECOLOGICAL RISK EVALUATION

This ecological risk evaluation used the same general approach as the preliminary human health evaluation, comparing chemical concentrations to ARARs. However, more qualitative judgments were used in the ecological evaluation to

Table 4.29 Comparison of Groundwater Contaminant
Concentrations with Health Criteria for Site 8
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/L) b/	Criterion Type Used a/	Criterion Value (mg/L)	Release Concentrations Exceed Criterion ?
Groundwater ingestion:					
Organics	bis(2-Ethylhexyl)phthalate	7.00E-03	SF	2.50E-03	YES
	1,2-Dichloroethene	4.80E-02	RfD	3.50E-01 c/	NO
	Tetrachloroethene	2.80E-03	SF	6.90E-04	YES
	TPH d/	3.00E+00	-	-	-
	Trichloroethene	3.50E-03	MCL	5.00E-03	NO
Inorganics	Barium	7.00E-02	MCL	1.00E+00	NO
	Lead	5.80E-03	MCL	5.00E-02	NO

a/ RfD = reference dose; SF = Slope Factor; MCL = maximum contaminant level.

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b/ mg/L = milligram per liter.

c/ Value is for the trans isomer.

d/ TPH = total petroleum hydrocarbons.

Table 4.30 Comparison of Subsurface Soil Contaminant Concentrations with Health Criteria for Site 8
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Subsurface soil ingestion:					
Organics	Acetone	1.40E-01	RfD	8.00E+03	NO
	TPH c/	2.60E+01	-	-	-
	Trichloroethene	4.00E-03	SF	6.40E+01	NO
Inorganics	Arsenic	2.22E+01	RfD	8.00E+01	NO
	Copper	1.72E+01	-	-	-
	Lead	1.37E+01	d/	5.00E+02	NO
	Selenium	3.50E-01	RfD	2.40E+02 e/	NO
	Zinc	4.63E+01	RfD	1.60E+04	NO

a/ Rfd = reference dose; SF = slope factor.

b/ mg/kg = milligram per kilogram.

c/ TPH = total petroleum hydrocabons.

d/ OSWER, 1989.

e/ Value is for selenious acid.

320SA\AU23405\T4-30.WK1

Table 4.31 Comparison of Surface Soil Contaminant
Concentrations with Health Criteria for Site 8
120th FIG, International Airport, Great Falls, Montana

Exposure Medium	Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Criterion Type Used a/	Criterion Value (mg/kg)	Release Concentrations Exceed Criterion ?
Surface soil ingestion:					
Organics	Acetone	9.50E-02	RfD	8.00E+03	NO
	Chlorobenzene	3.50E-02	RfD	1.60E+03	NO
	1,2-Dichlorobenzene	2.40E-01	RfD	7.20E+03	NO
	1,2,1,4-Dichlorobenzene	1.80E-01	SF	2.90E+01 c/	NO
	trans-1,2-Dichloroethene	8.00E-03	RfD	1.60E+03	NO
	Ethylbenzene	8.00E-03	RfD	8.00E+03	NO
	Toluene	4.60E-02	RfD	1.60E+04	NO
	TPH d/	1.40E+02	-	-	-
	Trichloroethene	2.60E-01	SF	6.40E+01	NO
	m,p-Xylene	1.40E-02	RfD	1.60E+05 e/	NO
	o-Xylene	1.00E-02	RfD	1.60E+05 e/	NO
Inorganics	Arsenic	7.40E+00	RfD	8.00E+01	NO
	Copper	1.98E+01	-	-	-
	Lead	1.49E+01	f/	5.00E+02	NO
	Zinc	4.83E+01	RfD	1.60E+04	NO

a/ RfD = reference dose; SF = slope factor.

b/ mg/kg = milligram per kilogram.

c/ Value is for 1,4-Dichlorobenzene.

d/ TPH = total petroleum hydrocarbons.

e/ Value is for total xylenes.

f/ OSWER, 1989.

320SA\AU\23405\T4-31.WK1

account for the diverse array of species and the less extensive evaluation methods available for risk determinations. Chemicals of concern were selected based on the results of site sampling. Potential exposure pathways and receptors were identified, and the potential toxicity of chemicals of concern was evaluated.

4.3.1 Selection of Chemicals of Concern

All of the chemicals detected on base were reviewed in light of potential impacts to ecological receptors. Chemicals of concern for the ecological risk assessment were chosen by the criteria described in section 4.2.1. Thus, as with the human health evaluation, every chemical detected in each medium at each site was retained as a chemical of concern if it was detected in excess of background concentrations or was not determined to be a lab contaminant.

4.3.2 Environmental Receptors

The base is located in a short-grass prairie province which is currently influenced by agricultural and urban uses. Wildlife common to short-grass prairies and agricultural areas include small rodents, prairie dogs, jack rabbits, coyotes, pronghorn, and various raptors and songbirds. Of endangered and threatened species known in Cascade County, only the bald eagle and peregrine falcon were noted in the vicinity of the airport during the late 1970s (Williams et al., 1986). Assessment of endangered species on the base in 1990 did not indicate any nesting areas of these two raptor species nor any breeding grounds of any endangered species (verbal communication, Major Iver Johnson of the 120th FIG, 4 September, 1991). Great Falls District 4 of the Montana Fish, Wildlife and Parks has only observed the bald eagle in riparian habitat on the Sun and Missouri Rivers and the peregrine falcon in passing through the area, according to Warden Steven Vinnedge (verbal communication, 4 September, 1991). There are no wetlands on the base.

Receptor organisms were identified by biological resource group as those likely to be present at the base. This preliminary evaluation focuses on terrestrial wildlife and vegetation receptors most likely to be present on site, and for which protective criteria are available. Aquatic species composition in ephemeral water bodies on the base (i.e., the drainage ditches) has not been determined. Because no permanent water bodies are known to exist on base, aquatic life was not considered a receptor group likely to be affected by chemicals of concern. For the wildlife receptor group, the ungulates, deer and pronghorn, were chosen as the representative species because of their general physiological similarities to domestic cattle, for which drinking water criteria exist. For the vegetation group, no specific species was chosen because the criteria used were for general terrestrial vegetation. Given the suspected wide diversity of species present onsite and the preliminary nature of the evaluation, it was not considered appropriate to choose more specific receptors. Appropriate risk analyses for the receptor categories were performed for each of the eight sites.

4.3.3 Identification of Ecological Exposure Pathways

Conceptually, the pathways offering the greatest potential for completion are those associated with soils, air, surface water, sediment, and shallow groundwater.

No data are available for air quality at the sites. However, contamination of the other media has been documented on site, and must therefore be evaluated. Probable pathway completion mechanisms are addressed separately for each site. In general, however, receptors may be exposed to chemical contaminants through direct or indirect pathways. Direct pathways are those which permit direct contact with or ingestion of contaminated media such as soil, sediment, or water. Indirect pathways are those in which an animal consumes other previously contaminated organisms. If exposure pathways between contaminated media and receptor organisms are not complete, contaminants do not constitute an environmental risk.

Exposure media and routes may differ among various organisms due to their physiological and behavioral differences. For example, raptors may be exposed to contaminants by consuming small rodents which have bioaccumulated contaminants through consumption of vegetation or surface water, whereas seed-eating birds may be exposed to contaminants from direct contact with soils, or through incidental ingestion of soil while foraging. Specific food chain pathways at the sites were not identified.

Soil. Soil exposure pathways are potentially important for plants and wildlife at the base. Terrestrial animals at the base may be directly and indirectly exposed to contaminants in the soil. Direct dermal contact with contaminated soil and incidental inhalation or ingestion of soil could occur among burrowing animals (e.g., many small mammal species) or among dustbathing animals (e.g., many bird species). In general, information for quantifying and evaluating the toxicity of dermal exposures to wildlife species is limited. Although there are criteria for evaluating risks to animals from direct and indirect soil ingestion, insufficient site-specific data were available for comparison with these criteria.

Incidental ingestion of soil as a possible direct exposure route can occur in several ways: small mammals may ingest soil while grooming, herbivorous animals such as rabbits may ingest soil while feeding on plants, and seed-eating bird species may ingest soil while foraging for seeds on the ground. Indirect exposure to soil contaminants may occur through ingestion of soil-dwelling invertebrates (e.g., earthworms) or grasses and other plants which may bioaccumulate contaminants. As with other exposure pathways, the importance of this pathway varies from species to species because of behavioral differences. For example, populations of animals such as field mice, which dwell in the ground and are fastidious groomers, may be more greatly affected by contaminated soils than other species which contact soil less often.

Other exposures of wildlife to soil contaminants may result during rainfall when surface runoff can transport soil particles to nearby drainage ditches. Exposure to soil contaminants via this pathway depends on such factors as the intensity of the storm (i.e., amount of rainfall), adsorption characteristics of the surface soils and the contaminants, the extent and type of vegetation covering the soil, the distance between the contaminated source and the ditches, and the degree of slope.

Plants may be directly exposed to contaminants in soil via uptake through their roots. Chemicals may accumulate in different plant tissues depending on the

species. Because chemical uptake is known to vary among plant species and tissue, evaluating the potential impacts to plants is often difficult. However, plant phytotoxic criteria and soil guidelines for some contaminants in soils are relatively well documented, so a comparison between onsite concentrations and criteria could be made.

Surface Water and Sediment. Most terrestrial wildlife species depend to some extent on surface water as a source of drinking water. There are no permanent surface water bodies on or near the base, and therefore aquatic organisms are not thought to be present at any of the eight sites. Animals that consume onsite water from drainage ditches or puddles after precipitation events may be exposed to contaminants through ingestion. In addition to ingestion, terrestrial wildlife also may be directly exposed to contaminants in surface water through dermal contact while drinking or foraging for food. Because no surface water data were available, a risk evaluation could not be made.

Exposure to chemicals present in sediments constitutes another possible exposure pathway for ecological receptors. Wading birds and other animals may be exposed to contaminants from direct contact with sediments while foraging for food in the ditches. Plants growing along or in the ditches may also be exposed to sediment contaminants through root uptake. As with soils, while there may be appropriate comparison criteria for animals for sediments, insufficient site-specific data were available for comparison with these criteria. However, plant phytotoxic criteria and soil guidelines are relatively well documented, and comparisons between onsite concentrations and criteria could be made.

Groundwater. Contaminants in shallow groundwater may constitute a risk to environmental receptors when the water is utilized by plants, when it discharges at springs or into wells from which animals may drink, and when surface waters are contaminated by groundwater discharges. Pathways may be direct or indirect and are most common where groundwater is shallow.

Plants with roots extending below the water table may concentrate contaminants found in groundwaters. This may cause direct phytotoxic effects. Similarly, the ingestion of contaminated drinking water may affect small and large mammals, birds, and all other organisms ingesting water derived from wells or springs. Indirect exposure may occur when animals consume affected plants or other animals. Groundwater concentrations were compared with livestock drinking water criteria and irrigation guidelines.

4.3.4 Environmental Risk Criteria

In the preliminary ecological evaluation, maximum detected concentrations are compared with appropriate protective criteria for representative organisms of each receptor group. Available chemical-specific standards, criteria, and guidelines for various media and the target biota are identified below.

4.3.4.1 Terrestrial Wildlife

Criteria have not been developed specifically for the protection of terrestrial wildlife. Research literature is usually the source of most of the relevant toxicity

data for these receptors. One source for toxicity values is studies reporting median lethal doses (LD_{50} s). The LD_{50} represents the oral dose which was lethal to 50 percent of an experimental population. LD_{50} s cannot be used directly to evaluate contaminant concentrations, but can be used to highlight which chemicals are toxic to mammals. In general, LD_{50} values less than 50 mg/kg body weight are acutely toxic, since toxicity is related to dose, compounds with LD_{50} s greater than 50 to 500 mg/kg are of less concern. It is important to keep in mind that LD_{50} s apply only to acute exposure. In general, doses associated with toxicity thresholds for chronic exposure are orders of magnitude lower.

Protective guidelines established for livestock drinking water can serve as general guidelines for terrestrial wildlife species such as pronghorn or deer which have physiologies similar to cattle. For this screening evaluation, it is assumed that pronghorn and deer are present on site. These guidelines, which are available only for inorganic compounds, are also summarized in table 4.32.

4.3.4.2 Terrestrial Vegetation

EPA guidelines, including those for soils and irrigation water, have been established for protecting plants from phytotoxic effects of selected inorganic contaminants. A primary source for these guidelines is *Hazardous Waste Land Treatment* (U.S. Environmental Protection Agency, 1983). When EPA guidelines were unavailable, similar threshold information was acquired from the technical literature.

Agricultural soil guidelines are also available and were used for evaluating risks to general terrestrial vegetation types (U.S. Environmental Protection Agency, 1983). In lieu of specific guidelines for sediments, for the purposes of this evaluation, sediment concentrations are compared with soil criteria for plants. Available criteria or guidelines for the protection of plants are summarized in table 4.33 for the potential chemicals of concern.

4.3.5 Ecological Hazard Evaluation

A preliminary ecological evaluation was conducted for each of the eight sites at the base. Ecological toxicity criteria were compared directly with maximum detected chemical concentrations (greater than 10 percent above background levels) at each site, by medium, to evaluate site-specific risks for each receptor group. The following paragraphs described the results of the risk evaluation for chemicals of concern, by site.

Site 1: Current Fire Training Area

The chemicals of concern are compared with environmental criteria in tables 4.34 through 4.36 and are discussed by medium for the biological groups at risk.

Soils. Potential environmental receptors exposed to contaminated surface soil at site 1 are plants and a variety of wildlife species. These receptors are more likely to contact surface soils than subsurface soils. Plant criteria include soil phytotoxic

Table 4.32 Guidelines for Evaluating the Toxicity of Chemicals
of Potential Concern to Terrestrial Wildlife
120th Fig, International Airport, Great Falls, Montana

Chemical (mg/kg)	Livestock LD ₅₀ ^{a/} (mg/L) ^{b/}	Drinking Water Criteria	Comments
Inorganics:			
Arsenic	10.5 c/	0.2	--
Barium	118 d/	--	LD ₅₀ for barium chloride in rats.
Cadmium	225 d/	0.05	LD ₅₀ in rats.
Chromium	19.8 e/	1.0	LD ₅₀ for hexavalent chromium in rats.
Copper	60 f/	0.5	LD ₅₀ for horses.
Lead	10 g/	0.1	LD ₅₀ for tetraethyl lead in mice.
Mercury	--	--	0.01--
Nickel	116 f/	--	LD ₅₀ in rats.
Selenium	6,700 h/	0.05	LD ₅₀ in rats.
Zinc	2,460 i/	25	LD ₅₀ for zinc acetate in rats.
Organics:			
Acetone	9,750 d/	--	LD ₅₀ in rats.
Benzene	3,800 d/	--	LD ₅₀ in rats.
Benzo(b)fluoranthene	--	--	--
Bis(2-ethylhexyl)phthalate	31,000 d/	--	LD ₅₀ in rats.
2-Butanone	3,400 j/	--	LD ₅₀ in rats.
Butylbenzylphthalate	2,330 h/	--	LD ₅₀ in rats.
Chlorobenzene	2,830 h/	--	LD ₅₀ in rats.
Chloroform	820 h/	--	LD ₅₀ in rabbits.
1,2-Dichlorobenzene	500 j/	--	LD ₅₀ in guinea pigs.
1,4-Dichlorobenzene	--	--	LD ₅₀ in rats.
1,2-Dichloroethene	770 j/	--	LD ₅₀ in rats.
Diethylphthalate	9,750 d/	--	LD ₅₀ in mice.
Di-n-butylphthalate	12,000 j/	--	LD ₅₀ in rats.
Ethylbenzene	3,000 k/	--	LD ₅₀ in rats.
Fluoranthene	2,000 h/	--	LD ₅₀ in rats.
2-Methylnaphthalene	5,000 d/	--	LD ₅₀ in rats.

Table 4.32, continued

Chemical (mg/kg)	Livestock LD ₅₀ ^{a/} (mg/L) ^{b/}	Drinking Water Criteria	Comments
Naphthalene	1,780 d/	--	LD ₅₀ in rats.
Phenanthrene	700	--	-- LD ₅₀ in rats.
Pyrene	300 i/	--	--
Tetrachloroethene	8,850 i/	--	LD ₅₀ in rats.
Toluene	5,000 d/	--	LD ₅₀ in rats.
Trichloroethene	4,920 d/	--	LD ₅₀ in rats.
TPH ^{m/}	--	--	--
Xylenes	5,000 i/	--	LD ₅₀ in rats for total xylenes.

^{a/} LD₅₀ = Median lethal dose; the dose of a test material that kills 50 percent of a group of test organisms. For these values, the dose is ingested.
mg/kg = milligram per kilogram

^{b/} Concentration above which toxic effects may occur. Assumed relevant to wildlife. Source: National Academy of Sciences, 1974.

^{c/} National Research Council, 1977.

^{d/} Sax, 1984.

^{e/} U.S. Environmental Protection Agency, 1987.

^{f/} National Academy of Sciences, 1980.

^{g/} Eisler, 1988.

^{h/} Sax and Lewis, 1989.

^{i/} Merck and Co., Inc., 1983.

^{j/} Registry of Toxic Effects of Chemical Substances (RTECS), 1980.

^{k/} U.S. Environmental Protection Agency, 1985.

^{l/} TPH = total petroleum hydrocarbons.

Table 4.33 Guidelines for Evaluating the Toxicity of
Chemicals of Potential Concern to Vegetation
120th FIG, International Airport, Great Falls, Montana

Chemical	Soil Guideline ^{a/} (mg/kg)	Soil Phytotoxic Concentration ^{a/} (mg/kg)	Irrigation Water Guideline ^{b/} (mg/L)	Comment
Inorganics:				
Arsenic	300 c/	25-85 c/	0.10	-- Generally insoluble and unavailable to plants.
Barium	2,000 b/	--	--	--
Cadmium	3 c/	2.5-5.0 d/	0.01	-- Unavailable for plant uptake when soil pH is greater than 6.0
Chromium	1,000 c/	100-500 c/	0.10	Generally unavailable for plant uptake when soil pH is greater than 6.5.
Copper	250 c/	70-640 c/	0.20	Not readily translocated to plant foliage.
Lead	1,000 c/	--	5.0	Low inherent toxicity to plants.
Mercury	--	> 10 c/	--	--
Nickel	100 c/	50-200 c/	0.20	--
Selenium	10 c/	--	0.02	--
Zinc	500 c/	500-2,000 c/	2.0	For continuous irrigation use on all soils. Essential plant nutrient.
Organics:				
Acetone	--	--	--	Rapid volatilization, oxidation, and biodegradation.
Benzene	--	525-20,000 e/	--	--
Benzo(b)fluoranthene	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	2,000 d/	--	--
2-Butanone	--	--	--	--
Butylbenzylphthalate	--	--	--	--
Chlorobenzene	--	--	--	--
Chloroform	--	--	--	--
1,2-Dichlorobenzene	--	--	--	--
1,4-Dichlorobenzene	--	--	--	--
1,2-Dichloroethene	--	--	--	--
Diethylphthalate	--	--	--	--
Di-n-butylphthalate	--	--	--	--
Ethylbenzene	--	190,000 g/	--	Metabolized or oxidized by a variety of organisms.

Table 4.33, continued

Chemical	Soil Guideline ^{a/} (mg/kg)	Soil Phytotoxic Concentration ^{a/} (mg/kg)	Irrigation Water Guideline ^{b/} (mg/L)	Comment
Fluoranthene	--	--	--	--
2-Methylnaphthalene	--	--	--	--
Naphthalene	--	--	--	--
Phenanthrene	--	--	--	--
Pyrene	--	--	--	--
Tetrachloroethene	--	--	--	No reported phytotoxic effects.
Toluene	--	--	--	No reported phytotoxic effects.
Trichloroethene	--	--	--	--
TPH	--	--	--	Low inherent toxicity to plants.
Xylenes	--	--	--	No reported phytotoxic effects.

^{a/} Value represents total soil concentrations recommended to avoid adverse biological effects on plants. mg/kg = milligrams per kilogram.

^{b/} National Academy of Science, 1974. mg/L = milligrams per liter.

^{c/} U.S. Environmental Protection Agency, 1983.

^{d/} U.S. Environmental Protection Agency, 1980.

^{e/} Eisler, 1986. Response shown is for ostrich ferns growing near the Housatonic River in Pittsfield, Massachusetts.

^{f/} Clement Assoc., 1985. Response range shown is for freshwater plants.

^{g/} Sax, 1987. Response shown is for tobacco seedling dipped in ethylbenzene solution.

^{h/} Chudhry et al., 1977.

**Table 4.34 Comparison of Surface Soil Contaminant
Concentrations with Ecological Criteria for Site 1
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.220	—	—
Diethylphthalate	0.270	—	—
Ethylbenzene	22.000	190000	No
Fluoranthene	4.900	—	—
2-Methylnaphthalene	13.000	—	—
Phenanthrene	9.500	—	—
Pyrene	14.000	—	—
Toluene	8.800	—	—
TPH c/	120,000	—	—
m,p-Xylene	150.000	—	—
o-Xylene	77.000	—	—
Inorganics			
Arsenic	17.7	25 – 85	No
Barium	763	2,000 d/	No
Cadmium	0.4	2.5 – 5.0	No
Chromium	19.5	100 – 500	No
Copper	22.3	70 – 640	No
Lead	139	1000 d/	No
Mercury	0.16	> 10	No
Nickel	17.7	50 – 200	No
Selenium	0.45	10 d/	No
Zinc	62.9	500 – 2,000	No

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

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**Table 4.35 Comparison of Subsurface Soil Contaminant
Concentrations with Ecological Criteria for Site 1
120th FIG International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.090	—	—
2-Butanone	0.014	—	—
Ethylbenzene	0.016	190000	No
Toluene	0.092	—	—
m,p-Xylene	0.054	—	—
o-Xylene	0.040	—	—
Inorganics			
Arsenic	13.3	25 – 85	No
Barium	548	2,000 c/	No
Copper	18.1	70 – 640	No
Selenium	0.42	10 c/	No

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ Soil guidelines. See Table 4.33.

320SAIAU/23405/T4-35.W/KI

Table 4.36 Comparison of Groundwater Contaminant
Concentrations with Ecological Criteria for Site 1
120th FIG, International Airport, Great Falls, Montana

Chemical of Concern	Maximum Release Concentration (mg/L) c/	Livestock Drinking Water Criteria a/ (mg/L)	Release Concentrations Exceed Criterion ?	Irrigation Water Guidelines b/ (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
Chloroform	0.0011	—	—	—	—
Inorganics					
Barium	0.138	—	—	—	—
Lead	0.0064	0.1	No	5	No
Selenium	0.0042	0.05	No	0.02	No
Zinc	0.952	25	No	2	No

a/ See Table 4.32.

b/ See Table 4.33.

c/ mg/L = milligrams per liter.

320SA\AU23405\T4-36.W\KJ

concentrations and agricultural soil guidelines. Criteria for general wildlife have not been established.

Soil phytotoxic criteria were available for all of the ten inorganic chemicals of concern in surface soils at site 1, but criteria for plants were available for only one of the eleven organic chemicals (ethyl benzene). None of these criteria were exceeded, indicating a low potential for phytotoxic effects. However, no criteria were available for TPH, precluding an evaluation of its potential adverse effects.

In subsurface soils at site 1, soil phytotoxic criteria were available for the four inorganic chemicals but only one of the six organic chemicals (ethyl benzene). None of these criteria were exceeded, indicating a low potential for phytotoxic effects (Table 4.35).

Groundwater. Four metals and one organic compound were detected in site 1 groundwater at concentrations greater than 10 percent above background levels (Table 4.36). The most likely receptors for groundwater are plants with roots extending the water table, plants irrigated with groundwater, and livestock or deer and pronghorn that may drink or contact groundwater if it were pumped to the surface. Criteria available for evaluating risks from water to wildlife are the livestock drinking water criteria (Table 4.32). For evaluating risk to plants irrigated with groundwater or whose roots extend to the water table, irrigation water criteria were used (Table 4.33). However, criteria were available only for lead, selenium, and zinc (Table 4.36). No criteria were exceeded, indicating a low potential for environmental effects from these chemicals.

Site 2: Drainage Ditch Off Old Power Check Pad

The chemicals of concern at site 2 are compared with environmental criteria in Tables 4.37 through 4.40 and are discussed by medium for the biological groups at risk.

Soils. Potential environmental receptors at site 2 are plants and a variety of wildlife species. The receptors are more likely to contact surface soils than subsurface soils. Plant criteria include soil phytotoxic concentrations and agricultural soil guidelines. Criteria for general wildlife have not been established.

Five organic compounds and seven metals were detected above background concentrations in surface soils (Table 4.37), and four metals of concern were identified in subsurface soils (Table 4.38). Phytotoxic criteria were available for all of the inorganic chemicals of concern but only one of the organic chemicals (bis(2-ethyl-hexyl)phthalate). None of these criteria were exceeded, indicating a low potential for phytotoxic effects. However, no criteria were available for TPH precluding an evaluation of its potential adverse effects.

Groundwater. Selenium, zinc, and TPH are the chemicals of concern identified in site 2 groundwater (Table 4.39). The most likely receptors for groundwater are plants which have access to the groundwater either through irrigation or through roots extending to the water table, and livestock or deer and pronghorn that may drink or contact groundwater if it were pumped to the surface. Criteria available for evaluating risks to these potential receptors include livestock watering criteria and

Table 4.37 Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 2
120th FIG, International Airport, Great Falls, Montana

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.170	—	—
bis(2-Ethylhexyl)phthalate	2.000	2000	No
Butylbenzylphthalate	1.400	—	—
di-n-butylphthalate	4.900	—	—
TPH c/	46	—	—
Inorganics			
Arsenic	8.7	25 – 85	No
Barium	231	2000 d/	No
Copper	29.6	70 – 640	No
Lead	17.7	1000 d/	No
Nickel	19.4	50 – 200	No
Selenium	0.5	10 d/	No
Zinc	82.3	500 – 2,000	No

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

320SA\AU23405\T4-37.WRI

**Table 4.38 Comparison of Subsurface Soil Contaminant
Concentrations with Ecological Criteria for Site 2
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Inorganics			
Cadmium	0.38	2.5 - 5.0	No
Copper	14.8	70 - 640	No
Lead	12	1000 c/	No
Mercury	0.055	> 10	No

a/ See Table 4.33.

3208A\AU23405\T4-38.WK1

b/ mg/kg = milligrams per kilogram.

c/ Soil guidelines. See Table 4.33.

**Table 4.39 Comparison of Groundwater Contaminant
Concentrations with Ecological Criteria for Site 2
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/L) c/	Livestock Drinking Water Criteria a/ (mg/L)	Release Concentrations Exceed Criterion	Irrigation Water Guidelines b/ (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
TPH d/	7	-	-	-	-
Inorganics					
Selenium	0.0142	0.05	No	0.02	No
Zinc	0.037	25	No	2	No

3208A\AU23405\T4-39.W\GJ

a/ See Table 4.32.

b/ See Table 4.33.

c/ mg/L = milligrams per liter.

d/ TPH = total petroleum hydrocarbons.

**Table 4.40 Comparison of Sediment Contaminant
Concentrations with Ecological Criteria for Site 2
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
bis(2-Ethylhexyl)phthalate	2.000	2000	No
Benzo(b)fluoranthene	1.700	—	—
TPH c/	590	—	—
Inorganics			
Arsenic	10.3	28 – 85	No
Cadmium	24.2	2.5 – 5.0	Yes
Chromium	64.9	100 – 500	No
Copper	66.9	70 – 640	No
Lead	131	1000 d/	No
Mercury	0.19	> 10	No
Nickel	37.5	50 – 200	No
Selenium	1.1	10 d/	No
Zinc	555	500 – 2,000	Yes

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

3205A/AU23405/T4-40.W/KJ

irrigation water guidelines. Criteria were not exceeded by maximum concentrations of selenium and zinc, but no criteria were available for TPH. These results indicate a low potential for adverse effects from exposure to these chemicals.

Sediment. Potential receptors for contaminants in sediments occurring in the ditch are animals which may forage in the drainage, and plants growing in or near the drainage. Criteria for evaluating risks from sediments to terrestrial wildlife have not been established, and, until site-specific data on the biota are available, no direct evaluation of risk for wildlife receptors can be performed. Soil phytotoxic concentrations or agricultural soil guidelines were used for evaluating risks to vegetation.

Of the three organic and nine inorganic chemicals of concern detected in sediments at site 2, phytotoxic criteria were available for all but benzo(b)fluoranthene and TPH. Two of the criteria, for cadmium and zinc, were exceeded, indicating the potential for adverse phytotoxic effects. However, no criteria were available for TPH, precluding an evaluation of its potential adverse effects.

Site 3: North Disposal and Fire Training Pit

The chemicals of concern are compared with environmental criteria in Tables 4.41 and 4.43 and are discussed by medium for the biological groups at risk.

Soils. Potential environmental receptors of contaminants of concern in surface and subsurface soils sampled at site 3 are plants and a variety of wildlife species. Available criteria include soil phytotoxic concentrations and agricultural soil guidelines.

Phytotoxic criteria were available for all eight of the inorganic chemicals of concern in surface soils, but for none of the four organic chemicals. None of the criteria were exceeded, indicating a low potential for adverse phytotoxic effects from chemicals of concern in surface soils at site 3. In subsurface soils, phytotoxic criteria were available for all four inorganic chemicals but none were exceeded, indicating a low potential for phytotoxic effects.

Groundwater. Only TPH and zinc were detected at levels above background concentrations in site 3 groundwater (Table 4.43). The most likely receptors for groundwater are plants with roots extending to the water table, plants irrigated with groundwater, and livestock or deer and pronghorn that may drink or contact groundwater if it were pumped to the surface. Criteria available for evaluating risks to environmental receptors include those for zinc in livestock drinking water and in irrigation water. No criteria were exceeded, indicating a low potential for adverse effects to receptors. However, no criteria were available for TPH, precluding an evaluation of its potential adverse effects, but the levels are relatively low and are unlikely to cause potential adverse effects.

Site 4: Former Fire Training Area 1

The chemicals of concern are compared with environmental criteria in with Tables 4.44 through 4.46 and are discussed by medium for the biological groups at risk.

Table 4.41 Comparison of Surface Soil Contaminant Concentrations with Ecological Criteria for Site 3
120th FIG, International Airport, Great Falls, Montana

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.250	—	—
Butylbenzylphthalate	0.200	—	—
Diethylphthalate	0.590	—	—
Toluene	0.007	—	—
Inorganics			
Arsenic	3.4	25 — 85	No
Barium	665	2000 c/	No
Chromium	29.9	100 — 500	No
Copper	21.8	70 — 640	No
Lead	13.9	1000 c/	No
Nickel	22.5	50 — 200	No
Selenium	0.46	10 c/	No
Zinc	71.1	500 — 2,000	No

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ Soil guideline. See Table 4.33.

320SA/AU23405/T4-41.WKI

Table 4.42 Comparison of Subsurface Soil Contaminant
Concentrations with Ecological Criteria for Site 3
120th FIG, International Airport, Great Falls, Montana

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Inorganics			
Arsenic	9.2	25 - 85	No
Copper	13.3	70 - 640	-
Lead	9.7	1000 c/	-
Nickel	15	50 - 200	No

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ Soil guidelines. See Table 4.33.

320SA\AU23405\T4-42.W\GI

**Table 4.43 Comparison of Groundwater Contaminants
Concentrations with Ecological Criteria for Site 3
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/L) c/	Livestock Drinking Water Criteria a/	Release Concentrations Exceed Criterion ?	Irrigation Water Guidelines b/ (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
TPH d/	2	-	-	-	-
Inorganics					
Zinc	0.066	25	No	2.0	No

a/ See Table 4.32.

b/ See Table 4.33.

c/ mg/L = milligrams per liter.

d/ TPH = total petroleum hydrocarbons.

320SAIAU/23405/T4-43.WK1

**Table 4.44 Comparison of Surface Soil Contaminant
Concentrations with Ecological Criteria for Site 4
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Inorganics			
TPH c/	1500	—	—
Organics			
Arsenic	7.4	25 – 85	No
Copper	18.5	70 – 640	No
Lead	16.7	1000 d/	No
Nickel	13.8	50 – 200	No
Zinc	48.4	500 – 2,000	No

320SA/AU23403/T4-44.W/K1

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

**Table 4.45 Comparison of Subsurface Soil Contaminant
Concentrations with Ecological Criteria for Site 4
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.160	-	-
Bis(2-Ethylhexyl)phthalate	0.240	2000	No
Butylbenzylphthalate	1.400	-	-
Diethylphthalate	1.700	-	-
Toluene	0.006	-	-
TPH c/	600	-	-
Inorganics			
Arsenic	7.9	25-85	No
Barium	1190	2000 d/	No
Chromium	20.6	100 - 500	No
Copper	34.9	70 - 640	No
Lead	15.4	1000 d/	No
Nickel	12.1	50 - 200	No
Zinc	48.8	500 - 2,000	No

320SA\AU23405\T4-45.WK1

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

**Table 4.46 Comparison of Groundwater Contaminant
Concentrations with Ecological Criteria for Site 4
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/L) c/	Livestock Drinking Water Criteria a/	Release Concentrations Exceed Criterion ?	Irrigation Water Guidelines b/ (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
TPH d/	3	—	—	—	
Inorganics					
Barium	0.259	—	—	—	—
Lead	0.0075	0.1	No	5.0	No
Selenium	0.0108	0.05	No	0.02	No
Zinc	0.032	25	No	2.0	No

320SA\AU23405\T4-46.WRI

a/ See Table 4.32.

b/ See Table 4.33.

c/ mg/L = milligrams per liter.

d/ TPH = total petroleum hydrocarbons.

Soils. Surface and subsurface soils were sampled at site 4. Potential environmental receptors are plants and a variety of wildlife species. These receptors are most likely to contact surface soils rather than subsurface soils. Available criteria include soil phytotoxic concentrations and agricultural soil guidelines.

Phytotoxic criteria were available for all chemicals of concern in surface soils except TPH, precluding an evaluation of its potential adverse effects. None of these criteria were exceeded, indicating a low potential for phytotoxic effects.

In subsurface soils, phytotoxic criteria were available for all seven inorganic chemicals but only one of six organic chemicals, bis(2-ethylhexyl)phthalate. None of these criteria were exceeded, indicating a low potential for phytotoxic effects. However, no criteria were available for TPH, precluding an evaluation of its potential adverse effects.

Groundwater. Four metals and TPH were detected above background levels in site 4 groundwater samples (Table 4.46). The most likely receptors for groundwater are plants with roots extending to the water table, plants irrigated with groundwater, and livestock or deer and pronghorn that may drink or contact groundwater if it were pumped to the surface. Criteria available for evaluating risks to environmental receptors include livestock watering and irrigation criteria. Criteria were not available for barium or TPH, precluding an evaluation of their potential adverse effects. No available criteria were exceeded, indicating a low potential for adverse effects to potential environmental receptors.

Site 5: Former Fire Training Area 2

The chemicals of concern are compared with environmental criteria in Tables 4.47 through 4.49, and are discussed by medium for the biological groups at risk.

Soils. Surface and subsurface soils were sampled at site 5. Potential environmental receptors are plants and a variety of wildlife species. These receptors are more likely to contact surface soils than subsurface soils. Available criteria include soil phytotoxic concentrations and agricultural soil guidelines.

Phytotoxic criteria were available for all of the chemicals of concern in surface soils except TPH. None of the criteria were exceeded, indicating a low potential for phytotoxic effects (Table 4.47).

In subsurface soils, two organic chemicals and six metals were identified as chemicals of concern. No phytotoxic criteria were available for comparison with the organics, acetone and toluene. However, all the metals of concern have phytotoxic criteria. None of the metals exceeded their phytotoxic criteria, indicating a low potential for adverse effects to vegetation (Table 4.48).

Groundwater. Only selenium, zinc, and TPH were detected in site 5 groundwater (Table 4.49). The most likely receptors for groundwater are plants with roots extending to the water table or which may be irrigated with groundwater, and livestock or deer and pronghorn that may drink or contact groundwater if it were pumped to the surface. Livestock watering criteria and irrigation water criteria are

**Table 4.47 Comparison of Surface Soil Contaminant
Concentrations with Ecological Criteria for Site 5
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
TPH c/	160	—	—
Inorganics			
Arsenic	7	25 — 85	No
Copper	31	70 — 640	No
Lead	9.5	1000 d/	No
Selenium	0.29	10 d/	No
Zinc	47	500 — 2,000	No

320SA\AU23405\T4-47.WRI

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

**Table 4.48 Comparison of Surbsurface Soil Contaminant
Concentrations with Ecological Criteris for Site 5
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.140	-	-
Toluene	0.010	-	-
Inorganics			
Arsenic	22.5	25 - 85	No
Chromium	22.8	100 - 500	No
Copper	31.6	70 - 640	No
Lead	12.7	1,000 c/	No
Nickel	16.1	50 - 200	No
Zinc	61.2	500 - 2,000	No

320SA\AU23405\T4-48.WKI

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ Soil guidelines. See Table 4.33.

Table 4.49 Comparison of Groundwater Contaminant
Concentrations with Ecological Criteria for Site 5
120th FIG, International Airport, Great Falls, Montana

Chemical of Concern	Maximum Release Concentration (mg/L) c/	Livestock Drinking Water Criteria a/ (mg/L)	Release Concentrations Exceed Criterion ?	Irrigation Water Guidelines b/ (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
TPH d/	4	—	—	—	—
Inorganics					
Selenium	0.0081	0.05	No	0.02	No
Zinc	0.051	25	No	2	No

320SAIAU23405\T4-49.WK1

a/ See Table 4.32.

b/ See Table 4.33.

c/ mg/L = milligrams per liter.

d/ TPH = total petroleum hydrocarbons.

available for selenium and zinc but not for TPH, precluding an evaluation of its potential adverse effects. None of the available criteria were exceeded, indicating a low potential for adverse health effect to livestock, deer, pronghorn, and plants.

Site 6: Aerospace Ground Equipment Area

The chemicals of concern are compared with environmental criteria in Tables 4.50 through 4.53 and are discussed by medium for the biological groups at risk.

Soils. Phytotoxic criteria were available for all seven inorganic chemicals of concern in surface soils. None of these criteria were exceeded, indicating a low potential for phytotoxic effects from the metals of concern. The organic chemicals of concern (acetone and toluene) and TPH could not be evaluated because phytotoxic criteria are not available (Table 4.50).

In subsurface soils, nine organics, TPH, and five inorganics were determined to be chemicals of concern. Phytotoxic criteria were available for all of the inorganic chemicals of concern but only for two of the organic chemicals [bis(2-ethylhexyl)phthalate and ethyl benzene]. None of these criteria were exceeded, indicating a low potential for phytotoxic effects (Table 4.51).

Groundwater. Two organic chemicals and six metals were detected above background at levels in site 6 groundwater samples (Table 4.52). The most likely receptors for groundwater are plants with roots extending to the water table, plants irrigated with groundwater, and livestock or deer and pronghorn that may drink or contact groundwater if it were pumped to the surface. Criteria available for evaluating risks to environmental receptors include livestock watering and irrigation criteria. None of these criteria were exceeded by maximum detected concentrations, though criteria were not available for all detected chemicals (Table 4.52). Nevertheless, these results indicate a low potential for adverse environmental effects.

Sediment. Potential receptors of contaminants in sediment are a variety of wildlife species which may forage in the drainage ditch at this site, as well as plants growing in or near the ditch. Soil phytotoxic concentrations or agricultural soil guidelines were used for evaluating risks to vegetation.

TPH and eight inorganic compounds were determined to be the chemicals of concern (Table 4.53). TPH was the only chemical concern for which a phytotoxic criteria was not available, precluding an evaluation of its potential adverse effects. Of the inorganics, cadmium exceeded its criteria value, indicating potential adverse effects to vegetation.

Site 7: Dry Well Off Corrosion Control Building

The chemicals of concern are compared with environmental criteria in Tables 4.54 through 4.56 and are discussed by medium for the biological groups at risk.

Soils. Surface and subsurface soils were sampled at site 7. Potential environmental receptors are plants and a variety of wildlife species. These receptors are

**Table 4.50 Comparison of Surface Soil Contaminant
Concentrations with Ecological Criteria for Site 6
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.520	-	-
Toluene	0.007	-	-
TPH c/	13,000	-	-
Inorganics			
Arsenic	7.2	25 - 85	No
Cadmium	0.35	2.5 - 5.0	No
Copper	43.4	70 - 640	No
Lead	28.3	1,000 d/	No
Nickel	12.4	50 - 200	No
Selenium	0.37	10 d/	No
Zinc	60.8	500 - 2,000	No

3208A\AU23403\T4- 50.WK1

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

Table 4.51 Comparison of Subsurface Soil Contaminant Concentrations with Ecological Criteria for Site 6
120th FIG, International Airport, Great Falls, Montana

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxic Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.570	—	—
bis(2-Ethylhexyl)phthalate	0.130	2,000	No
Ethylbenzene	1.600	190,000	No
2-Methylnaphthalene	2.700	—	—
Naphthalene	3.000	—	—
Toluene	17.000	—	—
TPH c/	8100	—	—
Trichloroethene	4.000	—	—
m,p-Xylene	7.900	—	—
o-Xylene	2.600	—	—
Inorganics			
Cadmium	0.41	2.5 – 5.0	No
Chromium	18.3	100 – 500	No
Copper	14.4	70 – 640	No
Lead	52.3	1,000 d/	No
Selenium	0.35	10 d/	No

320SA\AU23405T4-51.WK1

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

**Table 4.52 Comparison of Groundwater Contaminants
Concentrations with Ecological Criteria for Site 6
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/L) c/	Livestock Drinking Water Criteria a/ (mg/L)	Release Concentrations Exceed Criterion ?	Irrigation Water Guidelines b/ (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
Benzene	0.0018	-	-	-	-
Bis(2-Ethylhexyl)phthalate	0.021	-	-	-	-
Inorganics					
Arsenic	0.0015	0.2	No	0.10	No
Barium	0.215	-	-	-	-
Copper	0.006	0.5	No	0.20	No
Lead	0.0063	0.1	No	5.0	No
Mercury	0.00019	0.01	No	-	-
Zinc	0.052	25	No	2.0	No

3205AIAU23405IT4-52.WK1

a/ See Table 4.32.

b/ See Table 4.33.

c/ mg/L = milligrams per liter.

**Table 4.53 Comparison of Sediment Contaminant
Concentrations with Ecological Criteria for Site 6
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxicity Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
TPH c/	3,000	-	-
Inorganics			
Cadmium	6.4	2.5 - 5.0	Yes
Chromium	58.8	100 - 500	No
Copper	48.5	70 - 640	No
Lead	529	1,000 d/	No
Mercury	0.065	>10	No
Nickel	18.9	50 - 200	No
Selenium	0.41	10 d/	No
Zinc	284	500 - 2,000	No

3208A\AU73405\T4-53.WK1

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

Table 4.54 Comparison of Surface Soil Contaminant
Concentrations with Ecological Criteria for Site 7
120th FIG, International Airport, Great Falls, Montana

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxicity Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
TPH c/	34	—	—
Inorganics			
Copper	19	70 — 640	No
Lead	10.7	1,000 d/	No

320SA\AU23405\T4-54.WRI

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

**Table 4.55 Comparison of Subsurface Soil Contaminant
Concentrations with Ecological Criteria for Site 7
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxicity Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.100	—	—
Benzene	2.600	525 — 20,000	No
bis(2-Ethylhexyl)phthalate	5.400	2,000	No
di-n-butylphthalate	0.140	—	—
Ethylbenzene	24.000	190,000	No
2-Methylnaphthalene	42.000	—	—
Naphthalene	22.000	—	—
Toluene	140.000	—	—
TPH c/	19,000	—	—
m,p-Xylene	110.000	—	—
o-Xylene	49.000	—	—
Inorganics			
Copper	17.1	70 — 640	No
Lead	443	1,000 d/	No
Selenium	0.6	10 d/	No
Zinc	158	500 — 2,000	No

320SA\AU23405\T4-55.WRI

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

**Table 4.56 Comparison of Groundwater Contaminant
Concentrations with Ecological Criteria for Site 7
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/L) c/	Livestock Drinking Water Criteria a/ (mg/L)	Release Concentrations Exceed Criterion ?	Irrigation Water Guidelines b/ (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
Benzene	0.011	-	-	-	-
Ethylbenzene	0.160	-	-	-	-
2-Methylnaphthalene	0.011	-	-	-	-
Naphthalene	0.024	-	-	-	-
Xylenes (total)	0.500	-	-	-	-
Inorganics					
Arsenic	0.0015	0.2	No	0.10	No
Barium	0.095	-	-	-	-
Zinc	0.030	25	No	2.0	No

320SA\AU23405\T4-56.WK1

a/ See Table 4.32.

b/ See Table 4.33.

c/ mg/L = milligrams per liter.

more likely to contact surface soils than subsurface soils. Soil phytotoxic concentrations and agricultural soil guidelines were used to evaluate vegetation.

In surface soils, only TPH, copper and lead were detected above background levels (Table 4.54). No criteria are available for evaluating adverse effects to plants from TPH. However, no phytotoxic criteria were exceeded by copper and lead. These results indicate the potential for adverse ecological effects from surface soils are low.

In subsurface soils, eleven organic chemicals, including TPH, and four metals were detected above background levels. Of these contaminants, bis(2-ethyl-hexyl)phthalate, benzene, ethyl benzene, and all the inorganics had phytotoxic criteria (Table 4.55). None of the phytotoxic criteria were exceeded, indicating a low potential for adverse effects to vegetation. However, no criteria were available for TPH, precluding an evaluation of its potential adverse effects.

Groundwater. The most likely receptors for groundwater contaminants are plants with roots extending to the water table, plants irrigated with groundwater, and livestock or deer and pronghorn that may drink or contact groundwater if it were pumped to the surface. Livestock watering guidelines and irrigation water guidelines are available for evaluating potential risks from exposure to arsenic and zinc. Criteria are not available for the five organic chemicals of concern or for barium. Maximum detected concentrations of arsenic and zinc were within acceptable levels (Table 4.56). No available criteria were exceeded, indicating that the risk from groundwater appears to be low.

Site 8: Dry Well Off Composite Maintenance Building

The chemicals of concern are compared with environmental criteria in Tables 4.57 through 4.59 and are discussed by medium for the biological groups at risk.

Soils. Surface and subsurface soils were sampled at site 8. Potential environmental receptors include plants and a variety of wildlife species. These receptors are more likely to be exposed to surface soils than to subsurface soils. Available criteria include soil phytotoxic concentrations and agricultural soil guidelines. Criteria for general wildlife receptors are not available.

Fifteen above-background chemicals were detected in surface soils at site 8. Plant criteria were available for the four detected metals and for ethyl benzene (Table 4.57). No criteria were exceeded, indicating a low potential for phytotoxic effects. However, no criteria were available for TPH, precluding an evaluation of its potential adverse effects.

Two organic chemicals, TPH, and five metals were detected above background levels in subsurface soils (Table 4.58). Plant criteria were not available for TPH and the two detected organic compounds. Maximum metals concentrations were within acceptable levels for plants, indicating a low potential for adverse phytotoxic effects.

Groundwater. Five organic chemicals and two metals were detected above background concentrations in site 8 groundwater samples. The most likely recep

**Table 4.57 Comparison of Surface Soil Contaminant
Concentrations with Ecological Criteria for Site 8
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxicity Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.095	—	—
Chlorobenzene	0.035	—	—
1,2-Dichlorobenzene	0.240	—	—
1,2/1,4-Dichlorobenzene	0.180	—	—
trans-1,2-Dichloroethene	0.008	—	—
Ethylbenzene	0.008	190,000	No
Toluene	0.046	—	—
TPH c/	140	—	—
Trichloroethene	0.260	—	—
m,p-Xylene	0.014	—	—
o-Xylene	0.010	—	—
Inorganics			
Arsenic	7.4	25 – 85	No
Copper	19.8	70 – 640	No
Lead	14.9	1,000 d/	No
Zinc	48.3	500 – 2,000	No

320SA\AU23405\T4-57.WK1

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

**Table 4.58 Comparison of Subsurface Soil Contaminant
Concentrations with Ecological Criteria for Site 8
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/kg) b/	Soil Phytotoxicity Concentration a/ (mg/kg)	Release Concentrations Exceed Criterion ?
Organics			
Acetone	0.140	—	—
TPH c/	26	—	—
Trichloroethene	0.004	—	—
Inorganics			
Arsenic	22.2	25 — 85	No
Copper	17.2	70 — 640	No
Lead	13.7	1,000 d/	No
Selenium	0.35	10 d/	No
Zinc	46.3	500 — 2,000	No

320SAIAU23405YT4--58.WK1

a/ See Table 4.33.

b/ mg/kg = milligrams per kilogram.

c/ TPH = total petroleum hydrocarbons.

d/ Soil guidelines. See Table 4.33.

**Table 4.59 Comparison of Groundwater Contaminant
Concentrations with Ecological Criteria for Site 8
120th FIG, International Airport, Great Falls, Montana**

Chemical of Concern	Maximum Release Concentration (mg/L) c/	Livestock Drinking Water Criteria a/ (mg/L)	Release Concentrations Exceed Criterion ?	Irrigation Water Guidelines b/ (mg/L)	Release Concentrations Exceed Criterion ?
Organics					
bis(2-Ethylhexyl)phthalate	0.007	-	-	-	-
1,2-Dichloroethene	0.0480	-	-	-	-
Tetrachloroethene	0.0028	-	-	-	-
TPH d/	3	-	-	-	-
Trichloroethene	0.0035	-	-	-	-
Inorganics					
Barium	0.070	-	-	-	-
Lead	0.0058	0.1	No	5	No

3208AIAU23405IT4-59.W3K

a/ See Table 4.32.

b/ See Table 4.33.

c/ mg/L = milligrams per liter.

d/ TPH = total petroleum hydrocarbons.

tors for groundwater are plants with roots extending to the water table, plants irrigated with groundwater, and livestock or deer and pronghorn that may drink or contact groundwater if it were pumped to the surface. Livestock watering criteria and irrigation criteria were available only for lead. The criteria were not exceeded (Table 4.59).

4.4 UNCERTAINTY

There are several categories of uncertainties associated with this preliminary risk evaluation. All risk evaluations involve the use, of various degrees, of assumptions, judgment, and imperfect data. Because of the preliminary screening nature of this evaluation, fewer assumptions (which could increase uncertainty) were used.

Uncertainty in a risk evaluation may arise for many reasons, including:

- Inadequate or inappropriate environmental chemistry sampling and analysis
- Misidentification or failure to be all-inclusive in hazard identification
- Use of maximum rather than upper (95th-percentile) confidence intervals for chemical concentration values
- Choice of models or evaluation of toxicological data in dose-response quantification
- Assumptions concerning exposure scenarios and population distributions for both human and environmental receptors
- Assumptions regarding future site conditions and land uses.

Uncertainty may be magnified in the evaluation through combination of these variables.

In risk evaluations, procedures are designed to be conservative in order that they may screen for risks that require additional study. The net effect of combining numerous conservative assumptions is that the final estimates of risk may be greatly overestimated, but will guide potential future studies, such as the RI, that can more specifically estimate risks.

Environmental chemistry sampling and analysis error can stem from errors inherent in the sampling and analysis procedures, from a failure to take an adequate number of samples to arrive at sufficient areal resolution, or from the heterogeneity of the matrix being sampled. For example, at the base, no air samples and only a single groundwater sample from each site were used in the evaluation. A single sample may not be representative of the contaminants present or the contaminant concentrations at the site. One of the most effective ways of minimizing procedural or systematic error is to subject the data to a strict quality control review and to collect sufficient numbers of samples. Even with all data rigorously quality assured, however, error is still inherent in all analytical procedures. Because of these limitations, it may not be possible to definitively determine if a sample is truly representative of site conditions.

The maximum concentrations of chemicals of concern at each of the eight sites at the base were compared with health and environmental criteria to estimate the potential threat to identified receptors. Because attenuation and dispersion of chemicals of concern by natural processes may occur over time, the concentrations of chemicals to which receptors are eventually exposed may be less than those measured during this investigation.

In almost all risk evaluations, the largest source of uncertainty is in the development of comparison criteria. In environmental risk evaluations, toxicity thresholds vary considerably for different species. Because criteria are not available for all individual species, criteria for surrogate species must often be used. To compensate for this uncertainty, conservative assumptions are made. This is necessary to account for data gaps and gaps in toxicity information, and for the great differences among species in contaminant uptake, bioaccumulation, and biomagnification of chemicals of concern. Moreover, baseline data regarding the biota present at each of the sites, as well as biological sampling data, were not available for this study. Without information regarding potential receptors at the sites, species-specific toxicity guidelines such as LD₅₀s cannot be reasonably applied. The resulting evaluation therefore may not accurately represent the actual risk.

In the human health evaluation, health criteria for evaluating long-term exposures, such as RfDs or cancer slope factors, are based on concepts and assumptions which bias an evaluation in the direction of overestimation of health risk. These uncertainties are compensated for by using upper bounds for cancer potency factors for carcinogens and safety factors for RfDs for noncarcinogens. At best, the dose-response assumptions used in risk evaluation provide a rough but plausible estimate of the upper limit of risk. That is, the true risk is likely not much more than the estimated risk, but it could very well be considerably lower, even approaching zero.

In addition, there are varying degrees of confidence in the weight of evidence for carcinogenicity of a given chemical (section 4.2.3). EPA's weight-of-evidence classification provides information which can indicate the level of confidence or uncertainty in the carcinogenicity data obtained from studies in humans or experimental animals. Some of the uncertainties in the hazard evaluation are further compensated for by assuming that animal carcinogens behave as human carcinogens.

There are also inherent uncertainties in identifying exposure scenarios for evaluation and in determining the exposure parameters that are combined with toxicological information to estimate risk. For example, there are uncertainties regarding assumptions in estimating the likelihood that an individual or environmental receptor would come into contact with chemicals of concern originating at the site, the concentration of chemicals in the environmental medium of concern, and the period of time over which such exposures might occur. In general, use of conservative assumptions in estimating exposure-point concentrations and estimating chemical intakes will result in a conservative evaluation.

Because comparison criteria are not available for all chemicals of concern, certain potential health and/or environmental risks may be underestimated. For

example, protective criteria for risks posed to terrestrial wildlife from soils or sediments have not been established.

Also, it is not possible to evaluate the potential health or ecological risks from screening tests, such as TPH. Individual components of TPH may be identified with VOC and BNA organics test methods. However, many components of TPH will occur as tentatively identified compounds (TICs). The *Risk Assessment Guidance for Superfund* (U.S. Environmental Protection Agency, 1989) specifies that, when there are a large number of TICs relative to identified compounds, or if TIC concentrations appear high or site information (e.g., the presence of large amounts of TPH) indicates that TICs are indeed present, further evaluation of TICs is necessary. At this screening level, evaluation of TICs was not included. In addition, no human health or environmental criteria are available for TPH. Because several TPH measurements were unusually high, the lack of comparison criteria means that risks may be underestimated.

In some cases, it may be possible to make assumptions about the chemical structure or form of a chemical so that a comparison with a criterion value can be made. This may result in overestimating the potential health risk. For example, the criterion value for 1,2-DCE is isomer-specific. Therefore, it was assumed that all 1,2-DCE at the 120th FIG Base occurs as the trans-isomer so that an evaluation could be made. For purposes of comparison, it was also necessary to assume in the human health evaluation that all analyses of 1,2-/1,4-dichlorobenzene were 100 percent 1,4-dichlorobenzene, which represents a worst-case scenario.

Moreover, no site-specific information regarding environmental receptors was available, and therefore toxicity criteria for livestock drinking water or agricultural plants may not be directly applicable to resident animal and plant species. Lack of biological tissue samples further hampers the ability to accurately estimate the likelihood of pathway completion or the risks from bioconcentrations and biomagnification.

4.5 HUMAN HEALTH AND ECOLOGICAL RISK EVALUATION SUMMARY

A summary of the results of both the human health and ecological risk evaluations is presented in this section. Both of these evaluations are preliminary and may not fully characterize risks posed by contaminants at the site. This evaluation should be used only as a screening tool to guide future investigations of the site. In addition to specific recommendations, future investigations should determine general habitat types, including the presence of wetlands; species occurring at the base, including threatened or endangered species; and the likelihood of pathway completion based on current and projected land use and surface water flow patterns.

4.5.1 Site 1 Preliminary Risk Evaluation Conclusions

Screening activities at site 1 indicated high concentrations of VOCs in the burn pit. It was determined that, because of the high concentrations of VOCs, level C analysis would require sample dilution too great to allow for acceptable detection levels. It was apparent that gross fuel related contamination was present in soils in

the burn pit. Thus, the focus of the soil sampling activities at site 1 became delineation of contamination around the burn pit, for the purpose of determining the quantity of soils to be remediated. Therefore, the PRE for site 1 soils was prepared for soils data from the areas immediately surrounding the burn pit, with the assumption being that actual burn pit soils are to be remediated.

No potential human health risks from ingestion of contaminants were identified in this evaluation. Although inhalation pathways were not evaluated, inhalation risks associated with the release of VOCs from groundwater during showering are unlikely to be significant. Inhalation risks associated with contaminants in soils are similarly unlikely to be significant. In addition, there are unknown potential public health risks associated with high TPH measurements.

No ecological receptors were identified as being at risk from chemicals of concern at site 1. However, the TPH value of 120,000 mg/kg in surface soil indicates an unevaluated potential for adverse effects. Further investigations at the site are recommended for the purpose of remediating areas of contaminated soils delineated in this investigation.

4.5.2 Site 2 Preliminary Risk Evaluation Conclusions

In the human health risk evaluation, selenium exceeded its MCL by 0.0042 mg/L. Exceedance to that small degree probably is not significant and most likely does not pose a potential human health concern. Although no other risks were identified, there are unknown potential public health risks associated with TPH. Volatile organics were detected in surface soils, which may pose a potential public health concern from inhalation of contaminants.

Plants are potentially at risk from cadmium and zinc in sediments at site 2. Risk to wildlife from sediments and soils at this site could not be evaluated in the absence of site-specific biota data. In addition, risks from TPH concentrations in both surface soils and sediments could not be evaluated. Further investigations of the site for additional soil and sediment samples, soil and sediment pH measurements, and reconnaissance by a biologist would be needed to better evaluate risks to ecological receptors. Because cadmium, which exceeds the soils phytotoxicity criterion in sediments, is known to bioaccumulate and biomagnify in the food chain, evaluation of this potential indirect pathway through plant tissue analysis should be considered.

4.5.3 Site 3 Preliminary Risk Evaluation Conclusions

No potential human health risks from ingestion of contaminants were identified in this evaluation. However, there are unknown potential public health risks associated with TPH. In addition, volatile organics detected in surface soils may pose a potential public health concern from inhalation of contaminants.

No ecological receptors were identified as being at risk from chemicals of concern at site 3. TPH concentrations in groundwater are low enough to pose no risk to ecological receptors.

4.5.4 Site 4 Preliminary Risk Evaluation Conclusions

In the human health risk evaluation, selenium exceeded its MCL by 0.0008 mg/L. Exceedance by that small degree is probably not significant and most likely does not pose a potential human health risk. Although no other human health risks were identified, there are unknown potential human health risks associated with TPH.

No ecological receptors were identified as being at risk from chemicals of concern at site 4. However, risks from high TPH concentrations in surface and subsurface soils could not be evaluated. Further investigations of the site for additional soil samples, soil pH measurements, and reconnaissance by a biologist would be needed to better evaluate risks.

4.5.5 Site 5 Preliminary Risk Evaluation Conclusions

No potential human health risks from ingestion of contaminants were identified in this evaluation. However, there are unknown potential public health risks associated with TPH. In addition, volatile organics detected in subsurface soils may pose a potential public health concern to future construction workers from inhalation of contaminants.

No ecological receptors were identified as being at risks from chemicals of concern at Site 5. However, risks from TPH concentrations in surface soils could not be evaluated.

4.5.6 Site 6 Preliminary Risk Evaluation Conclusions

Because bis(2-ethylhexyl)phthalate exceeded its criterion value, there is a potential public health risk from ingestion of groundwater at Site 6. Furthermore, there are unknown potential health risks associated with TPH in soils and sediments. In addition, volatile organics detected both in surface and subsurface soils may pose a potential public health risk from inhalation of contaminants. Further study is needed to fully characterize the human health risks associated with this site.

Ecological receptors identified as being at risk from chemicals of concern at site 6 are plants exposed to sediments. Risks from high TPH concentrations in surface and subsurface soils and sediments could not be evaluated. Further investigations of the site, including additional soil and sediment samples, soil pH measurements, and reconnaissance by a biologist, would be needed to better evaluate risks. Although cadmium exceeds the soil phytotoxicity criterion in sediment and is known to bioaccumulate and biomagnify in the food chain, evaluation of this potential indirect pathway is unnecessary because this area is a primarily paved industrial operations area and is unlikely to have significant food chain impact.

4.5.7 Site 7 Preliminary Risk Evaluation Conclusions

Because benzene exceeded its MCL, there is a potential public health risk from ingestion of groundwater at Site 7. Furthermore, there are unknown potential health risks associated with TPH in soils. In addition, the volatile organics detected in groundwater may also pose a potential public health risk from inhalation of con-

taminants. Further study is needed to fully characterize the human health risks associated with this site.

No ecological receptors were identified as being at risk from chemicals of concern at site 7. However, risks from TPH concentrations in surface and subsurface soils could not be evaluated.

4.5.8 Site 8 Preliminary Risk Evaluation Conclusions

Because two chemicals of concern exceeded their criterion values at site 8, there is a potential public health risk from ingestion of groundwater at the site. Furthermore, there are unknown potential health risks associated with TPH in groundwater and soils. In addition, volatile organics were detected in all the sampled media and may pose a public health risk from inhalation of contaminants. Further study is needed to fully characterize the human health risks associated with this site.

No ecological receptors were identified as being at risk from chemicals of concern at site 8. However, risks from TPH concentrations in groundwater and soils could not be evaluated.

SECTION 5

IMMEDIATE RESPONSE ACTIONS TAKEN

The results of the SI investigations reported herein do not indicate any immediate threat to sensitive receptors. Therefore, no immediate response actions have been taken as of the preparation of this report.

SECTION 6

SUMMARY AND CONCLUSIONS

6.1 SUMMARY

Field investigations were conducted at eight potential hazardous waste sites at the 120th Fighter Interceptor Group (FIG), Great Falls, Montana. These sites were originally identified in the preliminary assessment. At each site, soil gas surveys were conducted, piezometers were constructed, soil borings were drilled and sampled, and monitoring wells were constructed and sampled. In addition, ground-penetrating radar surveys were conducted at sites 6, 7, and 8, and sediment samples were collected at sites 2 and 6.

The results of these investigations are described in detail in the preceding sections and are summarized below:

Sites	
1, 6, 7, and 8	significant soil contamination
2, 3, 4, and 5	low levels of soil contamination
6, 7, and 8	significant groundwater contamination (exceeding risk assessment criteria)
1, 2, 3, and 4	trace to low levels of groundwater contamination.

The preliminary risk evaluation (PRE) determined, within the limits of the available data, that possible threats to human health exist at sites 6, 7, and 8 due to groundwater contamination. The PRE also determined possible ecological hazards at site 1 due to soil contamination and at sites 2 and 6 due to elevated levels of metals in sediments from drainage ditches.

6.2 CONCLUSIONS

6.2.1 Data Gaps

Data gaps are defined as those data which must be collected before decisions concerning progression to the next step can be made. Based on this definition, only one data gap exists from this investigation. As discussed in section 6.2.2, groundwater level data at site 1 indicate that an additional monitoring well is needed at that site to ensure that samples are taken from a well directly downgradient from the contaminated area of site 1.

The only significant, planned activity described in the Work Plan for this facility which was not fully executed was the soil gas survey at sites 2, 4, and 5. As discussed in the Quality Assurance Report (appendix E), the completeness objectives for the soil gas survey were not achieved at these sites. However, as explained in appendix E, the goals of the soil gas survey were met because of other information obtained during the investigation. Therefore, no data gaps exist in soil gas survey results.

Since a mobile laboratory was not used during this investigation field screening data for soils samples could not be used for specific compound identification. This resulted in only qualitative screening data from soil borings. No quantitative analysis for identified contaminants could be performed prior to CLP analysis. However, comparison of HNU screening data (quantitative but not qualitative) and field GC screening data (qualitative but not quantitative) with CLP data (qualitative and quantitative) generally indicated good correlation. Therefore, no data gaps exist in the screening analytical data.

6.2.2 Recommendations

The investigation conducted at the base indicated the possibility of significant fuel and solvent-related contamination in areas which include sites 6, 7, and 8. Based on underground storage tank (UST) information available at the time of the investigation, it appears that some of the fuel related soil contamination in these areas may be due to leaking USTs which were recently removed. Because of this fuel contamination and indication of both fuel and solvent contamination of groundwater at monitoring wells for sites 6, 7, and 8, detailed investigations of these areas are recommended (as described in this section). These investigations should begin with a fuel tank inventory which includes activity status and tank integrity. This tank information can then be incorporated into the evaluation of investigation results.

Recommendations for future work at each of the eight sites at the base are presented below. It is also recommended that any future field work conducted at the base include a basewide hydrogeology investigation to determine the lithologic and hydrogeologic characteristics of the formation on which the base is located. Additional hydrogeologic information is needed because the data gathered during this investigation indicate areas of shallow groundwater and because anomalies in groundwater flow directions are apparent when data from the different sites is compared.

Site 1 - Current Fire Training Area

The PRE for site 1 states that the available data for soils do not exceed criteria for threats to human health and environment. However, the PRE states that the high level of TPH, for which no criteria exists, is a potential ecological threat. It is also possible that these soils will continue to be a source of contamination threatening groundwater at the site.

Screening activities at site 1 indicated high concentrations of VOCs in the burn pit. It was determined that level C analysis would require sample dilution too great

to allow for acceptable detection levels. It was apparent that gross fuel related contamination was present in soils in the burn pit. Thus, the focus of the soil sampling activities at site 1 became delineation of contamination around the burn pit, for the purpose of determining the quantity of soils to be remediated. The available lithologic data indicate that soils at the base are 3 to 8 feet deep. The analytical data indicate that contamination at site 1 is limited to the areas in and immediately surrounding the burn areas. For this reason, additional study is recommended for soils at the site, primarily to consider the option of contaminated soil removal or in situ treatment. It may be necessary to collect additional soil samples in the highest contamination areas for use in the evaluation of these options.

The analytical data at site 1 indicate contamination of groundwater at levels below the PRE criteria. Since groundwater level data obtained after installation of the monitoring well at site 1 indicate that the well is not directly downgradient of the areas of highest contamination, additional field work is recommended. This work should include construction of one monitoring well, to clearly confirm or deny any significant groundwater contamination, directly downgradient from the largest burn (based on the most recent water level data available). This information can then be used to support a recommendation for no further action or to plan future work.

Site 2 - Drainage Ditch Off Old Power Check Pad

The soil gas survey and soil borings at this site indicate minimal contamination only in small areas in the drainage ditch. The PRE for site 2 states that the available data for soils do not exceed criteria for threats to human health and environment, except for slightly elevated levels of cadmium and zinc in sediment samples taken in the drainage ditch. Due to the remote location of site 2, the limited area of contamination, and since it is not known if significant quantities of waste entered the ditch through the overflow pipe, preparation of a no further action decision document is recommended for soils at this site.

The analytical data at this site indicate low concentrations of TPH in the round 1 groundwater sample which was not confirmed by the round 2 sample. No other contaminants were detected in either sample. Since it is not known if significant quantities of waste entered the ditch from the overflow pipe, and since no contamination of groundwater could be confirmed from the monitoring well at the site, preparation of a no further action decision document for groundwater at site 2 is recommended.

Site 3 - North Disposal and Fire Training Pit

The soil gas survey at this site was limited by the presence of a large mound of waste asphalt. This mound was removed to allow soil borings in the area. The soil gas and soil boring data indicate no areas of significant soil contamination and no clearly defined contaminated area. The PRE for the site states that the available data for soils do not exceed criteria for threats to human health and environment. Due to the lack of significant contamination and the lack of any clearly defined

waste disposal area, preparation of a no further action decision document is recommended for soils at this site.

Analytical data for groundwater at the site do not indicate significant contamination from activities at the site. Site 3 is located within 100 feet of the edge of the bench on which the airport is located. The groundwater flow direction at site 3 is directly towards the edge of the bench. It is apparent that any contamination which may enter groundwater from site 3 would be discharged through seeps and springs on the side of the bench. Borings at the site indicate no significant source of contamination remaining in soils at the site. For these reasons, preparation of a no further action decision document for groundwater at this site is recommended.

Site 4 - Fire Training Area 1

The soil gas and soil boring data indicate no areas of soil contamination exceeding the PRE criteria. In addition, the available data do not indicate a clearly defined waste disposal area. Soils from this area were removed during extension of the runway, after the fire training area at this site was no longer in use. Clean soils were imported to the site during construction of the hush house. Due to the lack of significant contamination, the lack of any clearly defined waste disposal area, and the removal and replacement of soil which took place at the site, preparation of a no further action decision document is recommended for soils at this site.

Analytical data for groundwater at the site do not indicate significant contamination exceeding the PRE criteria. Soil data discussed above indicate no significant source for potential groundwater contamination. Therefore, preparation of a no further action decision document is recommended.

Site 5 - Fire Training Area 2

The soil gas and soil boring data indicate no areas of soil contamination exceeding the PRE criteria. In addition, the available data do not indicate a clearly defined waste disposal area. Soils from this area were removed during extension of the runway, after the fire training area at this site was no longer in use. Clean soils were imported to the site during construction of the alert barns. Due to the lack of significant contamination, the lack of any clearly defined waste disposal area, and the removal and replacement of soil at the site, preparation of a no further action decision document is recommended for soils at this site.

Analytical data for groundwater at the site do not indicate significant contamination exceeding the PRE criteria. Soil data discussed above indicate no significant source for potential groundwater contamination. Therefore, preparation of a no further action decision document is recommended.

Site 6 - Aerospace Ground Equipment Area

Analytical data for groundwater at the site indicate significant contamination exceeding the PRE criteria. The contaminants of concern (phthalates) could be from solvents reportedly disposed of in the dry well at site 6 but are also common laboratory contaminants. Some contamination of groundwater is indicated in other wells and piezometers in the vicinity of site 6. In addition, lithologic data collected

during this investigation indicate that shale and weathered sandstone layers exist for several feet below the soil rock interface. Since phthalates exceeding PRE criteria were detected in the monitoring well at site 6, and since no analytical data exists for materials between the bottom of the soil and the first occurrence of groundwater, additional field work is recommended. This work should include construction of two monitoring wells (including one upgradient well to be shared with site 7) to clearly confirm or deny any significant groundwater contamination, and at least two borings through the shale/sandstone layers to determine if any threat to groundwater exists from contamination in these layers.

The soil gas and soil boring data indicate significant soil contamination in the area immediately surrounding the dry well at site 6. The PRE for site 6 states that the available data for soils do not exceed criteria for threats to human health and environment, except for slightly elevated levels of cadmium and zinc in sediment samples taken in the drainage ditch. The soils at site 6, except for the drainage ditch itself, are paved over. A focused feasibility study for soils in the drainage ditch is recommended, primarily to consider removal of soils containing elevated concentrations of metals. Since contamination exceeding the PRE criteria is indicated in groundwater samples at site 6, and since the contaminated soils at site 6 may continue to provide a source for groundwater contamination, a remedial investigation to determine the extent of soil contamination at site 6 is recommended.

Site 7 - Dry Well Off Corrosion Control Building

The soil gas and soil boring data indicate significant soil contamination in the area immediately surrounding the dry well at site 7 and some contamination immediately outside the service door of the fire house, possibly from fire house activities. The concentrations of contaminants do not exceed the PRE criteria. Since contamination exceeding the PRE criteria is indicated in groundwater samples at site 7, and since the contaminated soils at site 7 may continue to provide a source for groundwater contamination, a remedial investigation to determine the extent of soil contamination at site 7 is recommended.

Analytical data for groundwater at the site indicate significant contamination exceeding the PRE criteria. The contaminant of concern (benzene) could be from fuels from USTs or fuel related wastes disposed of in a dry well. Some contamination of groundwater is indicated in other wells and piezometers in the primary operations area of the base, which includes site 7. In addition, lithologic data collected during this investigation indicate that shale and weathered sandstone layers exist for several feet below the soil rock interface. Since benzene exceeding PRE criteria was detected in the monitoring at site 7 and since no analytical data exists for materials between the bottom of the soil and the first occurrence of groundwater, additional field work is recommended. This work should include construction of two monitoring wells (including one upgradient well to be shared with site 6) to clearly confirm or deny any significant groundwater contamination, and at least two borings through the shale/sandstone layers to determine if any threat to groundwater exists from contamination in these layers.

Site 8 - Dry Well Off Composite Maintenance Building

The soil gas and soil boring data indicate significant soil contamination at site 8. The concentrations of contaminants do not exceed the PRE criteria. Since contamination exceeding the PRE criteria is indicated in groundwater samples at site 8, since the contaminated soils around the dry well at site 8 may continue to provide a source for groundwater contamination, and since the area of soil contamination has been delineated by soil boring and soil gas data collected during this investigation, a focused feasibility study for removal of contaminated soils at site 7 is recommended.

Analytical data for groundwater at the site indicate significant contamination exceeding the PRE criteria. The contaminants of concern (PCE and phthalates) could be from solvents disposed of in a dry well but phthalates are also common laboratory contaminants. Some contamination of groundwater is indicated in other wells and piezometers in the primary operations area of the base, which includes site 8. In addition, lithologic data collected during this investigation indicate that shale and weathered sandstone layers exist for several feet below the soil rock interface. Since PCE and phthalates exceeding PRE criteria were detected in the monitoring well at site 8 and since no analytical data exists for materials between the bottom of the soil and the first occurrence of groundwater, additional field work is recommended. This work should include construction of three monitoring wells (including one upgradient well) to clearly confirm or deny any significant groundwater contamination, and at least two borings through the shale/sandstone layers to determine if any threat to groundwater exists from contamination in these layers.

6.2.4 Decision Documents

No decision documents have been prepared for sites at the 120th FIG at this time. As discussed above, it is anticipated that no further action decision documents can be prepared for soils and groundwater at sites 2, 3, 4, and 5 and for groundwater only at site 1. However, additional groundwater data is needed to complete the decision document at site 1 because the latest groundwater level data indicate that the monitoring well at site 1 is not immediately downgradient of the area of greatest contamination.

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