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Environmental Information Document

Volume I

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Sandia National Laboratories/New Mexico Environmental Information Document

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ABSTRACT

The *Sandia National Laboratories/New Mexico (SNL/NM) Environmental Information Document (EID)* provides background information useful to SNL/NM personnel and contractors in preparing consistent and concise *National Environmental Policy Act (NEPA)* documentation. The scope of this document provides comprehensive baseline data needed to support a description of the existing environment at SNL/NM. The EID also provides a basic "description of the affected environment," required by the Council on Environmental Quality (CEQ) regulations in 40 CFR 1502.15. This is an essential prerequisite for assessing the environmental consequences (1502.18) of actions (projects) proposed by SNL/NM.

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Those individuals who authored or assembled data and information for the specific sections of the *Sandia National Laboratories/New Mexico Environmental Information Document (EID)* are listed in the Contributors section at the end of Vol. II. In addition, many other individuals, both within and outside SNL/NM, are acknowledged for their assistance in reviewing and validating the accuracy of information used in the EID, or for their help in improving the organization and presentation of the document.

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TABLE OF CONTENTS

SANDIA NATIONAL LABORATORIES/NEW MEXICO ENVIRONMENTAL INFORMATION DOCUMENT

Volume I: Contents

INTRODUCTION.....	INTRO-1
READER'S GUIDE.....	RG-1
EXECUTIVE SUMMARY.....	SUM-1
ACRONYMS AND ABBREVIATIONS	ACR-1
GLOSSARY	GLO-1
FACILITIES CROSS-REFERENCE LIST.....	FAC-1
CHAPTER 1 - GEOLOGY	1-1
EXECUTIVE SUMMARY.....	1-3
1.0 INTRODUCTION.....	1-5
2.0 STRUCTURAL GEOLOGY	1-6
3.0 SEISMOLOGY	1-12
4.0 STRATIGRAPHY	1-15
5.0 GEOMORPHOLOGY	1-22
6.0 PALEONTOLOGY.....	1-25
7.0 ENGINEERING GEOLOGY	1-26
8.0 SOILS	1-26
9.0 REFERENCES.....	1-35
CHAPTER 2 - LAND USE	2-1
EXECUTIVE SUMMARY.....	2-5
1.0 INTRODUCTION.....	2-7
2.0 DESCRIPTION OF THE KIRTLAND FEDERAL COMPLEX (KFC)	2-12

3.0 HISTORY OF LAND USE AT KIRTLAND AIR FORCE BASE (KAFB) AND DOE FACILITIES.....	2-12
4.0 CURRENT KIRTLAND FEDERAL COMPLEX (KFC) LAND USE.....	2-19
5.0 SURROUNDING LAND USE.....	2-48
6.0 REFERENCES.....	2-65
ATTACHMENTS	2-72
 CHAPTER 3 - HYDROLOGY AND WATER RESOURCES	 3-1
EXECUTIVE SUMMARY	3-5
1.0 INTRODUCTION.....	3-7
2.0 REGULATIONS FOR HYDROLOGY AND WATER RESOURCES USE.....	3-10
3.0 GROUNDWATER HYDROGEOLOGY	3-16
4.0 SNL/NM SURFACE HYDROLOGY	3-49
5.0 SNL/NM DISCHARGES	3-73
6.0 POTABLE WATER USE AT SNL/NM.....	3-96
7.0 REFERENCES.....	3-103
 CHAPTER 4 - AIR QUALITY AND METEOROLOGY.....	 4-1
EXECUTIVE SUMMARY	4-7
1.0 INTRODUCTION.....	4-9
2.0 REGULATORY SETTING	4-12
3.0 CLIMATE AND METEOROLOGY	4-17
4.0 CURRENT AIR QUALITY.....	4-63
5.0 SUMMARY OF AIR QUALITY TRENDS	4-108
6.0 REFERENCES.....	4-127
ATTACHMENTS	4-131
 CHAPTER 5 - ECOLOGY	 5-1
EXECUTIVE SUMMARY	5-3
1.0 INTRODUCTION.....	5-5
2.0 PHYSICAL, ADMINISTRATIVE, AND REGULATORY SETTING.....	5-6
3.0 ABIOTIC ENVIRONMENT.....	5-11
4.0 PRINCIPAL HABITATS AND VEGETATION TYPES	5-17
5.0 WILDLIFE COMMUNITIES	5-28
6.0 THREATENED, ENDANGERED, AND SENSITIVE SPECIES.....	5-33
7.0 SENSITIVE HABITATS AND OTHER ISSUES OF CONCERN.....	5-39
8.0 REFERENCES.....	5-43
ATTACHMENTS	5-49

Volume II: Contents

CHAPTER 6 - NOISE AND VIBRATION	6-1
EXECUTIVE SUMMARY	6-5
1.0 INTRODUCTION.....	6-7
2.0 REGULATORY INFORMATION AND METHODOLOGIES	6-8
3.0 NOISE SOURCES AT SNL/NM.....	6-15
4.0 NON-SNL/NM NOISE SOURCES	6-45
5.0 REFERENCES.....	6-59
ATTACHMENT.....	6-63
CHAPTER 7 - CULTURAL RESOURCES.....	7-1
EXECUTIVE SUMMARY	7-3
1.0 INTRODUCTION.....	7-5
2.0 PREHISTORIC OVERVIEW OF MIDDLE RIO GRANDE VALLEY.....	7-5
3.0 HISTORIC OVERVIEW OF MIDDLE RIO GRANDE VALLEY (A.D. 1540 - 1900S) ..	7-13
4.0 HISTORY OF SNL/NM.....	7-14
5.0 CULTURAL RESOURCE COMPLIANCE	7-17
6.0 SNL/NM CULTURAL RESOURCE INVENTORIES	7-24
7.0 KAFB CULTURAL RESOURCE STUDIES.....	7-27
8.0 SIGNIFICANT DOCUMENTS, RECORDS, AND ARTIFACTS	7-31
9.0 REFERENCES.....	7-34
CHAPTER 8 - VISUAL RESOURCES.....	8-1
EXECUTIVE SUMMARY	8-5
1.0 INTRODUCTION.....	8-7
2.0 PROCESS SUMMARY.....	8-10
3.0 OVERVIEW OF EXISTING SETTING.....	8-16
4.0 ANALYSIS OF VISUAL RESOURCES AT SNL/NM	8-24
5.0 REFERENCES.....	8-44
CHAPTER 9 - SOCIOECONOMICS AND COMMUNITY SERVICES.....	9-1
EXECUTIVE SUMMARY	9-3
1.0 INTRODUCTION.....	9-5
2.0 REGIONAL SOCIOECONOMIC SETTING	9-5
3.0 SNL/NM'S CONTRIBUTION TO THE REGIONAL SOCIOECONOMIC SETTING ...	9-22
4.0 REFERENCES.....	9-33

CHAPTER 10 - TRANSPORTATION	10-1
EXECUTIVE SUMMARY	10-5
1.0 INTRODUCTION.....	10-9
2.0 DEFINITIONS	10-10
3.0 ORGANIZATIONS AND OPERATIONS FOR HAZARDOUS MATERIAL	
TRANSPORTATION AT SNL/NM	10-16
4.0 TYPES AND QUANTITIES OF MATERIAL TRANSPORTED	10-28
5.0 EMERGENCY RESPONSE AND TRAINING	10-57
6.0 SNL/NM SITE-RELATED TRAFFIC	10-71
7.0 REFERENCES.....	10-79
ATTACHMENTS	10-89
CHAPTER 11 - MATERIAL MANAGEMENT	11-1
1.0 INTRODUCTION.....	11-5
2.0 RADIOACTIVE AND NUCLEAR MATERIAL MANAGEMENT	11-6
AT SNL/NM.....	11-6
3.0 CHEMICAL MATERIAL MANAGEMENT AT SNL/NM.....	11-27
4.0 EXPLOSIVE MATERIAL MANAGEMENT AT SNL/NM	11-42
5.0 NONHAZARDOUS MATERIAL MANAGEMENT AT SNL/NM	11-52
6.0 REFERENCES.....	11-58
ATTACHMENTS	11-65
CHAPTER 12 - WASTE MANAGEMENT	12-1
EXECUTIVE SUMMARY	12-5
1.0 INTRODUCTION.....	12-7
2.0 OVERVIEW OF WASTE MANAGEMENT	12-8
3.0 REGULATORY SETTING	12-15
4.0 WASTE STREAMS AND INVENTORIES.....	12-17
5.0 SNL/NM WASTE MANAGEMENT FACILITIES.....	12-27
6.0 POLLUTION PREVENTION AND WASTE MINIMIZATION	12-33
7.0 PACKAGING AND TRANSPORTATION OF WASTE IN 1996.....	12-39
8.0 WASTE DISPOSAL	12-44
9.0 SPECIAL ISSUES	12-53
10.0 REFERENCES.....	12-56
ATTACHMENTS	12-61

CHAPTER 13 - REGULATORY REQUIREMENTS	13-1
1.0 INTRODUCTION.....	13-3
2.0 REGULATORY CITATIONS.....	13-3
3.0 Status of SNL/NM Permits.....	13-5
4.0 AIR QUALITY	13-5
5.0 BIOLOGICAL RESOURCES	13-13
6.0 CULTURAL RESOURCES.....	13-16
7.0 ENVIRONMENTAL POLICY.....	13-20
8.0 HAZARDOUS WASTE/SUBSTANCES (INCLUDING RADIOACTIVE WASTE).....	13-21
9.0 NOISE.....	13-28
10.0 OCCUPATIONAL SAFETY AND HEALTH.....	13-28
11.0 PESTICIDES.....	13-30
12.0 TRANSPORTATION OF HAZARDOUS MATERIAL.....	13-31
13.0 UNDERGROUND STORAGE TANKS.....	13-34
14.0 WATER QUALITY AND DRINKING WATER	13-36
ATTACHMENTS	13-45
CONTRIBUTORS	CONTR-1

LIST OF TABLES

1-1. Earthquake Magnitude Classes as Measured on the Richter Scale	1-12
1-2. Moderate Magnitude Earthquakes Reported in New Mexico	1-14
1-3. General Soils Classification for the Kirtland Federal Complex.....	1-28
2-1. Land Ownership for the Kirtland Federal Complex	2-19
2-2. Kirtland Federal Complex Land Use Jurisdiction by Acreage	2-20
2-3. DOE Affiliates on the Kirtland Federal Complex	2-24
2-4. DOE Fee-Owned Land on the Kirtland Federal Complex	2-25
2-5. Tech Area I Activities	2-25
2-6. Permitted Utility and Right-of-Way Easements	2-44
2-7. Cities and Towns in the 80-Kilometer Radius Area of SNL/NM	2-52
2-8. Industrial Employers in Albuquerque.....	2-57
2-9. Native American Populations Within an 80-Kilometer Radius of SNL/NM	2-63
3-1. Data Sources and Contents	3-8
3-2. Hydraulic Conductivity for Fluvial Facies of the Ancestral Rio Grande of the Santa Fe Group	3-24
3-3. Storage Coefficient Values from Aquifer Tests in the Santa Fe Group.....	3-27
3-4. Hydraulic Conductivity for Alluvial Fan Facies of the Santa Fe Group.....	3-28

3-5. Hydraulic Conductivity for Perched Aquifer Intervals in Alluvial Fan Facies of the Santa Fe Group	3-29
3-6. Shallow Alluvium and Bedrock Hydraulic Conductivity Data in Hydrogeologic Regions 2 and 3	3-30
3-7. Chloride Mass Balance Estimated Recharge Rates	3-35
3-8. Physical Characteristics of Groundwater at SNL/NM, March 1996	3-45
3-9. Major Ion Concentrations in Groundwater at SNL/NM, March 1996	3-46
3-10. Streamflow Data Collected from Four Local U.S. Geological Survey Gauges during Water Year 1994	3-53
3-11. Streamflow Data Collected from Four Site-Wide Hydrogeologic Characterization Gauges during Water Year 1995	3-54
3-12. Streamflow Data Collected from Three Storm Water Monitoring Stations in 1995 and 1996	3-57
3-13. 1995 Storm Water Sampling Results	3-64
3-14. 1996 Storm Water Sampling Results	3-68
3-15. Fiscal Year 1996 Surface Discharges Requests	3-74
3-16. Semiannual Water Quality Parameters, December 1996, Lagoons 1 and 2	3-80
3-17. Tech Area IV Water Levels Measured to Date	3-81
3-18. SNL/NM Wastewater Monitoring Station Characteristics	3-83
3-19. Primary Regulatory Drivers for the Wastewater Program	3-85
3-20. Examples of Sanitary Sewer Discharges FY1996	3-87
3-21. SNL/NM Daily Wastewater Discharge Volumes	3-97
3-22. Adjustments to Wastewater Flows	3-98
4-1. Air Quality Regulations Potentially Applicable to SNL/NM	4-13
4-2. Summary of Air Quality Permits	4-15
4-3. Applicable Ambient Air Quality Standards	4-16
4-4. Summary of Meteorological Stations	4-26
4-5. Summary of Meteorological Data	4-29
4-6. Monthly Climatology for the National Weather Service Station	4-30
4-7. Stability Frequency Distribution at the National Weather Service Station	4-35
4-8. Three-Year Descriptive Climatology for SNL/NM A36 Tower	4-37
4-9. SNL/NM Meteorological Network Variations and Extremes	4-38
4-10. Stability Frequency Distribution at Tower A36	4-41
4-11. Climatological Mixing Heights for Albuquerque by Season	4-45
4-12. Seasonal Wind Frequency Distribution for the A36 Tower	4-47

6-11. Sound Pressure Levels From the 155-Millimeter Gun at the Terminal Ballistics Complex	6-30
6-12. Sound Pressure Levels From Detonations at the Explosives Applications Laboratory	6-32
6-13. Sound Pressure Levels From Detonations at the Sol se Mete Aerial Cable Facility	6-34
6-14. Sound Pressure Levels From the Rocket Sled Track at the	

4-17. SNL/NM Steam Plant Potential Emission Rates	4-73
4-18. Relationship Between Source Parameters and Operating Load for the Steam Plant	4-76
4-19. Source Parameters for SNL/NM Building 862 Generators	4-77
4-20. Potential Emission Rates for SNL/NM Building 862 Generators.....	4-77
4-21. SCREEN3 Model Conversion Factors	4-80
4-22. Screening Meteorology Wind Speed/Stability Array	4-81
4-23. Criteria Pollutant Monitoring Results for 1996 and Current Regulatory Standards	4-86
4-24. Quarterly and Annual Averages of PM ₁₀ at SNL/NM in 1996.....	4-87
4-25. Results of Volatile Organic Compound Analysis in 1996	4-89
4-26. Summary of Radionuclide Releases for 1996	4-93
4-27. Release Parameters for 1996 SNL/NM Radiological Sources.....	4-96
4-28. Summary of Concentration Collections	4-102
4-29. Summary of 1996 Air Quality Data Within the Albuquerque Basin	4-107
4-30. Criteria Pollutant Emissions From 1992 Through 1996	4-109
4-31. Emissions Trends for the Steam Plant	4-112
4-32. Chemical Volatile Organic Compound Emissions.....	4-112
4-33. Criteria Pollutant Results From 1994 to 1996 Compared to the Most Stringent Standard	4-113
4-34. Hazardous Air Pollutant Emissions at SNL/NM	4-119
4-35. Summary of Volatile Organic Compounds Sample Analyses at SNL/NM	4-121
4-36. Summary of Five-Year Data Trends for Air Quality Within Albuquerque Basin	4-125
5-1. Shrub Species in the Grassland Habitat.....	5-22
5-2. Tree and Shrub Species of the Riparian Woodland	5-26
5-3. Common Raptors and Other Birds in the Grassland Habitat	5-29
5-4. Species Designations Used by Federal and State Agencies with Management Jurisdiction at the KFC	5-34
5-5. Threatened, Endangered, and Sensitive Species Known to Occur at the KFC	5-36
6-1. Summary of Occupational and Community Noise Regulations	6-9
6-2. Models Used to Predict Sound Levels at SNL/NM	6-12
6-3. Short-Term Noise Impacts of SNL/NM Test Activities at Important Locations for 1997	6-19
6-4. Sound Pressure Levels From Detonations at the 10,000-Foot Sled Track	6-20
6-5. Sound Pressure Levels From Sonic Booms at the Sled Track Facility	6-24
6-6. Sound Pressure Levels From Rocket Motors at the 10,000-Foot Sled Track	6-24
6-7. Sound Pressure Levels From Collision Impact Tests at the Sled Track Facility	6-26
6-8. Sound Pressure Levels From Detonations at the Centrifuge Complex.....	6-27
6-9. Sound Pressure Levels From Detonations at the Terminal Ballistics Complex.....	6-28
6-10. Sound Pressure Levels From Rocket Motors at the Terminal Ballistics Complex.....	6-28

6-11. Sound Pressure Levels From the 155-Millimeter Gun at the Terminal Ballistics Complex.....	6-30
6-12. Sound Pressure Levels From Detonations at the Explosives Applications Laboratory ...	6-32
6-13. Sound Pressure Levels From Detonations at the Sol se Mete Aerial Cable Facility	6-34
6-14. Sound Pressure Levels From the Rocket Sled Track at the Sol se Mete Aerial Cable Facility	6-36
6-15. Sound Pressure Levels From Collision Impact Tests at the Sol se Mete Aerial Cable Facility	6-37
6-16. Sound Pressure Levels From Ballistics Test at the Sol se Mete Aerial Cable Facility.....	6-39
6-17. Sound Pressure Levels From Detonations at the Explosive Components Facility	6-41
6-18. Sound Pressure Levels From the Rocket Sled Track at the Drop Tower/Impact Complex.....	6-41
6-19. Sound Pressure Levels From Collision Impact Tests at the Drop Tower/Impact Complex.....	6-43
6-20. Noise Level Ranges and Day-Night Average Noise Levels	6-44
6-21. Average and Maximum Noise Levels	6-44
6-22. Typical Noise Levels From Construction and Industrial Equipment	6-45
6-23. Acreage Affected by Aircraft Noise	6-48
6-24. Summary of Operations at the Albuquerque International Sunport	6-48
6-25. Air Carrier Take Offs and Landings.....	6-50
6-26. Day-Night Average Noise Level Caused by Vehicles Traveling to Tech Areas and the Coyote Canyon Test Field	6-52
6-27. Frequency and Size of Detonations by Site.....	6-53
6-28. Sound Pressure Levels for the GRABS Site.....	6-55
6-29. Sound Pressure Levels for the Chestnut Site.....	6-56
6-30. Sound Pressure Levels for the High Energy Research Test Facility Site	6-56
6-31. Sound Pressure Levels for High Explosives at the U.S. Air Force Explosives Ordnance Disposal Site.....	6-57
6-32. Information About Noise and Vibration Data Sources	6-65
 7-1. Correlation Between Various Cultural Chronologies in the Southwest.....	7-6
 8-1. Levels of Scenic Attractiveness.....	8-11
8-2. Scenic Attractiveness Criteria for the Eastern Mexican Highlands	8-13
8-3. Travelways and Use Area Criteria and Level of Importance	8-14
8-4. Existing Scenic Integrity Levels	8-16
8-5. Scenic Attractiveness Levels of Landforms.....	8-30
8-6. Travelways and Use Areas Grouped by Concern Level	8-36
8-7. Visual Resource Analysis Summary.....	8-41

9-1. Historical Growth of the Regional Population Since WWII	9-7
9-2. Selected Characteristics of the Regional Population in 1990	9-7
9-3. Population Estimates and Projections for Five-Year Intervals	9-8
9-4. Selected Regional Housing Characteristics in 1990	9-9
9-5. Housing Unit Estimates and Projections for Five-Year Intervals.....	9-9
9-6. Regional Income and Poverty Characteristics Based on 1989 Incomes.....	9-10
9-7. 1996 Nonagricultural Employment by Major Industrial Sector	9-11
9-8. Employment and Unemployment of the Regional Civilian Labor Force	9-11
9-9. Classification of Workers in the Region in 1990	9-12
9-10. Occupations of Employed Persons 16+ Years Old in the Region in 1990	9-13
9-11. Areas Within 80 Kilometers of the Albuquerque Metropolitan Statistical Area.....	9-15
9-12. Schools Within an 80-Kilometer Radius of SNL/NM	9-16
9-13. College and University Populations Within an 80-Kilometer Radius of SNL/NM.....	9-18
9-14. Hospitals Within an 80-Kilometer Radius of SNL/NM	9-19
9-15. Correctional Facilities Within an 80-Kilometer Radius of SNL/NM.....	9-20
9-16. FY1998 General Budgets for County Governments	9-21
9-17. School District Finances for the 1996 to 1997 School Year.....	9-22
9-18. SNL's Impact on Central New Mexico's Economy	9-23
9-19. SNL/NM's Employees by Gender, Race, and Ethnicity	9-24
9-20. SNL/NM Employment Levels by Fiscal Year	9-25
9-21. Summary of Fire Protection Equipment and Personnel.....	9-27
9-22. 1996 Hazardous Waste Generation	9-30
9-23. City of Albuquerque Parks and Recreational Facilities	9-32
10-ES. Number of Receipts and Shipments at SNL/NM.....	10-6
10-1. SNL/NM Organizations Responsible for the Transportation of Hazardous Material.....	10-17
10-2. Number of Hazardous Material Receipts and Shipments at SNL/NM.....	10-29
10-3. Quantities of Hazardous Material Shipped and Received at SNL/NM by Year	10-31
10-4. Common Origins and Destinations for Material Shipped and Received at SNL/NM During 1996 and 1997.....	10-33
10-5. Onsite Explosives Transfer Pairs	10-36
10-6. Number of Hazardous Chemical Receipts and Shipments.....	10-40
10-7. SNL Shipments of Hazardous Chemicals by Destination for 1996 and 1997	10-41
10-8. Number of Receipts, Shipments, and Transfers of Explosive Material by United Nations Organization Hazard Class.....	10-42
10-9. Origins and Destinations of Explosive Shipments and Receipts.....	10-43
10-10. Origins and Destinations of Onsite Transfers.....	10-45
10-11. Summary of Offsite Shipments of Low-Level Radioactive Waste	10-50
10-12. Hazardous Chemical Waste Shipped According to U.S. Department of Transportation Hazard Class.....	10-50

10-13. Quantities and Destinations of SNL/NM Hazardous Chemical Waste Shipped	10-52
10-14. Summary of Onsite Transportation Incidents Involving Hazardous Material	10-55
10-15. Summary of Offsite Transportation Incidents Involving Hazardous Material	10-56
10-16. Emergency Action Levels	10-62
10-17. Emergency Worker Dose Limits	10-66
10-18. Estimate of Main Gate Traffic Volume in Twenty-Four Hours	10-76
10-19. Summary of Traffic Accidents Involving SNL/NM Vehicles	10-77
10-20. Radioactive Material	10-89
10-21. Comparison of Data From Electronic Databases on Transportation of Radioactive Material	10-94
10-22. Hazardous Chemicals	10-97
10-23. Comparison of Shipment Totals Recorded by Three Data Sources	10-99
10-24. Explosive Material	10-102
10-25. Comparison of Data From Electronic Databases on Transportation of Explosive Material	10-105
10-26. Summary of DOE's Analyses of Transportation Hazards	10-111
10-27. Summary of SNL/NM National Environmental Policy Act Documents	10-113
10-28. Summary of SNL/NM Facility Safety Documents	10-115
10-29. Summary of SNL/NM Hazard Assessment Documents	10-117
10-30. Average Radiation Doses Received by Nuclear Material Handlers on the Nuclear/General Material Storage Team	10-119
10-31. Hazardous Chemical Receipts Exceeding ERPG-2 and ERPG-3 Threshold Quantities	10-123
10-32. Shipments of Hazardous Chemicals That are Potentially Hazardous in Comparison to ERPG Thresholds	10-124
10-33. Average Radiation Doses Received by Radioactive and Mixed Waste Collection Personnel	10-126
10-34. Annual Incident-Free Impacts for Highway Shipments of SNL/NM LLW to Nevada Test Site and Envirocare	10-127
10-35. Annual Accident Risk Estimates for Highway Shipment of SNL/NM Low-Level Waste to the Nevada Test Site and Envirocare	10-128
11-1. Surplus Inventory of Nuclear Material	11-17
11-2. Inventory Reduction Efforts at SNL/NM	11-19
11-3. Total Nuclear Material at SNL/NM	11-19
11-4. Key Acts for Chemical Regulation	11-29
11-5. Regulatory Drivers for a Chemical Inventory	11-30
11-6. Hazardous Chemicals by Facility	11-31
11-7. SNL/NM Chemical Management Systems and Programs	11-40
11-8. Compatibility Groups for Explosives	11-48

11-9. Trends for Property Reapplication Fiscal Year 1993 to FY1996	11-53
11-10. Radiological Parameters for Isotopes Used at SNL/NM	11-65
11-11. Summary of Vulnerabilities.....	11-77
11-12. Tier One - Emergency and Hazardous Chemical Inventory.....	11-83
11-13. Tier Two - Emergency and Hazardous Chemical Inventory.....	11-83
12-1. Waste Types at SNL/NM.....	12-11
12-2. Overview of Waste Management Activities and Facilities.....	12-15
12-3. Hazardous Waste Generated - Calendar Year 1992 to CY1995	12-23
12-4. Inventory Data for all Radioactive Waste Generated - Calendar Year 1992 to CY1995.....	12-24
12-5. Hazardous Waste Generation for 1996	12-25
12-6. Radioactive Waste Generation for 1996	12-26
12-7. 1996 Solid Waste Generation	12-27
12-8. Summary of SNL/NM Waste Management Facilities.....	12-27
12-9. Mixed Waste Treatments, Quantity Limits, and Amounts Treated in 1996	12-31
12-10. SNL/NM Annual Rate Goals for Pollution Prevention and Waste Minimization for 1999	12-34
12-11. Spending Trends and Purchase Goals for Pollution Prevention Affirmative Procurement.....	12-35
12-12. Material Recycled by SNL/NM.....	12-38
12-13. Waste Packaging Overview by Waste Type.....	12-39
12-14. Summary of Waste Transportation by Waste Type.....	12-41
12-15. RCRA Waste Shipped.....	12-42
12-16. TSCA Waste Shipped	12-42
12-17. Radioactive Waste Shipped to Offsite Facilities	12-43
12-18. Radioactive Waste Shipped in 1996.....	12-43
12-19. Waste Disposal Site Options.....	12-45
13-1. Federal Regulations for Air Quality.....	13-5
13-2. New Mexico Regulations for Air Quality	13-8
13-3. Albuquerque/Bernalillo County Regulations for Air Quality.....	13-10
13-4. Federal Regulations for Threatened and Endangered Species	13-14
13-5. New Mexico Regulations for Threatened and Endangered Species	13-16
13-6. Federal Regulations for Cultural Resources.....	13-17
13-7. New Mexico Regulations for Cultural Resources.....	13-20
13-8. Federal Regulations for Environmental Policy.....	13-21
13-9. Federal Regulations for Hazardous Waste.....	13-23
13-10. CERCLA Regulations for ReporQuantities and Emergency Planning	13-25
13-11. TSCA Regulation for Polychlorinated Biphenyls.....	13-26

13-12. New Mexico Regulation for Hazardous Waste Management.....	13-27
13-13. Federal Regulations for Occupational Safety and Health	13-29
13-14. New Mexico Regulation for Pesticides	13-31
13-15. Federal Regulations for Transportation of Hazardous Material	13-32
13-16. Federal Regulation for Underground Storage Tanks.....	13-35
13-17. New Mexico Regulation for Underground Storage Tanks.....	13-36
13-18. Federal Regulations for Water Quality	13-37
13-19. Federal Regulations for Drinking Water	13-40
13-20. New Mexico Regulations for Water Quality	13-41

LIST OF FIGURES

RG-1. Location of the Kirtland Federal Complex in Relation to the State of New Mexico, Bernalillo County, and the City of Albuquerque.....	RG-3
RG-2. Kirtland Federal Complex in Relation to Major Transportation Corridors.....	RG-4
1-1. Regional Tectonic Setting of the Albuquerque Basin	1-7
1-2. Diagrammatic Geologic Cross-Sections of the Central Albuquerque Basin.....	1-8
1-3. Major Faults on the Kirtland Federal Complex	1-10
1-4. New Mexico Earthquakes of Richter Magnitude 3.5 or Larger.....	1-13
1-5. Generalized Stratigraphic Column and Time Scale	1-16
1-6. Generalized Surface Geology of Surveyed Areas of the Kirtland Federal Complex	1-19
1-7. Geomorphic Subprovinces	1-23
1-8. Major Soil Types at the Kirtland Federal Complex.....	1-31
2-1. Kirtland Federal Complex Land Use.....	2-9
2-2. General Land Use and Jurisdictions.....	2-11
2-3. 1929 Aerial View to the East of Oxnard Field	2-14
2-4. 1947 Aerial View of Sandia Base	2-15
2-5. 1962 Aerial View of KAFB including Tech Area I.....	2-18
2-6. Quantity Distance Safety Zones and Ordnance Impact Areas of the KFC.....	2-23
2-7. DOE-Owned Land Within the Kirtland Federal Complex	2-27
2-8. Tech Area I	2-28
2-9. Tech Area II	2-29

4-17. Illustration of Outflow/Stagnation/Return Flow Cycle.....	4-49
4-18. Nocturnal Wind Patterns at SNL/NM.....	4-51
4-19. Daytime Wind Patterns at SNL/NM	4-55
4-20. Tech Area I Sources	4-65
4-21. Northeast Tech Area III Sources	4-66
4-22. Tech Area IV Sources	4-67
4-23. Tech Area V Sources	4-68

2-16. U.S. Air Force Land Permitted to DOE for SNL/NM Utility and Right-of-Way Easements	2-45
2-17. Land Leased to DOE as Buffer Zones	2-47
2-18. Land Ownership Within the 80-Kilometer Radius of SNL/NM.....	2-49
2-19. Land Coverage Within the 80-Kilometer Radius of SNL/NM	2-53
2-20. Land Coverage Within the 16-Kilometer Radius of SNL/NM	2-54
2-21. Agricultural Land and Rangeland Within the 80-Kilometer Radius of SNL/NM.....	2-55
2-22. Residential and Commercial Land Use Within the 16-Kilometer Radius of SNL/NM	2-56
2-23. Public Lands Within the 80-Kilometer Radius of SNL/NM	2-60
2-24. Native American-Owned Lands Within the 80-Kilometer Radius of SNL/NM.....	2-64
3-1. SNL/NM Hydrogeologic Regions.....	3-19
3-2. Well and Spring Locations at the Kirtland Federal Complex.....	3-25
3-3. Potentiometric Surface for the Regional Groundwater System at SNL/NM and Kirtland Air Force Base	3-37
3-4. Annual Water-Level Elevation Declines in the Santa Fe Group Regional Aquifer System	3-38
3-5. Potentiometric Surface for the Perched Aquifer System Near Tijeras Arroyo.....	3-41
3-6. Remote Area Drainage Map.....	3-50
3-7. Storm Water Sampling Locations.....	3-55
3-8. Storm Water Drainages in Tech Areas I, II, and IV	3-59
3-9. 100- and 500-Year Floodplains	3-61
3-10. SNL/NM's Wastewater Monitoring Station Locations	3-84
4-1. Generalized Regional Tectonic Map of the Albuquerque Basin.....	4-18
4-2. Generalized Regional Cross-Sections through the Albuquerque Basin.....	4-20
4-3. Generalized Geology in the Vicinity of SNL/NM	4-21
4-4. Meteorological Stations within the City of Albuquerque	4-24
4-5. Meteorological Stations within the Albuquerque Basin	4-25
4-6. Period Windroses for the City of Albuquerque	4-31
4-7. Period Windroses for the Albuquerque Basin.....	4-32
4-8. Daytime Windroses for the City of Albuquerque.....	4-33
4-9. Nighttime Windroses for the City of Albuquerque.....	4-34
4-10. Meteorological Monitoring Network at SNL/NM	4-36
4-11. Three-Year Wind Climatology at SNL/NM.....	4-39
4-12. Generalized Flow Within a Valley.....	4-42
4-13. Illustration of Building-Induced Downwash Flow.....	4-43
4-14. Effect of Turbulent Dispersion on a Plume	4-46
4-15. Illustration of Pollutant Stagnation.....	4-47
4-16. Cold Air Drainage Representation.....	4-48

4-17. Illustration of Outflow/Stagnation/Return Flow Cycle.....	4-49
4-18. Nocturnal Wind Patterns at SNL/NM.....	4-51
4-19. Daytime Wind Patterns at SNL/NM.....	4-55
4-20. Tech Area I Sources	4-65
4-21. Northeast Tech Area III Sources.....	4-66
4-22. Tech Area IV Sources.....	4-67
4-23. Tech Area V Sources.....	4-68
4-24. Lurance Canyon Burn Site Sources	4-69
4-25. Monthly Fuel Usage for the SNL/NM Steam Plant Boilers.....	4-74
4-26. Relationship Between Exit Velocity and Operating Load for the Steam Plant.....	4-75
4-27. Relationship Between Exit Temperature and Operating Load for the Steam Plant.....	4-75
4-28. Ambient Air Monitoring Stations at SNL/NM.....	4-85
4-29. Air Quality Stations Within the City of Albuquerque.....	4-104
4-30. Air Quality Stations Within the Albuquerque Basin.....	4-105
4-31. Trend of Nitrogen Oxides Emissions.....	4-109
4-32. Trend of Carbon Monoxide Emissions	4-110
4-33. Trend of Total Suspended Particles Emissions	4-110
4-34. Trend of Sulfur Dioxide Emissions	4-111
4-35. Criteria Pollutant Monitoring Station Diurnal Concentrations Averaged for Each Hour.....	4-115
4-36. Monthly Maximum Short-Term Carbon Monoxide Concentrations Plotted Over Time and Compared to Regulatory Standards	4-116
4-37. Monthly and Maximum 24-Hour Average Nitrogen Dioxide Concentrations Plotted Over Time and Compared to Regulatory Standards	4-117
4-38. Monthly and 1-Hour Maximum Ozone Concentrations Plotted Over Time and Compared to Regulatory Standards	4-117
4-39. Monthly Average PM ₁₀ and Minimum and Maximum 24-Hour Concentrations for SNL/NM	4-118
4-40. Air Quality Trends for CO Within the Albuquerque Basin	4-126
4-41. Air Quality Trends for O ₃ Within the Albuquerque Basin	4-126
4-42. Air Quality Trends for PM ₁₀ Within the Albuquerque Basin.....	4-126
4-43. Daytime Windroses for the Albuquerque Basin.....	4-131
4-44. Nighttime Windroses for the Albuquerque Basin.....	4-132
4-45. Summer Windroses for the City of Albuquerque	4-133
4-46. Winter Windroses for the City of Albuquerque	4-134
4-47. Summer Windroses for the Albuquerque Basin	4-135
4-48. Winter Windroses for the Albuquerque Basin	4-136

5-1. Administrative Boundaries of the Kirtland Federal Complex.....	5-9
5-2. Major Soil Types at the Kirtland Federal Complex.....	5-15
5-3. Major Vegetation Types at the Kirtland Federal Complex.....	5-19
6-1. Noise Thermometer	6-10
6-2. Noise Contour Index Map.....	6-17
6-3. Noise and Vibration Contours for the 10,000-Foot Sled Track	6-21
6-4. Sonic Boom Noise Contour for the 10,000-Foot Sled Track.....	6-23
6-5. Rocket Motor Noise Contour for the 10,000-Foot Sled Track.....	6-25
6-6. High Explosive Noise Contours for the Terminal Ballistics Complex	6-29
6-7. 155-Millimeter Gun Noise Contour for the Terminal Ballistics Complex.....	6-31
6-8. High Explosive Noise Contours for the Explosives Applications Laboratory	6-33
6-9. High Explosive Noise Contours for the Sol se Mete Aerial Cable Facility	6-35
6-10. Three-Inch Gun Noise Contours for the Sol se Mete Aerial Cable Facility.....	6-38
6-11. High Explosive Noise Contours for the Explosive Components Facility	6-40
6-12. Rocket Motor Noise Contour for the Rocket Sled Track at the Drop Tower/Impact Complex.....	6-42
6-13. Location of the Kirtland Federal Complex in Relation to the City of Albuquerque	6-46
6-14. 1995 Noise Contours for the Albuquerque International Sunport	6-49
6-15. Noise Contours for the GRABS, Chestnut, and HERTF Sites	6-54
6-16. High Explosive Noise Contours for the U.S. Air Force Explosives Ordnance Disposal Site.....	6-58
8-1. General Location Map.....	8-8
8-2. Study Area	8-9
8-3. Scenery Management System Process	8-12
8-4. Entrance to Visitor Center	8-19
8-5. Wyoming Gate	8-19
8-6. Eubank Gate.....	8-19
8-7. Aerial View of Tech Area I.....	8-19
8-8. Robotics Manufacturing Science and Engineering Laboratory	8-19
8-9. Microelectronics Development Laboratory	8-19
8-10. Explosive Components Facility.....	8-19
8-11. Lab News Building	8-19
8-12. Tech Area I Standards Building.....	8-20
8-13. Mobile Office Trailers	8-20
8-14. National Atomic Museum From Wyoming Boulevard	8-20
8-15. Tech Area II, Looking South.....	8-20
8-16. Tech Areas III and V, View to the Southwest	8-20
8-17. Tech Area IV, Looking West	8-20

8-18. Robotics Vehicle Range	8-20
8-19. Solar Tower.....	8-20
8-20. Vertical Axis Wind Turbine	8-23
8-21. Coyote Springs, KAFB Property	8-23
8-22. Sol se Mete Aerial Cable Facility.....	8-23
8-23. Lurance Canyon Burn Site	8-23
8-24. SNL/NM Boundary Adjacent to Four Hills Neighborhood	8-23
8-25. Isleta Boundary, View Into Buffer Zone	8-23
8-26. Historic Development Patterns.....	8-27
8-27. Vacant Building in the Withdrawn Area	8-31
8-28. Vacant Building	8-31
8-29. Electric Transmission Lines, View to the South.....	8-31
8-30. Forest Fire Location, View to the Southeast at Northern Withdrawn Area.....	8-31
8-31. Scenic Attractiveness.....	8-33
8-32. Grasslands.....	8-35
8-33. Four Hills and Foothills Formation.....	8-35
8-34. Tijeras Arroyo and Associated Banks and Terraces, View to the Northeast.....	8-35
8-35. Hubbell Bench, Pediment and Rolling Terrain of Manzanita Foothills.....	8-35
8-36. Mountainous Terrain of Northern Manzanita Mountains	8-35
8-37. Madera Canyon Road and Manzanita Mountains.....	8-35
8-38. Scenic Classes	8-39
8-39. Description of Visual Resource Units	8-41
9-1. Total Employment at SNL/NM From FY1980 to FY1997	9-25
10-1. SNL/NM Emergency Response Organizational Structure	10-58
10-2. Onsite and Offsite Emergency Organizations	10-60
10-3. Road Network for City of Albuquerque, New Mexico.....	10-73
10-4. SNL/NM and Kirtland Air Force Base Site Map	10-75
11-1. Special Nuclear Material Inventory	11-14
11-2. Surplus Special Nuclear Material Inventory	11-14
11-3. Inventory of Source Nuclear Material	11-15

11-11. Receiving Nonaccountable Radioactive Material at SNL/NM.....	11-67
11-12. Receiving Accountable Nuclear Material at SNL/NM.....	11-68
11-13. Receiving Category I or II Special Nuclear Material at SNL/NM	11-69
11-14. Transferring Nonaccountable Radioactive Material at SNL/NM.....	11-70
11-15. Transferring Accountable Nuclear Material at SNL/NM	11-71
11-16. Transferring Category I or II Special Nuclear Material at SNL/NM.....	11-72
11-17. Storing Nonaccountable Radioactive Material at SNL/NM.....	11-73
11-18. Storing Accountable Nuclear Material at SNL/NM	11-74
11-19. Nuclear Material Disposition Process	11-82
12-1. Summary of Waste Management Processes	12-10
12-2. Waste Management Facilities	12-30
12-3. Recycling Trends and Goals at SNL/NM.....	12-36
12-4. Disposal Site Options.....	12-48
12-5. SNL/NM Environmental Restoration Sites.....	12-55
12-6. Estimates of Environmental Restoration Waste Generation.....	12-56

INTRODUCTION

This *Sandia National Laboratories/New Mexico Environmental Information Document (EID)* compiles information on the existing environment, or environmental baseline, for SNL/NM. Much of the information is drawn from existing reports and databases supplemented by new research and data. The *SNL/NM EID*, together with the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document*, provide a basis for assessing the environment, safety, and health aspects of operating selected facilities at SNL/NM.

The environmental baseline provides a record of the existing physical, biological, and socioeconomic environment at SNL/NLM prior to being altered (beneficially or adversely) by proposed programs or projects. More specifically, the EID provides information on the following topics:

- Geology
- Hydrology and Water Resources
- Ecology
- Cultural Resources
- Socioeconomics and Community Services
- Material Management
- Regulatory Requirements
- Land Use
- Air Quality and Meteorology
- Noise and Vibration
- Visual Resources
- Transportation
- Waste Management

A phased development of the *SNL/NM EID* is consistent with the need for periodic updates to reflect the current status of SNL/NM's environmental conditions and/or more recent sources of information as they become available. The EID is a source of information on SNL/NM operations and neither seeks to assess the impacts nor present conclusions on environmental impacts from these operations.

Information in this *SNL/NM EID* is generally current to 1996, although it may vary from fiscal year 1996 (October 1, 1995 to September 30, 1996) to calendar year 1996, depending upon how certain records are kept.

READER'S GUIDE

This Reader's Guide provides guidance on using this document. For ease of use, this document is divided into two volumes. **Volume I** contains Chapters 1 through 5:

- Chapter 1, "Geology"
- Chapter 2, "Land Use"
- Chapter 3, "Hydrology and Water Resources"
- Chapter 4, "Air Quality and Meteorology"
- Chapter 5, "Ecology"

Volume II contains Chapters 6 through 13:

- Chapter 6, "Noise and Vibration"
- Chapter 7, "Cultural Resources"
- Chapter 8, "Visual Resources"
- Chapter 9, "Socioeconomics and Community Services"
- Chapter 10, "Transportation"
- Chapter 11, "Material Management"
- Chapter 12, "Waste Management"
- Chapter 13, "Regulatory Requirements"

To facilitate use of this document, the following features have been incorporated:

- A tab appears before each major topic in the document.
- A master table of contents appears in each volume.
- A master acronym list appears in each volume.
- A master glossary appears in each volume.
- A listing of facility names used in this document and their relation to facility names used in the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* appears in each volume.
- Each chapter has its own table of contents.
- References appear at the end of every chapter.
- A list of contributors for the entire document appears at the end of Volume 2.

To orient the reader geographically, this Reader's Guide includes two reference maps.

Figure RG-1 indicates that SNL/NM is located in the Kirtland Federal Complex (KFC), southeast of Albuquerque, New Mexico. The term "KFC" is used to denote the physical complex that encompasses Kirtland Air Force Base (KAFB), lands owned by DOE and its affiliates (including SNL/NM), and portions of the Cibola National Forest withdrawn from public entry by the U.S. Air Force (USAF) and DOE.

The second map, Figure RG-2, presents the transportation corridors in the vicinity of the KFC.

Figure RG-1. Location of the Kirtland Federal Complex (KFC) in Relation to the State of New Mexico, Bernalillo County, and the City of Albuquerque

Figure RG-2. Kirtland Federal Complex (KFC) in Relation to Major Transportation Corridors

EXECUTIVE SUMMARY

The following provides a summary of the information found in Chapters 1 through 13 of the *Sandia National Laboratories/New Mexico Environmental Information Document (EID)*. Each chapter also has its own executive summary.

Chapter 1, "Geology"

The Kirtland Federal Complex (KFC), which includes SNL/NM within its boundaries, is situated in the eastern portion of the Albuquerque Basin. This basin is about 145 kilometers (90 miles) long and up to 48 kilometers (30 miles) wide. The basin is located along the Rio Grande Rift zone that lies within the northern portion of the Eastern Mexican Highlands section of the Basin and Range physiographic province.

The Albuquerque Basin is bordered by major faults and bisected by the northeast-trending Tijeras Fault zone, forming two half-grabens. The Tijeras Fault acts as a zone of strain accommodation between differential extension rates of the northern and southern subbasins.

The KFC is located in a structurally complex area. A number of major regional faults intersect within the area, resulting in a diverse pattern of fault trends and displacements. There is no record of movement on these faults in historic times.

The Albuquerque Basin is primarily filled with poorly consolidated sediments that have eroded from the surrounding mountain areas during the uplift of the Sandia, Manzanita, and Manzano Mountains, which started about 26 million years ago. Surface soils at the KFC are developed in fluvial, alluvial-fan, colluvial, and eolian surficial deposits. Variations in soil properties reflect differences in sediment characteristics, length of exposure to surficial weathering, and local climate.

The City of Albuquerque is located in Seismic Risk Zone 2B, which, by definition, is a region that can be expected to experience moderate earthquake effects corresponding to Intensity VII of the Modified Mercalli Intensity Scale of 1931.

Chapter 2, "Land Use"

Kirtland Federal Complex (KFC) is the term used to denote the physical complex that encompasses Kirtland Air Force Base (KAFB), land owned by DOE and its affiliates, including SNL/NM, and portions of the Cibola National Forest withdrawn from public entry by the U.S. Air

Force (USAF) and DOE. The KFC covers approximately 51,559 acres of high desert land southeast of Albuquerque, New Mexico. SNL/NM land use is part of complex land ownership and use agreements that define jurisdictions and land use areas within the KFC.

The KFC has developed over the last 50 years as a multi-user industrial research and development complex. Simultaneous growth and development of Albuquerque and other areas within the region of influence (ROI) has also affected SNL/NM activities and continues to influence the options for future use of DOE land and facilities used by SNL/NM. Land use on the KFC results from KAFB activities of the USAF and other agencies with the KFC, including SNL/NM. Land use planning for the various ownership and use jurisdictions within the KFC is accomplished by the USAF, SNL/NM (in cooperation with DOE), and the U.S. Forest Service (USFS).

The chapter also discusses surrounding land uses within 16-kilometer (10-mile) and 80-kilometer (50-mile) radii. Specific land uses and their significance to the area include agricultural, residential and commercial, industrial, and public. Land use descriptions include land coverage characteristics and land ownership. In addition, this chapter identifies the Native American-owned lands within the 80-kilometer (50-mile) radius around SNL/NM.

Chapter 3, "Hydrology and Water Resources"

Groundwater characteristics within the Kirtland Federal Complex (KFC) vary among and within three hydrogeologic regions. The characteristics of these regions include aquifer type (i.e., unconfined/confined, porous media/fractured rock, and regional/perched), hydraulic properties (hydraulic conductivity, storativity, and porosity), horizontal groundwater-flow directions, vertical hydraulic gradients, trends in water-level decline resulting from water supply pumping, and groundwater geochemistry. Many of these characteristics are directly related to the geologic media that provide the local framework for the regional aquifer.

Floods and runoff occur most commonly during the summer thunderstorm season (July through September) when approximately 50% of the average rainfall occurs. Snow in the Manzano Mountains can produce local runoff in the mountains, which rarely reaches the lower portions of the arroyos or the Rio Grande. The accuracy of calculated floodplains for SNL/NM is limited because of the lack of historical information about the nature of storms at the KFC.

The only wetlands on the KFC consist of several springs, all within the tributaries to Arroyo del Coyote. The water originating from these springs travels only a short distance before infiltrating into the soil. The total combined area of these wetlands is less than one acre.

Currently, SNL/NM maintains six wastewater monitoring stations. Four stations measure general outfalls (industrial and sanitary effluents) and are the final discharge points into the publicly owned treatment works (POTW). Discharges into the POTW are regulated by the City of Albuquerque Public Works Department. All wastewater is treated by the City of Albuquerque in accordance with the National Pollutant Discharge Elimination System (NPDES) permit requirements before being discharged into the Rio Grande.

The City of Albuquerque and Kirtland Air Force Base (KAFB) supply water to SNL/NM. The total average water use recorded by KAFB was 3,150,685 gallons per day. SNL/NM water consumption was estimated to be 1,206,225 gallons per day. Beginning in 1996, SNL/NM has funded several water conservation projects including a site-comprehensive water audit and plan, installation of water meters, and a water conservation web site. A water conservation officer was designated to manage the sitewide efforts to reduce SNL/NM water consumption by 30% by the year 2004.

Chapter 4, "Air Quality and Meteorology"

Operations at SNL/NM emit both radiological emissions and nonradiological emissions. Nonradiological emissions include criteria pollutants and hazardous air pollutants (HAPs). The criteria pollutants include nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO₂), particulate matter (PM), and volatile organic compounds (VOCs). HAPs are those pollutants listed in Title III of the *Clean Air Act* (CAA). Operations emitting these pollutants include research and development facilities, environmental remediation, waste handling, steam-generated heat, and electrical power generators.

Air quality at SNL/NM is governed by regulations promulgated locally by the Albuquerque/Bernalillo County (A/BC) Air Quality Control Board (AQCB) and federally by the U.S. Environmental Protection Agency (EPA). The A/BC AQCB promulgates regulations in the New Mexico Administrative Code (NMAC) for compliance with the CAA as well as applicable state and local air quality requirements.

The largest source of criteria pollutant emissions at SNL/NM is the Steam Plant, which operates five steam-generating boilers. The boilers are dual-fired with natural gas (the primary fuel) and diesel fuel. The NO_x emissions from the Steam Plant and CO emissions from the electric-power generators require SNL/NM to apply for a CAA Title V operating permit. The operating permit application and subsequent permit summarizes all of the applicable requirements for governing air quality at SNL/NM.

Actual criteria and HAP emissions, including radionuclides, are relatively small during normal SNL/NM operations. For 1996, approximately 178 tons of criteria pollutants resulted from the

significant pollutant sources and approximately 2.4 tons of HAPs resulted from the use of chemicals. The radiological sources at SNL/NM include the TANDEM Accelerator, Particle Fusion Accelerator, Annular Core Research Reactor (ACRR), Sandia Pulsed Reactors (SPRs) II and III, and radiological sources from several miscellaneous research and development laboratories. The cumulative dose to a maximally exposed individual located on Kirtland Air Force Base (KAFB) and associated with SNL/NM operations for 1996 was 0.007 millirem, which was well below the regulatory standard of 10 millirems per year.

Meteorological and ambient air monitoring data assists the Environmental Monitoring and Reporting Department in assessing the impact of emissions. Ambient air monitoring shows that emissions from SNL/NM point sources have a relatively small impact in comparison with vehicle emissions on KAFB. SNL/NM did not exceed air quality standards during 1996.

Chapter 5, "Ecology"

Information regarding the biological and ecological resources at the Kirtland Federal Complex (KFC) exists in a wide variety of sources that range from biological survey reports prepared for SNL/NM, the U.S. Air Force (USAF), and resource management agencies, to more general publications such as field guides and reference books on the flora and fauna of New Mexico. Because biological and ecological resources are best understood within the context of the physical and cultural setting at the KFC, which are described in other chapters, this chapter provides brief synopses of key information from other chapters that are relevant to understanding the ecology of the KFC, including the following:

- Physical, administrative, and regulatory setting of the KFC as it pertains to biological and ecological resources.
- Abiotic environment of the KFC as it pertains to habitat conditions.
- Major habitat and vegetation types on the KFC and wildlife communities that reside in these habitats.
- Threatened, endangered, and sensitive species on the KFC.
- Sensitive habitats and other issues related to biological and ecological resources on the KFC.
- Plants, amphibians, reptiles, birds, and mammals that are known or expected to occur on the KFC.

Chapter 6, “Noise and Vibration”

The assessment of noise and vibration sources at SNL/NM focused on a number of issues:

- Identifying noise and vibration by activity, source, and location.
- Identifying the range of noise- and vibration-producing events.
- Discussing noise and vibration propagation and sensitive receptors.
- Providing historical trend data of working conditions.
- Developing a noise-and-vibration related information base.

Noise generated by manmade activities in and around the Kirtland Federal Complex (KFC) is identified as the area’s baseline sounds. The relatively steady sound levels at the KFC and in the vicinity of SNL/NM can be categorized into two major groups: transportation and stationary-type sources.

Transportation sources include primarily vehicular traffic and aircraft from the Albuquerque International Sunport and Kirtland Air Force Base (KAFB). Sources related to SNL/NM and KAFB activities include tests of high explosives, tests using rocket motors, tests producing sonic booms, and tests involving large caliber weapons.

Aircraft noise is the most prevalent sound at SNL/NM because aircraft using the primary runway for the Albuquerque International Sunport fly directly over SNL/NM. Aircraft take off and land in an easterly direction on this runway about 75% to 80% of the time. The major sources of noise at SNL/NM include explosive testing, rocket motors used at both the Sled Track and the Aerial Cable Facility, occasional sonic booms at the Sled Track, and some construction noise from Tech Area I. Because of the distance between SNL/NM facilities and the boundaries of KAFB, very little noise and vibration is experienced beyond KAFB.

Chapter 7, “Cultural Resources”

Between 1989 and 1991, DOE and SNL/NM sponsored cultural resource surveys and assessments for all DOE-owned properties used by SNL/NM. Some of these 36 surveys, reviews, and assessments addressed specific projects while others were general assessments of entire tech areas. None of the surveys identified any archaeological properties eligible for the National Register of Historic Places (NRHP).

Since 1991, SNL/NM has sponsored an additional 35 cultural resource surveys. These surveys encompassed areas located on a variety of land jurisdictions within the boundaries of the Kirtland Federal Complex (KFC), including properties used by SNL/NM but owned by the U.S. Air Force (USAF) and the U.S. Forest Service (USFS). For the Environmental Restoration (ER) Project, the surveys covered a total of 2,445.4 acres through new assessments and reviews.

Remains of historic structures associated with sheep herding, ranching, and other activities are located near the base of Four Hills in Coyote Canyon. The USFS's Withdrawn Area contains the Coyote Canyon Mining District and other sites associated with mining.

The potential for historic buildings and structures associated with the World War II (WWII) and Cold War eras is highest in the areas where potential for prehistoric and historic archaeological materials is lowest. All of the developed portions of DOE land within the KFC have potential for properties related to these themes.

The DOE/Kirtland Area Office (KAO) has determined that Tech Area II is eligible to the NRHP as a Historic District, with the majority of the larger buildings in the area contributing to that status. As a result of this determination, DOE/KAO has initiated *National Historic Preservation Act (NHPA)* Section 106 consultation with regard to undertakings proposed in Tech Area II.

Chapter 8, "Visual Resources"

Visual resource data for SNL/NM was collected from February through April 1997 and included all areas of SNL/NM and leased lands. The visual characteristics of SNL/NM consist of mostly flat, gently sloping grassland terrain to the west and mountainous terrain to the east. Motorists mainly see the tops of the Four Hills formation and Tech Area I without direct views into modified areas. Views from eastbound Interstate 40 are directed to the east and are of short duration.

In the broad conceptual view, most of SNL/NM is considered to be in a mid-range for moderate scenic public value. The northwestern areas of SNL/NM around Tech Area I and II are considered to have high scenic quality, even though the areas have been extensively modified by development. This results from the high number of observers and users (both SNL/NM and non-SNL/NM) in the area, as well as the high concern among the users for the scenery in the area. Care should be taken in siting and design of future development activities to protect visual resources in these areas of high scenic classification.

Chapter 9, "Socioeconomics and Community Services"

The Albuquerque metropolitan statistical area (MSA) has grown in population by a factor of six in the 50 years between 1940 and 1990. The total Albuquerque MSA population is projected to

reach 700,000 by the turn of the century. In 1994, 22% of all workers within the MSA were employed by the public sector as military personnel, government employees, or contract personnel. The public sector payroll in 1994 exceeded \$2 billion, which was more than one-fourth of the total wages and salaries paid in the region.

SNL/NM is the fifth largest employer in New Mexico. During fiscal year 1995 (FY1995), all SNL operations had an operating budget of 1.46 billion. During the same period, SNL/NM employed 8,118 persons, and paid approximately \$450 million in wages and salaries, nearly one-fourth of the total public sector payroll in the region. For every \$100 spent by SNL/NM during FY1995, another \$194 in economic activity was created in the Albuquerque MSA. Approximately 10% of economic activity in the region is directly or indirectly attributable to SNL/NM.

For every 100 jobs at SNL/NM during FY1995, an additional 190 jobs were generated in the Albuquerque MSA. Nearly 10% of all jobs in the region are attributable to SNL/NM. The \$450 million paid in direct wages and salaries by SNL/NM during FY1995 generated an additional \$670 million in wages and salaries for those who provided goods and services to SNL/NM, its employees, and their families.

Chapter 10, "Transportation"

Hazardous materials most frequently shipped or received by SNL/NM are radioactive material and hazardous chemicals, although SNL/NM also ships a substantial amount of explosives, hazardous chemical waste, radioactive low-level waste (LLW), and nonhazardous solid waste. SNL/NM ships radioactive material, hazardous chemicals, and explosives to DOE, the U.S. Department of Defense (DoD), and commercial facilities throughout the United States. SNL/NM ships hazardous waste to licensed commercial treatment and disposal facilities, and ships radioactive LLW to the Nevada Test Site (NTS) at Mercury, Nevada, or to Envirocare in Clive, Utah. SNL/NM ships mixed low-level waste (MLLW) to Envirocare or to Perma-Fix Incorporated in Gainesville, Florida. SNL/NM sends nonhazardous waste to the Rio Rancho, New Mexico, Sanitary Landfill.

SNL/NM also conducts onsite transfers of hazardous material, including radioactive material, hazardous chemicals, and explosives. Although such transfers are performed by trained personnel on the Transportation/Distribution Team, they are not specifically tracked with record-keeping. All types of waste are commonly collected and transported on site to storage or processing facilities for preparation for offsite shipment.

The records for transportation incidents and accidents associated with SNL/NM operations show that during 1994 through 1996, five onsite and five offsite transportation incidents have occurred. However, there was only one onsite incident in which a vehicle carrying a hazardous

cargo was involved in an actual traffic accident. All of the other onsite and offsite incidents involved violations of procedures or regulations in shipping or transferring hazardous material. None of the incidents resulted in the release of hazardous material into the environment or in any harm to workers or the public.

Chapter 11, "Material Management"

Radioactive Material - For nuclear material management operations, SNL/NM employs "total life cycle cost" analysis, a structured process for identifying, evaluating, and analyzing all costs associated with programs and projects from "cradle to grave." Over the years, SNL/NM has adopted a two-pronged planning approach to managing nuclear material and maintaining inventories at mission-essential levels. The first goal was to develop a plan to reduce large quantities of surplus nuclear material that no longer supported ongoing or projected programs. Secondly, the Nuclear Materials Management Operations required planning of future direct-funded projects (including total life cycle cost analyses) to ensure funding for the decontamination and decommissioning (D&D) phases of projects that utilize nuclear material.

SNL/NM is continually eliminating unneeded nuclear material from its inventory. SNL/NM has already disposed of over 22 metric tons of surplus material (nearly 80% of its surplus nuclear material) since January 1996. Reducing this surplus material has resulted in a number of significant beneficial impacts on SNL/NM operations. These benefits include elimination of safeguard and security targets, elimination of nuclear material items that are difficult to measure, reduction of highly irradiated spent nuclear fuel, consolidation of waste material, construction of a Hot Cell Facility (HCF) for material characterization and packaging, establishment of an approved low-level waste program at the Nevada Test Site (NTS), elimination of two nuclear facilities, reduction in sources of radioactive hazards and personnel exposures, and a significant reduction in the amount of space required for nuclear material storage.

Chemicals - The primary management strategy for the control and management of hazardous chemicals at SNL/NM is to protect the health and safety of workers, the public, and the environment. Managers who direct day-to-day work within each line organization are primarily responsible for planning work activities using the Integrated Safety Management System (ISMS) and ensuring that the necessary environment, safety, and health (ES&H) provisions and support are incorporated into the work plans, considered in the budget decision process, and implemented during the operation or activity.

Explosives - Explosives management includes material development, storage review, acquisition and retention, and retention justification. Life cycle costs include acquisition,

storage, storage review, disposal, management, and the mixed waste Explosive Component Surveillance Program for nuclear weapon components.

An Explosive Inventory System (EIS) is being developed and implemented by SNL/NM to track all explosives and explosive-containing devices and assemblies from acquisition through use, storage, reapplication, and transfer or disposal. The EIS provides information on material composition, characteristics, and shipping requirements; life cycle cost information; plan of use; and duration of ownership. The EIS includes a corporate-wide inventory system of all energetic material owned or controlled by SNL/NM line organizations.

Nonhazardous Material - Nonhazardous material includes property that has an expected life of two years or longer or consumable material with a shorter life expectancy. Property generally is solid in form, more substantial in nature, and of a longer life than consumable material represented by office supplies, disposable items, and consumable components for experiments.

The Enhanced Property Management System (EPMS) is used to manage inventory controls for equipment and sensitive items. The EPMS is a database or information system that tracks the owner and location of all property maintained in the system. All equipment and components (including sensitive items) with an acquisition value over \$5,000 are tracked from acquisition to recycle or reapplication. Examples of sensitive items include cameras, tools, computers, radios, and anything that is attractive for personal use and easily converted to cash.

Chapter 12, "Waste Management"

The activities of waste management include planning, process definition, and operational procedures development and implementation. An environment, safety, and health (ES&H) program document (PG470185) describes the functions and operations of waste management. The scope of operations begins with the process and people that generate the waste. Generators work with the liaisons and waste management departments to package waste correctly for collection and transfer to centralized onsite waste storage or staging areas.

The hazardous waste generated at SNL/NM is predominantly chemical laboratory trash generated from experiments, testing, and other research and development (R&D) activities, and infrastructure fabrication and maintenance. Environmental restoration (ER) and decontamination and decommissioning (D&D) projects generate large quantities of waste. Hazardous waste is usually managed directly by waste management departments, although an exception to this is waste from large projects focused on asbestos abatement, which is managed separately by facilities departments through subcontracts.

While commercial, large-scale industries may generate a continuous and uniform type of waste that constitutes a consistent waste stream, this is not the case at SNL/NM. Because it is a

research facility, SNL/NM waste is the result of experimental work, with individual waste streams. Many SNL/NM processes are unique and generate single versions of the waste from a given process. For these reasons, it is difficult to generalize about waste generation or to categorize waste streams into a few high-volume waste types.

In general, waste management facilities are known as treatment, storage, and disposal facilities (TSDFs). SNL/NM has limited waste treatment facilities and only the small Classified Waste Landfill. The waste management facilities at SNL/NM vary in size, capacity, and scope of operations, depending on the waste types for which they are designed.

Storage facilities are available for all waste types. Planned lengths of time for storage vary by waste type. Under routine operations at the Hazardous Waste Management Facility (HWMF), all hazardous waste is transported off site within one year of waste pickup. Although radioactive waste storage facilities do not require a storage permit, SNL/NM operates these facilities in accordance with DOE 5820.2A and DOE 5633.3B. Of the radioactive waste types, only mixed low-level waste (MLLW) and mixed transuranic (MTRU) waste require *Resource Conservation and Recovery Act (RCRA)*-permitted storage facilities because of their RCRA-regulated hazardous constituents. Storage of low-level waste (LLW) and transuranic (TRU) waste does not require a RCRA permit and is managed in accordance with DOE 5820.2A.

SNL/NM is committed to pollution prevention as a corporate initiative to reduce waste generation, conserve resources, reduce health and safety risks, and create cost savings. SNL/NM has achieved significant reductions in waste generation, water use, and air emissions, and has increased recycling and affirmative procurement of recycled material.

Chapter 13, "Regulatory Requirements"

This chapter provides a summary of federal, New Mexico, City of Albuquerque, and Bernalillo County environmental statutes, ordinances, and regulations. It also includes a description of selected pertinent executive orders and DOE orders, along with a list of current SNL/NM environmental permits and permit applications. This chapter also summarizes federal and state statutes and associated regulations.

Some of the regulatory requirements identified and summarized do not currently apply to SNL/NM operations but may "potentially" apply. For example, the U.S. Environmental Protection Agency (EPA) has, with a few exceptions, authorized the State of New Mexico to assume primary jurisdiction (primacy) over air quality, water quality, and hazardous waste. Nevertheless, this chapter includes the EPA requirements because they form the basis and context for state requirements. Also, although highly unlikely, the state could request or the EPA could assert federal jurisdiction over some programs in the future.

ACRONYMS AND ABBREVIATIONS

1,1-DCA - 1,1-dichloroethane

1,2-DCE - Cis-1,2-dichloroethene

A.D. - In the year of the Lord (*Anno Domini*)

A/BC - Albuquerque/Bernalillo County

AAQS - ambient air quality standards

ABW - Air Base Wing

ACF - Aerial Cable Facility

ACGIH - American Conference of Governmental Industrial Hygienists

ACHP - Advisory Council on Historic Preservation

ACRR - Annular Core Research Reactor

AEA - *Atomic Energy Act of 1954*

AEC - Atomic Energy Commission

AEHD - Albuquerque Environmental Health Department

AFEOD - Air Force Explosive Ordnance Disposal

AFWL - Air Force Weapons Laboratory

AHPA - *Archaeological and Historic Preservation Act of 1974*

AIHA - American Industrial Hygiene Association

AIP - agreement in principle

ACRONYMS AND ABBREVIATIONS (Continued)

AIRDOS - EPA computer model

AIRFA - *American Indian Religious Freedom Act of 1978*

ALARA - as low as reasonably achievable

ALI - annual limit on intake

ALOHA - aerial location of hazardous atmospheres

ALS - advanced life support

Am - americium

AML - Advanced Materials Laboratory

AMPL - Advanced Manufacturing Process Laboratory

ANSI - American National Standards Institute

APCD - Air Pollution Control Division

API - American Petroleum Institute

APPRM - Advanced Pulsed-Power Research Module

APS - Albuquerque Public Schools

AQC - Air Quality Compliance

AQCA - *New Mexico Air Quality Control Act*

AQCB - Air Quality Control Board

Ar - argon

ACRONYMS AND ABBREVIATIONS (Continued)

ARG - Accident Response Group

ARPA - *Archaeological Resources Protection Act of 1979*

ASME - American Society of Mechanical Engineers

ASER - annual site environmental report (SNL/NM)

AT&T - American Telephone and Telegraph

awc - available water capacity

B.C. - Before Christ

B.P. - Before present

BLM - Bureau of Land Management

BMHA - building modifications hazard assessment

BOD - biological oxygen demand

BPIP - Building Profile Input Program (EPA)

Br⁻ - bromide

BTU - British thermal unit

C - centigrade (Celsius)

CAA - *Clean Air Act*

CAAA - *Clean Air Act Amendments*

CAB - Citizens Advisory Board

ACRONYMS AND ABBREVIATIONS (Continued)

CaCO₃ - calcite (calcium carbonate)

CAM - continuous air monitor

CAMEO - computer-aided management of emergency operations

CAMU - corrective action management unit

CAN - Clean Air Network (Program)

CAS - Chemical Abstracts Service

CCCP - Chemical Carcinogen Control Program

CCHP - Corporate Chemical Hygiene Plan

CCTC - Coyote Canyon Test Complex

CCTF - Coyote Canyon Test Field

CDP - census designated place

CEDE - committed effective dose equivalent

CEQ - Council on Environmental Quality

CERCLA - *Comprehensive Environmental Response, Compensation, and Liability Act*

CFR - *Code of Federal Regulations*

CGI - Chambers Group Incorporated

CI - Criticality Index

CIS - Chemical Information System

ACRONYMS AND ABBREVIATIONS (Continued)

Cl⁻ - chloride

CO - carbon monoxide

COD - chemical oxygen demand

CONUS - continental United States

CPMS - Criteria Pollutant Monitoring Station

CRMP - cultural resource management plan

CSR - customer service request

CSRL - Compound Semiconductor Research Laboratory

CTF - Coyote Test Field

CTTF - Countermine Technology Test Facility

CWA - *Clean Water Act*

CWDR - Chemical/Material Waste Disposal Request

CWL - Chemical Waste Landfill in Tech Area III, SNL/NM (ER Site 74)

CWVOC - Classified Waste VOC (Station)

CY - calendar year

D&D - decontamination and decommissioning

DAC - derived air concentration

DARTAB - EPA computer model

ACRONYMS AND ABBREVIATIONS (Continued)

dB - decibel

dB(A) - decibel A-weighted

DEAR - Department of Energy Acquisition Regulation

DETT - Design, Evaluation, and Test Technology Center

DI - deionized

DNL - day-night average noise level (same as "L_{dn}")

DOA - Department of Agriculture (NM)

DoD - Department of Defense (U.S.)

DOE - Department of Energy (U.S.)

DOE/AL - Department of Energy/Albuquerque Operations Office (U.S.)

DOI - Department of the Interior (U.S.)

DOT - Department of Transportation (U.S.)

DP - discharge plan

DPS - Department of Public Safety

DR - disposal request

DSSI - Diversified Scientific Solutions Incorporated

DSWA - Defense Special Weapons Agency

E.O. - executive order

ACRONYMS AND ABBREVIATIONS (Continued)

EA - environmental assessment

EAL - emergency action level

EAP - Employee Assistance Program

ECF - Explosive Components Facility

EDC - Explosives Development Committee

EDE - effective dose equivalent

EH - Explosives Handler

E_H - oxidation-reduction potential

EIB - Environmental Improvement Board (NM)

EID - environmental information document

EIS - environmental impact statement and Explosives Inventory System

EOC - Emergency Operations Center

EOD - Explosives Ordnance Disposal

EP - emergency preparedness

EPA - Environmental Protection Agency (U.S.)

EPCRA - *Emergency Planning and Community Right-to-Know Act*

EPMS - Enhanced Property Management System

ER - environmental restoration

ACRONYMS AND ABBREVIATIONS (Continued)

ERCS - emergency response communication sheets

ERD - emergency response director

ERDA - Energy Research and Development Administration (U.S.)

ERO - Emergency Response Organization

ERPG - emergency response planning guide

ERT - Emergency Response Team (ES&H)

ES&H - environment, safety, and health

ES&H SOP - environment, safety, and health standard operating procedure

ESA - *Endangered Species Act*

ESRC - Explosives Storage Review Committee

ETC - Explosives Training Committee

F - (degrees) Fahrenheit

FAA - Federal Aviation Administration

FAR - *Federal Aviation Regulation*

FEMA - Federal Emergency Management Agency

FIFRA - *Federal Insecticide, Fungicide, and Rodenticide Act*

FLAME - Fire Laboratory for the Accreditation of Model and Experiments (formerly called SMERF)

FONSI - finding of no significant impact

ACRONYMS AND ABBREVIATIONS (Continued)

FR - *Federal Register*

FWPCA - *Federal Water Pollution Control Act*

FY - fiscal year

GDC - general design criteria

GEP - good engineering practice

GHA - ground hazard area

GIF - Gamma Irradiation Facility

GIS - Geographic Information System

GMI - Groundwater Management Incorporated

GMT - Greenwich Mean Time

GOCO - Government-owned contractor-operated

GPPAP - *Albuquerque-Bernalillo County Ground-Water Protection Policy and Action Plan*

GRABS - Giant Reusable Air Blast Simulator

GWPMPP - *Groundwater Protection Management Program Plan (SNL/NM)*

HA - hazards analysis

HABS - Historic American Buildings Survey

HAD - hazard assessment document

HAER - Historic American Engineering Record

ACRONYMS AND ABBREVIATIONS (Continued)

HAM - hazard assessment and minimization

HAP - hazardous air pollutant

HASP - health and safety plan

HAZCOM - Hazard Communication Program

HAZMAT - hazardous material

HBWSF - High Bay Waste Storage Facility

HCF - Hot Cell Facility

HCIA - *Hazardous Chemicals Information Act*

HCO₃ - bicarbonate

HEPA - high-efficiency particulate air

HERMES - High-Energy Radiation Megavolt Electron Source

HERTF - High Energy Research Test Facility

HEU - highly enriched uranium

HMTA - *Hazardous Materials Transportation Act*

HR - hydrogeologic region

HSWA - *Hazardous and Solid Waste Amendments*

HUD - Department of Housing and Urban Development (U.S.)

HVAC - heating, ventilating, and air conditioning

ACRONYMS AND ABBREVIATIONS (Continued)

HVAR - high-velocity aircraft rocket

HWMDS - Hazardous Waste Management Data System

HWMF - Hazardous Waste Management Facility

IC - incident commander

ICF - inertial confinement fusion

ICS - Incident Command System

ICSSC - Interagency Committee on Seismic Safety in Construction

ID - identification

IEEE - Institute of Electrical and Electronics Engineers

IH - industrial hygiene

IHIR - industrial hygiene investigation report

IHMS - information for hazardous material shipment

IMRL - Integrated Materials Research Laboratory

INEEL - Idaho National Engineering and Environmental Laboratory

INF - intermediate nuclear forces

IPS - Integrated Procurement System

IRCP - International Commission on Radiological Protection

IRP - (KAFB) Installation Restoration Program

ACRONYMS AND ABBREVIATIONS (Continued)

ISC3 - Industrial Source Complex-3

ISEEMS - Integrated Safety, Environmental, and Emergency Management System

ISMS - Integrated Safety Management System

ISS - Interim Storage Site

IT - International Technology Corporation

ITRI - Inhalation Toxicology Research Institute

J - a data qualifier indicating an estimated constituent concentration

JIC - Joint Information Center

JIDP - Job Incurred Disability Program

JIT - Just-In-Time

K - (degrees) Kelvin, (element) potassium

k - thousand(s)

KAFB - Kirtland Air Force Base

KAO - Kirtland Area Office

KFC - Kirtland Federal Complex

Kr - krypton

KTF - Kauai Test Facility

KUMMSC - Kirtland Underground Munitions Maintenance and Storage Complex

ACRONYMS AND ABBREVIATIONS (Continued)

KUPM - KUMMSC Pollutant Monitoring Station

LAB STD - Laboratory Standard Program

LANL - Los Alamos National Laboratory

LANMAS - Local Area Network Nuclear Material Accountability System

LCF - latent cancer fatalities

L_{dn} - day-night average noise level (same as "DNL")

LDR - land disposal restriction

LECS - Liquid Effluent Control System

Legacy - Legacy Resource Management Program (a DoD Program)

LEPC - local emergency planning committee

L_{eq} - equivalent sound level

LEV - local exhaust ventilation

LIHE - Light Initiated High Explosives (Facility)

LIRI - Lovelace Inhalation Research Institute

LLW - low-level waste

LWDS - Liquid Waste Disposal System

M - million

M&O - management and operating

ACRONYMS AND ABBREVIATIONS (Continued)

MAC - maximum allowable concentration (established by the New Mexico Water Quality Control Commission)

MBA - Material Balance Area

MBTA - *Migratory Bird Treaty Act*

MCAM - Material Control and Accountability Measurement

MCL - maximum contaminant level (established by the U.S. EPA Primary Drinking Water Regulations in 40 CFR 141.11[b] and subsequent amendments)

MCLG - maximum contaminant level goals

MCP - mobile command post

MDL - Microelectronics Development Laboratory

MEI - maximally exposed individual

µg/m³ - micrograms per cubic meter

ML&TC - Marking, Labeling, and Tracking Committee

MLLW - mixed low-level waste

MOA - memorandum of agreement

MOU - memorandum of understanding

MRGCOG - Middle Rio Grande Council of Governments

MSA - metropolitan statistical area

MSDS - material safety data sheet

ACRONYMS AND ABBREVIATIONS (Continued)

MSGPRO - missing program

MSSAD - Material Systems and Security Audits Department

MTRU - mixed transuranic

MW - monitoring well

MWL - Mixed Waste Landfill in Tech Area III, SNL/NM (ER Site 76)

MWPMM - Mixed Waste PM₁₀ Monitoring Station

MWVOC - Mixed Waste VOC (Station)

N/A - not applicable

NAAQS - national ambient air quality standards

NAGPRA - *Native American Graves Protection and Repatriation Act of 1990*

NCDC - National Climatic Data Center

NCRP - U.S. National Council on Radiation Protection and Measurements

NEC - National Electrical Code

NEIC - National Earthquake Information Center

NEPA - *National Environmental Policy Act*

NESHAP - *National Emission Standards for Hazardous Air Pollutants*

NEST - Nuclear Emergency Search Team

NEW - net explosive weight

ACRONYMS AND ABBREVIATIONS (Continued)

NFA - no further action

NFPA - *National Fire Protection Act*, National Fire Protection Association

NG - neutron generator, and natural gas

NGF - Neutron Generator Facility

NGMF - Neutron Generator Manufacturing Facility

NHPA - *National Historic Preservation Act of 1966*

NIIMS - National Interagency Incident Management System

NMAAQS - New Mexico ambient air quality standard

NMAC - *New Mexico Administrative Code*, and nuclear material accountability clerk

NMDGF - New Mexico Department of Game and Fish

NMED - New Mexico Environment Department

NMEIB - New Mexico Environmental Improvement Board

NMFRCD - New Mexico Forestry and Resource Conservation Division

NMITS - Nuclear Material Inventory Tracking System

NMMAS - Nuclear Material Management Accounting System

NMMO - Nuclear Materials Management Operations

NMMSS - Nuclear Materials Management and Safeguards System

NMRT - nuclear material radioactive transfer

ACRONYMS AND ABBREVIATIONS (Continued)

NMSA - *New Mexico Statutes Annotated*

NMSF - Nuclear Materials Storage Facility

NMSU - New Mexico State University

NMT - nuclear material transfer

NMWQCC - New Mexico Water Quality Control Commission

NO₂ - nitrogen dioxide

NO_x - nitrogen oxides

NOAA - National Oceanographic and Atmospheric Administration

NOI - Notice of Intent

NPDES - National Pollutant Discharge Elimination System

NPDWR - National Primary Drinking Water Regulations

NPS - National Park Service

NRC - Nuclear Regulatory Commission, and National Response Center

NRHP - National Register of Historic Places

NSDWR - National Secondary Drinking Water Regulations

NSPS - new source performance standards

NTS - Nevada Test Site

NTU - nephelometric turbidity unit(s)

ACRONYMS AND ABBREVIATIONS (Continued)

NWS - National Weather Service

OBE - operating basis earthquake

ODS - ozone-depleting substance

OEA - occupational exposure assessment

OHSRC - Occupational Health and Safety Review Commission

OI - operating instruction

OMB - Office of Management and Budget

OP - operating procedure

OPA - *Oil Pollution Act*

ORPS - Occurrence Reporting and Processing System

ORNL - Oak Ridge National Laboratory

OSHA - *Occupational Safety and Health Act*, Occupational Safety and Health Administration

PAG - protective action guide

PAR - protective action recommendation

Pb - lead

PBFA - Particle Beam Fusion Accelerator

PCB - polychlorinated biphenyl

PEIS - programmatic environmental impact statement

ACRONYMS AND ABBREVIATIONS (Continued)

PEP - propellants, explosives, and pyrotechnics

PEPER - propellants, explosives, and pyrotechnics evaluation and reapplication

PETL - Processing and Environmental Technology Laboratory

pH - measure of acidity or alkalinity (negative logarithm of the hydrogen ion concentration)

PHA - preliminary hazard assessment

PHS - preliminary hazards screen

PIO - public information officer

PLO - Public Land Order

PM - particulate matter

PM₁₀ - particulate matter less than 10 microns in diameter

PM_{2.5} - particulate matter less than 2.5 microns in diameter

PNNL - Pacific Northwest National Laboratory

PO - purchase order

POTW - publicly-owned treatment works

PPCA - *Pollution Prevention Control Act*

PPE - personal protective equipment

PPH - pounds per hour

ppm - parts per million

ACRONYMS AND ABBREVIATIONS (Continued)

PPMP - Personal Property Management Process

PRC - PRC Environmental Management Incorporated

PS Dept - New Mexico Public Safety Department

PSAP - Personnel Security Assurance Program

PSEL - Photovoltaic Systems Evaluation Laboratory

PSM - process safety management

Pu - plutonium

PVC - polyvinyl chloride

PWS - public water supply system(s)

QA - quality assurance

QC - quality control

QD - quantity distance

R&D - research and development

RAM - radiation area monitor, and radioactive material

RAT - Radiological Assistance Team

Rb - rubidium

RCRA - *Resource Conservation and Recovery Act*

RCT - radiological control technician

ACRONYMS AND ABBREVIATIONS (Continued)

REAC/TC - Radiation Emergency Assistance Center/Training Center

RFI - RCRA facility investigation

RHEPP - Repetitive High-Energy Pulsed Power Unit

RMA - Radioactive Material Area

RMMA - Radioactive Material Management Area

RMSEL - Robotic Manufacturing Science and Engineering Laboratory

RMT - Radioactive Material Transfer

RMWMF - Radioactive and Mixed Waste Management Facility

RO - reverse osmosis

ROA - Revised Ordinance of Albuquerque

ROI - region of influence

RQ - reportable quantity

RRC - receiving records clerk

RRDA - resource, recovery, and disposition account

RTAC - Radiation Technical Advisory Council

RTG - radioisotopic thermoelectric generator

RWP - radiological work permit

S&SCTA - Safeguards & Securities Central Training Academy

ACRONYMS AND ABBREVIATIONS (Continued)

SA - safety assessment

SABRE - Sandia Accelerator and Beam Research Experiment

SAD - Safety Assessment Document

SAF - Storage Action Form

SAR - safety analysis report and storage action request

SARA - *Superfund Amendments and Re-Authorization Act*

SC - specific conductance

SCB - steel-containment box

SDWA - *Safe Drinking Water Act*

SECOM - Security Communications

SER - Sandia Experimental Reactor

SERC - State Emergency Response Commission

SESC - Sandia Explosives Safety Committee

SF - standard form

SFR - South Fence Road

SHPO - state historic preservation officer

SID - safety information document

SIP - state implementation plan

ACRONYMS AND ABBREVIATIONS (Continued)

SLAM - standards for state and local air monitoring stations

SMAC - Shipment Mobility/Accountability Collection

SMERF - Smoke Emission Reduction Facility (now called FLAME)

SMH - Special Material Handler

SMS - Scenery Management System

SNAP - Systems for Nuclear Auxiliary Power

SNL - Sandia National Laboratories

SNL/CA - Sandia National Laboratories/California

SNL/NM - Sandia National Laboratories/New Mexico

SNM - special nuclear material

SO₂ - sulfur dioxide

SO₄ - sulfate

SOP - standard operating procedure

SOR - Starfire Optical Range

SPA - sawdust-propellant-acetone (mixture)

SPDES - State Pollutant Discharge Elimination System

SPHINX - Short-Pulse High Intensity Nanosecond X-Radiator

spp. - species

ACRONYMS AND ABBREVIATIONS (Continued)

SPR - Sandia Pulsed Reactor

SRS - Savannah River Site

SSE - safe shutdown earthquake

SSM - stockpile stewardship and management

STAR - shock thermodynamics applied research

START - Strategic Arms Reductions Treaty

STW - Solar Tower West

SVOC - semivolatile organic compound

SWEIS - sitewide environmental impact statement

SWHAS - Sandia Workplace Hazards Awareness System

SWHC - Sitewide Hydrogeologic Characterization (Project)

SWISH - Small Wind Shielded (Facility)

SWMF - Solid Waste Management Facility

SWP - safe work permit

SWTF - Solid Waste Transfer Facility

TATB - triaminotrinitrobenzene 380

T/E - threatened or endangered species

TCA - trichloroethane

ACRONYMS AND ABBREVIATIONS (Continued)

TCE - trichloroethylene

TCP - traditional cultural property

TDS - total dissolved solids

TDSI - Transformer Disposal Specialist Incorporated

TEDE - total effective dose equivalent

TEVES - Thermal Enhanced Vapor Extraction System

TI - transportation index

TID - tamper indicating device

TLV - threshold limit value

TNMHC - total non-methane hydrocarbons

TNT - trinitrotoluene

TPY - tons per year

TRC Mariah - TRC Mariah Associates Incorporated

TRE - Thunder Range East

TRI - toxic release inventory

TRS - Target Road South

TRU - transuranic

TSCA - *Toxic Substances Control Act*

ACRONYMS AND ABBREVIATIONS (Continued)

TSD - Transportation Safeguards Division

TSDF - Treatment, Storage, and Disposal Facility

TSP - total suspended particulates

TSR - tritium supply and recycle

TTF - Thermal Treatment Facility

TTR - Tonopah Test Range

TVI - Albuquerque Technical-Vocational Institute

TWA - time-weighted average

U.S. - United States

U.S.C. - United States Code

U - uranium

UBC - Uniform Building Code

UHWM - uniform hazardous waste manifest

UIC - underground injection control

UN - United Nations

UNM - University of New Mexico

UNM-BBER - University of New Mexico-Bureau of Business and Economic Research

UNO - United Nations Organization

ACRONYMS AND ABBREVIATIONS (Continued)

US NRC - U.S. Nuclear Regulatory Commission

USAF - U.S. Air Force

USDA - U.S. Department of Agriculture

USDW - underground sources of drinking water

USFS - U.S. Forest Service

USFWS - U.S. Fish and Wildlife Service

USGS - U.S. Geological Survey

UST(s) - underground storage tank(s)

USTR - underground storage tank regulations

UTM - Universal Transverse Mercator (coordinates)

UXO - unexploded ordnance

VCM - voluntary corrective measure

VMS - Visual Management System

VOC - volatile organic compound

WAC - waste acceptance criteria

WCO - Waste Certification Official

WCOC - Waste Characterization Oversight Committee

WETL - Weapons Evaluation Test Laboratory

ACRONYMS AND ABBREVIATIONS (Continued)

WIPP - Waste Isolation Pilot Plant

WPA - Works Progress Administration

WQCC - Water Quality Control Commission (NM)

WW - wastewater

WWII - World War II

X - xenon

Z_o - site-specific roughness lengths

GLOSSARY

A₁ - The maximum activity of special-form radioactive material permitted in a Type A package.

See also "highway route controlled quantity."

A₂ - The maximum activity of radioactive material, other than special-form or low-specific activity radioactive material, permitted in a Type A package. See also "highway route controlled quantity."

Abiotic - Nonliving; of a physical or chemical nature.

Accident risk - Potential consequences to receptor populations that would be exposed to releases of radioactive material in the event of a serious transportation accident that resulted in the loss of containment or shielding of the material by the package. See also "incident-free impacts."

Accountable nuclear material - Divided into three types: special nuclear material (SNM), source nuclear material, and other nuclear material. SNM is fissionable nuclear material suitable for nuclear weapons. Source nuclear material can be used to produce SNM although it is not fissionable. Other nuclear material cannot be used to produce SNM and is not fissionable. Accountable nuclear material is monitored and managed more closely than nonaccountable radioactive material because of its attractiveness for use in nuclear weapons. All three types of accountable nuclear material are further divided into four category levels based on their attractiveness, with Category I being the most attractive and Category IV the least attractive. See also "radioactive material."

Adit - A mine passage that is horizontal or near horizontal at the surface.

Advisory Council on Historic Preservation - The advisory body to the President of the United States and Congress created by Section 106 of the *National Historic Preservation Act of 1966*.

Aesthetics - Generally, the study, science, or philosophy dealing with beauty and with judgments concerning beauty. In scenery management, it describes landscapes that give visual and sensory enjoyment. The theory of perception or of susceptibility.

Aftershock - Minor earthquake following a greater one and originating at or near the same place.

GLOSSARY (Continued)

Agricultural land use - Land used for the purpose of producing food crops or for grazing of livestock.

Air carriers - Airlines such as American Airlines that serve Albuquerque International Sunport with large passenger jet aircraft.

Alert - Class of operational emergency that must be declared when events are in progress or have occurred which involve an actual or potential substantial degradation of the safety of the shipment. Any release of hazardous material (radiological or nonradiological) is expected to be limited to small fractions of the appropriate protective action guide (PAG) or emergency response protection guide (ERPG) exposure levels. See also "operational emergency."

Alluvial - Deposited by flowing water.

Alluvial fan - A low, cone-shaped deposit of alluvium (i.e., sediment) made by a stream, generally issuing from mountainous constrictions (gorges) out onto a level plain.

Alpha particle - A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus and has a mass number of 4 and an electrostatic charge of +2. It has low penetrating power and a short range (a few centimeters in air). (See "alpha radiation.")

Alpha radiation - A strongly ionizing, but weakly penetrating, form of radiation consisting of positively charged alpha particles emitted spontaneously from the nuclei of certain elements during radioactive decay. Alpha radiation is the least penetrating of the four common types of ionizing radiation (alpha, beta, gamma, and neutron). Even the most energetic alpha particle generally fails to penetrate the dead layers of cells covering the skin and can be easily stopped by a sheet of paper. Alpha radiation is most hazardous when an alpha-emitting source resides inside an organism. (See "alpha particle.")

Ambient sound - Combination of relatively steady sounds interspersed by short-term increases in sound levels as the result of acoustic events associated with activities at specific locations.

Ancestral - Qualification used to refer to a geologic feature at some earlier geologic time.

GLOSSARY (Continued)

Annual limit on intake - Activity of a radionuclide that, if inhaled or ingested along by reference man, would result in a committed dose equivalent equal to that of the most limiting primary guide.

Anthropogenic - Caused by man, as air pollution.

Arroyo - A watercourse in an arid environment typified by short-term surface flows and long periods of dry conditions.

As low as reasonably achievable (ALARA) - An approach to radiation protection to manage and control worker and public exposures (both individual and collective) and releases of radioactive material to the environment to as far below applicable limits as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit but a process for minimizing doses to as far below limits as is practicable.

Association - A level of ecological organization typified by the dominance or codominance of particular plant species within a biome.

Atomic Energy Commission (AEC) - Established in 1946, it was superseded, in turn, by the U.S. Energy Research and Development Administration (ERDA) in 1975 and DOE in 1977.

Attenuation - The decrease with distance of a quantity, such as the reduction of noise over distance from a source.

Authorization basis - Those aspects of the facility design basis and operational requirements relied upon by DOE to authorize operation. These aspects are considered to be important to the safety of facility operations. The authorization basis is described in documents such as the facility safety analysis report and other safety analyses, hazard classification documents, the technical safety requirements, DOE-issued safety evaluation reports, and facility-specific commitments made in order to comply with DOE rules, orders, or policies.

Avoidance - Modification of a project or other undertaking so that effects on cultural resources that would have resulted from the originally designed actions do not occur.

GLOSSARY (Continued)

Background - The distant part of a landscape. Area located from 4 miles to infinity from the observer.

Basin - A geographically extensive, depressed area into which the adjacent land drains, having few or no surface outlets.

Bedrock - A general term for the rock, usually solid, that underlies soil or other unconsolidated surface material.

Beta radiation - Ionizing radiation consisting of fast moving, positively or negatively charged elementary particles emitted from atomic nuclei during radioactive decay. Beta radiation is more penetrating, but less ionizing than alpha radiation. Negatively charged beta particles are identical to electrons; positively charged beta particles are known as positrons. Both are stopped by clothing or a thin sheet of metal.

Biodiversity - A key element and indicator of the health of an ecological system; refers to the number of species that are found in an area and the relative abundance of each. High biodiversity refers to the condition in which there are both a large number of species and a relatively high abundance of each.

Biohazardous waste - Includes the following:

- Discarded live and attenuated vaccines.
- Discarded material contaminated with recognizable fluid blood, fluid blood products, containers, or equipment containing blood that is fluid.
- Discarded material contaminated with excretion, exudate, or secretions known to be infected with a highly communicable disease agent.
- Animal carcasses and animal waste products suspected of being contaminated with infectious agents.

GLOSSARY (Continued)

Biological resource - In this document, this term means an organism-specific resource that relates to an individual or a population of individuals (all of the same species) occurring at the Kirtland Federal Complex (KFC) for at least part of the year. For example, a population of sensitive species would be considered a biological resource.

Biome - A natural community of plants and animals characterized by a distinctive vegetation within a formation. Biomes represent geographical entities that typically form disjunctive units on a regional landscape. See also "biotic community."

Biotic community - Used in this document as an equivalent term to "biome."

Biotic province - A biogeographic unit typified by a distinct group of species associated with a particular geographical region (for example, the Great Plains, the Great Basin, and the Chihuahuan Desert).

Brisance - The shock produced when material explodes.

Buffer zone - At Kirtland Federal Complex (KFC), the area surrounding a testing site. The size and configuration of a buffer area or zone is defined in terms of the type and quantity of explosives and the type(s) of facilities or land use adjacent to the site. Evacuation or appropriate shelter of all personnel during the testing is required.

Candidate species - Plants and animals native to the United States for which the U.S. Fish and Wildlife Service or the National Marine Fisheries Service has sufficient information on biological vulnerability and threats to justify proposing to add them to the threatened and endangered species list, but cannot do so immediately because other species have a higher priority for listing. The Services determine the relative listing priority of candidate taxa in accordance with general listing priority guidelines published in the *Federal Register*. (See "endangered species" and "threatened species.")

Cantonment area - The portion of Kirtland Air Force Base (KAFB) that includes offices, storage buildings, residential housing, mission support equipment, and community service facilities.

GLOSSARY (Continued)

Capping inversion - Layer where the temperature increases with height; also called an "elevated inversion."

Character type - Large physiographic area of land which has common characteristics of landforms, rock formations, water forms, and vegetative patterns.

Characteristic - The naturally established landscape within a scene or scenes being viewed.

Chemical - Any element, chemical compound, or mixture of elements and/or compounds.

Chemical Information System (CIS) - A container tracking and bar coding system for chemicals used, stored, and manufactured at SNL/NM.

Chemical waste - Term that SNL/NM uses in MN471001, *ES&H Manual*, to include any chemical (liquid, solid, or gas) which becomes a waste because it can no longer be used for its intended purpose, or it is declared to be a waste. This large grouping of waste includes hazardous as well as nonhazardous waste and recyclable material.

ChemMasterTM - A chemical inventory system, based on self-reporting, currently used to keep track of chemicals used, stored, and manufactured at SNL/NM.

Colluvium - Rock fragments, sand, etc. that accumulate on steep slopes or at the foot of cliffs.

Common landscape - Refers to prevalent, usual, or widespread landscape variety within a character type. It also refers to ordinary or undistinguished visual variety.

Commuters - Airlines such as Mesa Airlines that serve Albuquerque International Sunport with passenger turboprop aircraft.

Component - A recognizable, temporally discrete occupation at a site (for example, a site could have two components: a historic WWII component and a prehistoric component).

Condensate - A product of condensation; especially a liquid obtained by condensation of a gas or vapor.

GLOSSARY (Continued)

Consultation - The process used to obtain the view or advice of parties concerned with the management of cultural resources.

Continuous noise - Sounds that last longer than one second (or reoccur within one second) such as music or sounds of city traffic.

Contrast - Diversity of adjacent parts. The closer the juxtaposition of two dissimilar perceptions, in time or space, the more powerful the appeal.

Corridors - The linear features of a habitat that provide travel routes for wildlife moving from one part of their home range to another, such as from a water source to a feeding area or bedding area.

Cultural resource - Cultural resources include, but are not limited to, the following broad range of items and locations:

- Archaeological material (artifacts) and sites dating to the prehistoric, historic, and ethnohistoric periods that currently appear on the ground surface or buried beneath it
- Standing structures that are over 50 years of age or are important because they represent a major historic theme or era
- Cultural and natural places, select natural resources, or sacred objects that have importance for Native Americans and other ethnic groups
- American folklife tradition and arts

Cultural resources include anything that is:

- A "historic property" as defined in 36 CFR Part 800, *Protection of Historic and Cultural Properties*, Section 2(e).

GLOSSARY (Continued)

- An “archaeological resource,” including any surface, subsurface, or submerged location, such as a site, building, structure, shipwreck, cave, rockshelter, midden, or feature that contains material remains of prehistoric and historic human life or activities that are at least 100 years of age and are of archaeological interest, or as defined in 43 CFR Part 7, *Archaeological Resources Protection Act*, Section 3, and the Act's Uniform Regulations, Section 3(a).
- A Native American “cultural item” as defined in the *Native American Graves Protection and Repatriation Act of 1990*, Section 2(3).
- Part of a “collection” as defined in 36 CFR Part 79, *Curation of Federally-Owned and Administered Archaeological Collections*, Section 4(b).

Cultural resource survey - The process used to locate and record basic information about prehistoric and historic cultural resources in the field. Archaeological survey methods include walking over the project area.

Day-night noise level - The A-weighted sound level measured during a 24-hour period where 10 dB is added to the sound level measurements taken between the hours of 10 p.m. and 7 a.m. before the sound level measurements are averaged. This procedure helps to take into account the usual increased interfering effects of noise during the night, particularly when people are sleeping. Abbreviated as “DNL” and “L_{dn}.”

Decibel - A unit for expressing the relative intensity of sounds on a logarithmic scale from zero for the average, least perceptible sound, to about 130 for the average level at which sound causes pain to humans. For traffic and industrial noise measurements, the A-weighted decibel (dBA), a frequency-weighted noise unit, is widely used. The A-weighted decibel scale corresponds approximately to the frequency response of the human ear and thus correlates well with loudness.

Decibel A-weighted scale - A modification of the standard sound pressure level scale that better approximates the hearing response of the human ear. It is abbreviated “dB(A).”

Deflagrate - To burn rapidly with intense heat and sparks.

GLOSSARY (Continued)

Design basis - The set of requirements that bound the design of systems, structures, and components within the facility. These design requirements include consideration of safety, plant availability, efficiency, reliability, and maintainability. Some aspects of the design basis are important to safety, although others are not.

Diffuse radiological release - Release that does not originate from point sources (i.e., emanating from a stack or building vent). Diffuse sources include radionuclide emissions that originate from areas of surface contamination.

Diffuse source - A release or potential to emit pollutants into the air from an area source (soil, water, or structure) after the source is disturbed.

Dip - The angle at which strata are inclined from horizontal; it is measured perpendicular to the strike.

Distance zones - Areas of landscapes denoted by specified distances from the observer. Used as a frame of reference in which to discuss landscape characteristics or activities of man.

Distinctive landscape (level A) - Refers to extraordinary or special landscapes; these are attractive and stand out from common landscapes.

Dose (radiological) - A generic term meaning absorbed dose, dose equivalent, effective dose equivalent, committed dose equivalent, committed effective dose equivalent, or committed equivalent dose, as defined elsewhere in this glossary.

Dose assessment - A written evaluation of the dose equivalent at a point of interest from an activity.

Ecological resource - In this document, this term means the collection of all factors that comprise the environment with which these organisms interact. For example, a habitat or the specific habitat features on which a population of sensitive species would be considered an ecological resource.

GLOSSARY (Continued)

Ecological risk assessment - The process that evaluates the likelihood that adverse ecological-effects may occur or are occurring as a result of exposure to one or more stressors, such as chemical contamination or the physical disturbance of habitat.

Ecology - A branch of science dealing with the interrelationships of living organisms with one another and with their nonliving environment.

Ecosystem management - The use of an ecological approach that blends social, physical, economic, and biological needs and values to ensure productive, healthy ecosystems.

Eddy - Current of air that runs opposite to the main flow.

Edge - The line where an object or area begins or ends; serves as a boundary.

Effect - An action involving a cultural resource that "...may alter characteristics of the property that may qualify the property for inclusion in the National Register" (36 CFR Part 800, *Protection of Historic and Cultural Properties*, Section 9[a]; the criteria of adverse effects are identified in Section 9[b]).

Effective dose equivalent (EDE) - The dose value obtained by multiplying the dose equivalents received by specified tissues or organs of the body by the appropriate weighting factors applicable to the tissues or organs irradiated, and then summing all of the resulting products. It includes the dose from radiation sources internal and external to the body. The effective dose equivalent is expressed in units of rems or sieverts.

Elevated inversion - Layer where the temperature increases with height; also called a "capping inversion."

Emergency response planning guide (ERPG)-2 - A health effect level; with respect to chemical dispersion, the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms which could impair an individual's ability to take protective action.

GLOSSARY (Continued)

Emergency response planning guide (ERPG)-3 - A health effect level; with respect to chemical dispersion, the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to one hour without experiencing or developing life-threatening health effects.

Endangered species - Plants or animals that are in danger of extinction through all or a significant portion of their ranges and that have been listed as endangered by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures outlined in the *Endangered Species Act* and its implementing regulations (50 CFR 424). (See threatened species.) The lists of endangered species can be found in 50 CFR 17.11 (wildlife), 50 CFR 17.12 (plants), and 50 CFR 222.23(a) (marine organisms).

Enhancement - The act of increasing positive scenic attributes where few exist.

Eolian - Deposit transported and arranged by the wind (e.g., eolian dunes).

Ephemeral drainage - A stream or reach of a stream that flows briefly in response to precipitation in the immediate vicinity, whose channel is at all times above the watertable.

Ephemeral stream - One that flows only for a short duration during and following rainfall or snowmelt.

Ethnographic research - The scientific study of cultural resources through the analysis of data gathered during ethnographic fieldwork.

Ethnographic study - The process of identifying and documenting resources of ethnic importance. This process may include interviewing, participant observation, questionnaires, and/or archival research.

Ethnohistoric - Pertaining to the maintenance and passing on of the history of an ethnic group orally rather than by written records.

GLOSSARY (Continued)

Exclusive use - The sole use of a conveyance by a single consignor for which all initial, intermediate, and final loading and unloading are carried out in accordance with the direction of the consignor or consignee.

Existing scenic integrity ("existing visual condition") - Current state of the landscape, considering previous human alterations.

Explosive - Any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, shock, or other suitable initiation stimulus, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to material that either detonates or deflagrates. DOE explosives may be dyed various colors except pink, which is reserved for mock explosives. DOE explosives include primary and secondary explosives, propellants, and pyrotechnics.

Explosive material - For the purpose of onsite transfers of explosive material, an explosive material is defined as any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, shock, or other suitable initiation stimulus, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to material that either detonates or deflagrates. DOE explosives may be dyed various colors, except pink, which is reserved for mock explosives. Any substance, component, or material that satisfies this definition would be transferred as an explosive material by SNL/NM.

For the purposes of offsite shipments and receipts of explosive material, an explosive is any material that satisfies the definition of a hazardous material as defined in 49 CFR 172.101 and satisfies the definition of an explosive in 49 CFR 173.50 as "...any substance or article, including a device, which is designed to function by explosion (i.e., extremely rapid release of gas and heat) or which, by chemical reaction within itself, is able to function in a similar manner even if not designed to function by explosion, unless the substance or article is otherwise classed under the provision of this subchapter."

Any substance, component, or material that satisfies this definition would be shipped by SNL/NM as a DOT Hazard Class 1 explosive material (49 CFR 173.50). Any substance, component, or material shipped to SNL/NM as DOT Hazard Class 1 material would be received by SNL/NM as an explosive material.

GLOSSARY (Continued)

Explosive waste - For the purpose of both onsite transfers and offsite shipments, an explosive waste is defined as an explosive material for which there is no individual or corporate plan of use or which is potentially damaged, unstable, or otherwise unsafe to use. Examples of explosive waste include misfired or damaged components, debris that is contaminated with explosives, explosive chunks, and explosives dissolved in solvents or water/isopropanol solutions. Any material that satisfies this definition would be transferred as an explosive material at SNL/NM or shipped as an explosive material by SNL/NM as a DOT Hazard Class 1 material (49 CFR 173.50).

Fan - A sediment deposit in the shape of a fan, generally formed upon exiting a confined mountain valley into an open plain.

Fault - A planar or gently curved fracture in the earth's crust across which there has been relative displacement.

Fault zone - A wide zone of relative displacement of numerous fractures, as opposed to a single, distinctive, and isolated fracture.

Feature - A visually distinct or outstanding part, quality, or characteristic of a landscape.

Fee-owned - Full and unconditional ownership of surface, subsurface, and air rights. The words "fee," "fee-owned," and "fee-title" are used interchangeably. "DOE-owned" is the terminology most used in this document.

Floodplains - The lowlands and relatively flat areas adjoining inland and coastal waters and the flood-prone areas of offshore islands. Floodplains include, at a minimum, that area with at least a 1.0% chance of being inundated by a flood in any given year.

The *base floodplain* is defined as the area which has a 1.0% or greater chance of being flooded in any given year. Such a flood is known as a 100-year flood.

The *critical action floodplain* is defined as the area which has at least a 0.2% chance of being flooded in any given year. Such a flood is known as a 500-year flood. Any activity for which even a slight chance of flooding would be too great (e.g., the storage of highly volatile, toxic, or water reactive materials) should not occur in the critical action floodplain.

GLOSSARY (Continued)

The *probable maximum flood* is the hypothetical flood that is considered to be the most severe reasonably possible flood, based on the comprehensive hydrometeorological application of maximum precipitation and other hydrological factors favorable for maximum flood runoff (e.g., sequential storms and snowmelts). It is usually several times larger than the maximum recorded flood.

Flow vector - Direction toward which the wind is blowing.

Fluvial - Of, or pertaining to, rivers.

Fluvial deposit - A sedimentary deposit consisting of material transported by, suspended in, or laid down by a river stream.

Foreground - Detailed landscape generally found from the observer to one-half mile away.

Form - Structure, mass, or shape of a landscape or an object. Landscape form is often defined by edges or outlines of landforms, rockforms, vegetative patterns, waterforms, or the enclosed spaces created by these attributes.

Formation (hydrology) - The primary stratigraphic unit which can be mapped or described.

Formation (ecology) - The structure of vegetation in terms of the relative dominance of trees, shrubs, and herbaceous plants.

Fractures - Breaks in rocks due to intense folding or faulting.

French drain - An underground passage for water, consisting of loose stones covered with earth.

Fumigation condition - When the layer below the plume height becomes neutral to unstable and the plume mixes rapidly to the surface, a situation that is common during nighttime and early morning hours.

GLOSSARY (Continued)

Gamma radiation (rays) - High-energy, short wavelength, electromagnetic radiation emitted from the nucleus of an atom during radioactive decay. Gamma radiation frequently accompanies alpha and beta emissions and always accompanies fission. Gamma rays are very penetrating and are best stopped or shielded by dense materials, such as lead or depleted uranium. Gamma rays are similar to, but are usually more energetic than, x-rays. (See also "alpha radiation" and "beta radiation.")

General aviation aircraft - Private and corporate aircraft that use the Albuquerque International Sunport.

General emergency - Class of operational emergency that must be declared when events have occurred that involve an actual or imminent catastrophic reduction in the safety of the shipment. Any release of hazardous material (radiological or nonradiological) is expected to exceed appropriate PAG or ERPG exposure levels in a general public area. If the event has occurred on a DOE site, the release is expected to exceed appropriate PAG or ERPG exposure levels off site. See also "operational emergency."

Geochemistry - The interaction of water, minerals, and organic material in the soil.

Graben - A block, generally long compared to its width, that has been downthrown along faults relative to rocks on either side.

Granite - A coarse-grained igneous rock consisting mainly of quartz and feldspar minerals.

Grassland - A vegetation formation typified by the dominance of grasses, with little or no shrub or tree overstory.

Gravel - The coarsest of alluvial sediments, consisting of rounded rock and mineral pieces larger than two millimeters, including cobbles and boulders.

Group - A stratigraphic unit consisting of two or more formations.

Gypsum - A calcium sulfate mineral commonly associated with evaporite settings.

Habitat - The place or type of site where an organism naturally or normally lives and grows.

GLOSSARY (Continued)

Habitat type - A distinct set of environmental conditions, including topography, geology, soils, and vegetation, that can be used to define an area for its potential to support a particular species or group of species.

Half-graben - A depressed block bound on one side by a fault.

Hazardous chemical - Any chemical that constitutes a physical or health hazard. See also "hazardous chemical material."

Hazardous chemical material - For the purpose of onsite transfers, a material is considered a hazardous chemical as defined in MN470094, *Handling Chemicals at SNL/CA*, and the Occupational Safety and Health Administration's (OSHA's) regulation (29 CFR 1910.1200, Appendix A). A material is considered a hazardous chemical at SNL/NM if "... there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees." The term "health hazard" includes chemicals that are:

- Carcinogens
- Reproductive toxins
- Corrosives
- Hepatotoxins
- Neurotoxins
- Agents that damage the lungs, skin, eyes, or mucous membranes
- Toxic or highly toxic agents
- Irritants
- Sensitizers
- Nephrotoxins
- Agents that act on the hematopoietic systems

Any material satisfying this definition would be transferred on site at SNL/NM as a hazardous chemical.

For the purpose of offsite shipments or receivals, a hazardous chemical is defined as any material or substance that satisfies the U.S. Department of Transportation (DOT) definition of a hazardous material in 49 CFR 171.8. Any material that satisfies this definition would be shipped by SNL/NM as a hazardous material under the appropriate DOT hazard class that would apply to the following types of hazardous chemicals:

GLOSSARY (Continued)

- Gases - DOT Hazard Class 2 (49 CFR 173.115)
- Flammable and combustible liquids - DOT Hazard Class 3 (49 CFR 173.120)
- Flammable solids - DOT Hazard Class 4 (49 CFR 173.124)
- Oxidizers and organic peroxides - DOT Hazard Class 5 (49 CFR 173.128)
- Poisons - DOT Hazard Class 6 (49 CFR 173.132)
- Corrosives - DOT Hazard Class 8 (49 CFR 173.136)

OSHA and DOT differ in their definitions of hazardous material because OSHA is concerned with hazards associated with using the material, whereas DOT is concerned with how the material may be released and if the material could cause harm if it is released during transportation.

Hazardous material - Term used to refer to radioactive material, chemicals, and explosives. The U.S. Department of Transportation (DOT) 49 CFR 171.8 defines a hazardous material as "...a material or substance, including a hazardous substance, which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated." See also "radioactive material," "hazardous chemical material," and "explosive material."

Hazardous medical waste - Hazardous chemical waste comprising but not limited to biohazardous waste and sharps waste. See also "biohazardous waste" and "sharps waste."

Hazardous substance - As defined by the U.S. Department of Transportation (DOT), if the material, including its mixtures and solutions, is listed in the appendix to 49 CFR 172.101 and if its quantity, in one package, equals or exceeds the reportable quantity listed in the appendix.

GLOSSARY (Continued)

Hazardous waste - A category of waste regulated under the *Resource Conservation and Recovery Act (RCRA)*. To be considered hazardous, a waste must be a solid waste under RCRA and must exhibit at least one of four characteristics described in 40 CFR 261.20 through 40 CFR 261.24 (i.e., ignitability, corrosivity, reactivity, or toxicity) or be specifically listed by the U.S. Environmental Protection Agency in 40 CFR 261.31 through 40 CFR 261.33.

Source, special nuclear, or byproduct materials as defined by the *Atomic Energy Act* are not hazardous waste because they are not solid waste under RCRA.

Health hazard - A chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system, and agents that damage the lungs, skin, eyes, or mucous membranes. See also "hazardous chemical material."

Hematopoietic systems - Systems that control formation of blood cells in the body.

Hepatotoxin - Relating to or causing damage to the liver.

Hertz - A unit of frequency that is equal to one cycle per second.

Hibernaculum - The domicile in which an animal hibernates or overwinters.

High scenic integrity level - A scenic integrity level meaning human activities are not visually evident. In high scenic integrity areas, proposed activities may only repeat attributes of form, line, color, and texture found in the existing landscape.

Highway Route Controlled Quantity - As defined in 49 CFR 173.403(l), a quantity within a single package that exceeds: (1) 3,000 times the A_1 value of the radionuclides as specified in 49 CFR 173.433 for special-form radioactive material; (2) 3,000 times the A_2 value of the radionuclides as specified in 49 CFR 173.433 for normal-form radioactive material; or (3) 30,000 Curies, whichever is least. These values are either listed in 173.435 or may be derived in accordance with the procedure prescribed in 173.433.

GLOSSARY (Continued)

Historic - The periods after the advent of written history in a geographic region. For example, the historic period in what is now the southeastern U.S. began with the arrival of Europeans in that region in the early 1500s.

High-noise level - Noise that is greater than the following threshold limit values (TLVs) for noise^a:

Time Period	Duration per Day	Sound Level dB(A) ^b
Hours	24	80
	16	82
	8	85
	4	88
	2	91
	1	94
Minutes	30	97
	15	100
	7.50 ^c	103
	3.75 ^c	106
	1.88 ^c	109
	0.94 ^c	112
Seconds	28.12	115
	14.06	118
	7.03	121
	3.52	124
	1.76	127
	0.88	130
	0.44	133
	0.22	136
	0.11	139

^aNo exposure to continuous, intermittent, or impact noise in excess of a peak C-weighted level of 140 dB.

^bSound level in decibels are measured on a sound level meter, conforming as a minimum to the requirements of the American National Standards Institute Specification for Sound Level Meters, S1.4 (1983)⁽²⁾ type S2A, and set to use the A-weighted network with slow meter response.

^cLimited by the noise source—not be administrative control. It is also recommended that a dosimeter or integrating sound level meter be used for sounds above 120 decibels.

When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered rather than the individual effect of each. If the sum of the following fractions:

$$\frac{C_1}{T_1} + \frac{C}{T_2} + \dots + \frac{C_n}{T_n}$$

GLOSSARY (Continued)

exceeds unity, then the mixed exposure should be considered to exceed the TLV. C_1 indicates the total duration of exposure at a specific noise level, and T_1 indicates the total duration of exposure permitted at that level. All on-the-job noise exposures of 80 dB(A) or greater should be used in the above calculations.

Historic property - Properties that appear on or are eligible for the National Register of Historic Places (NRHP).

Hydraulic conductivity - The rate at which a unit cross-sectional area of soil will transmit water under a unit hydraulic gradient.

Hydrology - The science that relates to the water of the earth.

Igneous - A rock formed by solidification from a molten or partially molten state.

Impulse noise - Sounds that last less than one second (or reoccur more than one second apart) such as hammer striking an anvil.

Incident-free impacts - Consequences to receptors involved in or close to the transportation activities. See also "accident risk."

Indistinctive landscape (level C) - Refers to areas where landform, vegetative patterns, waterform, and cultural land use have low scenic quality.

Indurated - Descriptive of a rock or soil hardened or consolidated by pressure, cementation, or heat.

Industrial land use - Land used for research or manufacturing facilities or plants. Airports are included as industrial areas due to large-scale movement, storage, and maintenance of heavy equipment. Industrial land use can be described as "light" or "heavy." Light industrial use includes research and component assembly and manufacturing operations such as those performed at SNL/NM. Heavy industrial use involves large manufacturing operations and facilities.

GLOSSARY (Continued)

Infiltration - The process of water passing through the surface of the soil through joints and pores; this water does not necessarily (and, in most cases, mostly does not) recharge the aquifer beneath it, due to evaporation.

INPUFF - Gaussian-integrated puff model used to model semi-instantaneous releases and predict impacts from open detonation and open burning.

Intactness - Untouched or unaltered, especially by anything that harms or diminishes its character.

Intermittent stream or spring - One that does not flow year-round.

Interstratified - Descriptive of strata layered between, or alternating with, other strata.

Inventory - The process of locating cultural resources and gathering information about them through archaeological surveys, ethnographic fieldwork, or archival searches.

Inversion - An atmospheric condition in which the normal properties of layers of air are reversed; a temperature reversal in which a layer of warm air traps cooler air near the surface of the earth, preventing the normal rising of surface air.

Isotope - Any of two or more variations of an element in which the nuclei have the same number of protons (i.e., the same atomic number) but different numbers of neutrons so that their atomic masses differ. Isotopes of a single element possess almost identical chemical properties, but often different physical properties (e.g., carbon-12 and -13 are stable, carbon-14 is radioactive).

Joint-use agreement - See "outgrants."

Kirtland Federal Complex - Physical and geographical area containing DOE and U.S. Air Force (USAF) 377th Air Base Wing (ABW) facilities, and U.S. Forest Service (USFS) lands withdrawn from public use.

Lagomorph - Mammals of the order Lagomorpha, which includes rabbits (for example, cottontails) and hares (for example, jackrabbits).

GLOSSARY (Continued)

Land coverage - Surface coverage of a land area. Land coverage characteristics of an area include a range from vegetation or surface geology to urban or other built-environment categories. Land use constraints or indicators may be identified based on land coverage characteristics of a given area.

Land use permit - A temporary right of exclusive or non-exclusive use of real property. It is generally applicable to granting another federal agency the right to use DOE property or vice versa.

Land use planning - The process of establishing comprehensive criteria and objectives on which to base decisions regarding development of land.

Landform - Any physical, recognizable form, feature, or attribute of the earth's surface, having a characteristic shape, and produced by natural causes (for example, a mountain, valley, or plain).

Landscape character - Particular attributes, qualities, and traits of a landscape that give it an image and make it identifiable or unique.

Landscape visibility - Accessibility of the landscape to observers, referring to one's ability to see and perceive landscapes.

Latent cancer fatality (LCF) - Deaths from cancer resulting from, and occurring some time after, exposure to ionizing radiation or other carcinogens.

Limestone - A bedded, sedimentary deposit consisting chiefly of calcium carbonate, usually as the mineral calcite.

Lithology - The systematic description of rocks, in terms of mineral composition and texture, usually as observed by the eye.

Loam - A soil texture that is a mixture of sand, silt, and clay and that demonstrates the optimal properties of all three for plant growth.

GLOSSARY (Continued)

Local list property - Property that is less than \$5,000 in value (excluding laboratory equipment and automated data processing equipment [ADP] such as computers), which is sent to state and federal agencies in New Mexico for reuse.

Low-level radioactive waste or low-level waste - Radioactive waste that is not high-level waste, transuranic waste, spent nuclear fuel, or byproduct tailings from processing of uranium or thorium ore.

Low-level radioactive waste is generated in many physical and chemical forms and levels of contamination. (See "radioactive waste.")

Major safety zone - A zone where danger exists to personnel or property during testing periods. Evacuation or appropriate shelter of all personnel during the testing is required.

Major source - Emissions from any facility with the potential to emit 100 tons per year or greater of any criteria pollutant, 10 tons per year of any hazardous air pollutant (HAP), or 25 tons per year of any combination of HAPs.

Management plans - Environmental stewardship management plans developed by the U.S. Forest Service (USFS) and U.S. Air Force (USAF) for lands on the Kirtland Federal Complex (KFC) for which these entities maintain management responsibility for natural resources. *Environmental Analysis Ecosystem Management Plan, National Forest Lands in and Adjacent to the Military Withdrawal* is the USFS plan and *Integrated Natural Resources Management Plan 1995-2000* is the USAF plan.

Manhattan Engineer District - Established in August 1942, this district of the U.S. Army Corps of Engineers was the agency authorized to oversee the design, production, and testing of the first nuclear weapons. On January 1, 1947, the district transferred authority over nuclear weapons stewardship to the civilian authority of the newly established Atomic Energy Commission; the district was abolished later that year.

Manhattan Project - A U.S. Government project, named for the Manhattan Engineer District, that produced the first nuclear weapons during World War II from 1942 to 1946. The Hanford Site, the Oak Ridge Reservation, and the Los Alamos National Laboratory were created for this effort.

GLOSSARY (Continued)

Material - Property with an expected life of two years or longer and material with a shorter life expectancy. Property generally is solid and more substantial in nature than material, which includes office supplies, disposable items, and consumables for experiments.

Maximally exposed individual (MEI) - A hypothetical individual whose location and habits result in the highest total radiological or chemical exposure (and thus dose) from a particular source for all exposure routes (e.g., inhalation, ingestion, direct exposure).

Maximum projected width - Greatest horizontal distance covered by a building when viewed from any angle.

Medical waste - Waste that includes discarded live and attenuated vaccines; discarded material contaminated with recognizable fluid blood, fluid blood products, containers, or equipment containing blood that is fluid; discarded material contaminated with excretion, exudate, or secretions known to be infected with a highly communicable disease agent; and animal carcasses and animal waste products suspected of being contaminated with infectious agents.

Metamorphic - Those rocks formed in the solid state, whose original mineralogy, texture, or composition has been changed in response to pronounced changes of temperature, pressure, and chemical environment.

Middleground - The zone between the foreground and the background in a landscape. The area located from one-half mile to four miles from the observer.

Migratory nongame bird of management concern - U.S. Fish and Wildlife Service (USFWS) designation for nongame, migratory bird species for which current evidence indicates that populations are declining within one or more regions of the United States and may potentially be in jeopardy without special management consideration. Also shortened to "species of management concern." See also "species of concern."

Millirem (mrem) - 1/1,000th rem; a unit of absorbed radiation dose.

Mixed layer - Layer of the troposphere ranging from the surface up to a few thousand meters where constituents rapidly become mixed.

GLOSSARY (Continued)

Mixed waste - Waste that contains both hazardous waste, as defined under the *Resource Conservation and Recovery Act (RCRA)* and source, special nuclear, or byproduct material subject to the *Atomic Energy Act*.

Mixing height - Altitude of a capping inversion.

Mott - An island-like group or cluster of trees on a prairie.

National Register of Historic Places (NRHP) - The official list of the Nation's cultural resources that are worthy of preservation. The National Park Service maintains the list under direction of the Secretary of the Interior. Buildings, structures, objects, sites, and districts are included in the National Register for their importance in American history, architecture, archaeology, culture, or engineering. Properties included on the National Register range from large-scale, monumentally proportioned buildings to smaller-scale, regionally distinctive buildings. The listed properties are not just of nationwide importance; most are significant primarily at the state or local level. Procedures for listing properties on the National Register are found in 36 CFR 60.

Nephrotoxin - Poisonous to the kidney.

Neurotoxin - Poisonous complexes, especially of protein, that act on the nervous system.

Neutron access tube - A pipe emplaced in the ground (usually vertically) for purposes of passing a neutron probe through it, to measure soil water content at various depths or locations.

Neutron probe - A device commonly used to measure soil or rock moisture by emitting high-energy neutrons and counting the low-energy neutrons produced by the interaction of the high-energy neutrons with hydrogen atoms usually associated with water molecules.

Neutron radiation - The emission of neutrons from atomic nuclei. Neutrons are uncharged subatomic particles of nearly the same mass as protons. Interaction with atomic nuclei in matter results indirectly in ionization and thus an absorbed dose to biological material. Neutron bombardment of heavy nuclei (e.g., uranium, plutonium) can result in fission. Highly penetrating, neutrons can be stopped by thick masses of concrete, water, or paraffin.

GLOSSARY (Continued)

No effect - The situation in which an action involving a cultural resource will not "...alter characteristics of the property that may qualify the property for inclusion in the National Register" (36 CFR 800, *Protection of Historic and Cultural Properties*, Section 9[a]).

Noise - An unwanted sound.

Nonhazardous material - All other types of material that are routinely handled by SNL/NM that are not considered potentially dangerous.

Normal fault - A fault where the upper surface moved down relative to the lower surface.

Nuclear material - Subclass of radioactive material defined by the *Atomic Energy Act of 1954 (AEA)*. Nuclear material is used principally by the U.S. government for national security and defense purposes, but is also utilized by the civilian nuclear power industry to generate electricity and by numerous universities for research purposes. Nuclear material is further divided (by DOE 5633.3B, *Control and Accountability of Nuclear Materials*) into special nuclear material (SNM), source material, and other nuclear material.

Onsite impacts - Impacts and risks associated with the onsite transportation of radioactive material.

Operational emergency - A significant accident, incident, event, or natural phenomenon that seriously degrades the safety or security of DOE facilities. This category applies to transportation accidents involving hazardous material.

The three classes of operational emergencies include the following, listed in order of increasing severity: alert, site area emergency, and general emergency. Differentiation of these classes by severity is for the purpose of specifying appropriate emergency actions, including required response activities and notifications, commensurate with the degree of hazard presented by the event. See also "alert," "site area emergency," and "general emergency."

GLOSSARY (Continued)

Other nuclear material - Includes radioactive isotopes produced by exposure of an element to radiation from the process of producing or using special nuclear material (SNM).

Examples include other transuranic elements (i.e., those with an atomic weight greater than uranium), such as americium, berkelium, californium, neptunium, and curium.

Further examples of other nuclear material are the hydrogen isotopes of tritium and deuterium; any deuterium compound, including heavy water; lithium-6; and nuclear-grade graphite.

Outcrop - A segment of bedrock exposed above the ground surface.

Outfall - The place where an effluent is discharged into receiving waters.

Outgrants - Leases, licenses, easements, permits, use agreements, joint-use agreements, and other agreements which change the government's interest in or control of real property by conferring property rights to another government agency, non-federal entity (e.g., state or local government), or a private party.

Overstory - The uppermost layer of vegetation in a forest or woodland, consisting of the canopies of trees.

Pediment - A planar, erosional, sloping rock surface forming a ramp up to the front of a mountain range in an arid region, which is carved in bedrock with a thin veneer of fluvial gravel.

Permeability - The property or capacity of a porous rock, sediment, or soil for transmitting a fluid without impairment of the structure.

Person-rem - A unit of collective radiation dose applied to populations or groups of individuals (see collective dose); that is, a unit for expressing the dose when summed across all persons in a specified population or group. One person-rem equals 0.01 person-sieverts (Sv).

Personnel - SNL/NM employees and Sandia-directed contractors (contract personnel who work under a contract for which SNL/NM retains accountability for the outcome of the work and whose work is routinely directed by SNL/NM employees).

GLOSSARY (Continued)

Peroxidizable waste - Chemical waste that forms shock-sensitive peroxide crystals.

Physical hazard - A chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive), or water-reactive.

Piedmont - A sloped surface lying or formed at the base of a mountain, which connects the mountain to the level of adjacent plains.

Playa - The flat-floored bottom of an undrained desert basin that at times becomes a shallow lake.

Playa lake - Broad, shallow sheets of water that quickly gather and almost as quickly evaporate.

Point source - A source of emission having a single exhaust point; that is, a stack or a vent.

Pollutants - Term used to refer to air emissions, wastewater discharges, hazardous waste, mixed waste, transuranic (TRU) waste, low-level waste (LLW), and solid waste.

Prehistoric - The period of time before the advent of written history in a geographic region. The prehistoric period in the various regions of North America is the time before the arrival of Europeans in each of these regions.

Proposed species - A species for which a proposed rule for listing on the Endangered Species List has been published in the *Federal Register*.

Public lands - Historically, lands administered by the Bureau of Land Management (BLM) through the U.S. Department of Interior. In describing land use categories, however, other surface ownership classifications are included as "public land." These include U.S. Forest Service (USFS) land, National Park Service land, U.S. Fish and Wildlife Service (USFWS) land, state land, and city-owned parks, recreation, and open space areas.

GLOSSARY (Continued)

Pyrophoric - Capable of igniting spontaneously when exposed to air, such as certain finely divided metals.

Quantity distance (QD) safety zones - Explosives testing safety zones determined by the types of explosives or testing involved, the quantities of explosives used in tests, and the land uses or types of facilities adjacent to the testing area. Three types of QD safety zones include buffer zones, special siting zones, and major safety zones.

Radioactive half-life - Amount of time required for a given isotope to decay to one half of its original mass.

Radioactive material - For the purpose of onsite transfers, radioactive material can be defined as any material, equipment, or system component determined to be contaminated or suspected of being contaminated. Radioactive material also includes activated material, sealed and unsealed sources, and material that emits ionizing radiation. Any substance, component, or material that satisfies this definition would be transferred as a radioactive material. For the purpose of offsite shipments and receipts, the U.S. Department of Transportation (DOT) has established a definition of radioactive material in 49 CFR 173.403. According to DOT's definition, a radioactive material is "any material having a specific activity greater than 0.002 microcuries per gram." Any material that satisfies this definition would be shipped by SNL/NM as a radioactive material or DOT Hazard Class 7, as defined in 49 CFR 173.403. Any material shipped to SNL/NM from an offsite location as a radioactive shipment under DOT definitions and regulations would be received by SNL/NM as a radioactive material receipt.

Radioactive waste - In general, waste that is managed for its radioactive content. Waste material that contains source, special nuclear, or byproduct material is subject to regulation as radioactive waste under the *Atomic Energy Act*. Also, waste material that contains accelerator-produced radioactive material or a high concentration of naturally occurring radioactive material may be considered radioactive waste.

Raptor - A predatory bird that seizes its prey with its feet, which are typically modified for this purpose with hooked claws (talons). These include eagles, hawks, falcons, and owls.

RCRA-nonregulated waste - Chemical waste that is **not** identified as hazardous by 40 CFR 261 and may be disposed of in a Subtitle D facility as solid waste.

GLOSSARY (Continued)

Receival - Movement of a specific quantity of hazardous material transported from one location to another by means of a particular conveyance.

Recharge - Water reaching the water table or aquifer.

Region of influence - Wake effects zone that results when the minimum distance between a stack and a building is less than or equal to five times the lesser of the height or projected width of the building.

Relief - A maximum regional difference in elevation.

Residential and commercial land use - A land use category that includes a mixture of residential and commercial and/or retail use. Residential and commercial land use areas are interspersed with institutional land uses, such as schools and hospitals.

Rinsate - Liquid produced when flushing equipment of material with a fluid, usually water, for purposes of cleaning or recovering a contaminant for analysis.

Riparian - Pertaining to, situated in, or adapted to living on the banks of rivers and streams.

Risk factor - Health effects from radiation exposure may be calculated from doses by multiplying the dose by an appropriate conversion factor, known as a risk factor. This risk factor has the dimensions of health effect per unit dose per person and may include a time factor.

Roentgen equivalent man (rem) - A measure of an absorbed dose from any ionizing radiation that will produce a biological effect approximately equal to that produced by one roentgen of x-ray or gamma radiation.

Ruderal - Adapted to living in disturbed habitats; early successional; often regarded as "weedy."

Runoff - That portion of precipitation that flows in surface streams or arroyos.

Runoff coefficient - The fraction of precipitation that does not infiltrate or evaporate.

GLOSSARY (Continued)

Sacred site - A place or location associated with the religious beliefs or practices of Native Americans or other ethnic groups. In addition to churches and other formal religious sites, these may include natural places or locations used for religious purposes or considered to be important in religious beliefs.

Sand - A rock or mineral particle having a diameter from 0.05 to 2 millimeters.

Sandia Explosives Safety Committee (SESC) - The SNL/NM standing environment, safety, and health (ES&H) committee that oversees the Explosives Safety Program and all subcommittees on explosives; provides guidance to line organizations; and reviews safety training, safety appraisals, new explosives, storage, marking, labeling, and tracking.

Savannah - A vegetation formation typified by a grassland understory with an open overstory of widely spaced trees.

Scenic attractiveness - The scenic importance of a landscape based on human perceptions of the intrinsic beauty of landform, rockform, waterform, and vegetative pattern that reflects varying visual perception attributes of variety, unity, vividness, intactness, coherence, mystery, uniqueness, harmony, balance, and pattern. It is classified as: A - Distinctive, B - Typical, and C - Indistinctive.

Scenic class - A system or classification describing the importance or value of a particular landscape or portion of that landscape.

Scenic integrity - State of naturalness, or conversely, the state of disturbance created by human activities or alteration. Integrity is stated in degrees of deviation from the existing landscape character.

Scenic quality - The essential attributes of landscape that when viewed by people, elicit psychological and physiological benefits to individuals and, therefore, to society in general.

Scrubland - A vegetation formation typified by a dominance of shrubs with little or no tree overstory.

GLOSSARY (Continued)

Sediment - Solid fragments that originate from the weathering of rocks and are transported by, suspended in, or deposited by, air, water, or ice.

Sedimentary rock - A rock formed by the accumulation and cementation of mineral grains transported by wind, water, or ice to the site of deposition, or chemically precipitated at the depositional site.

Sensitive species - Species that are in the process of being listed as threatened or endangered, or those that received special designation by one or more government agencies, because they are either known to be declining or considered vulnerable to impacts due to such factors as rarity and limited distribution.

Sensitizer - A chemical that causes a substantial proportion of exposed people or animals to develop an allergic reaction in normal tissue after repeated exposure to the chemical.

Sharps waste - Any device having acute rigid corners, edges or protuberances capable of cutting or piercing, including, but not limited to: (1) hypodermic needles, syringes, blades, and needles with attached tubing; and (2) broken glass items such as pipettes and blood vials contaminated with medical waste.

Shipment - The movement of a specific quantity of hazardous material transported from one location to another by means of a particular conveyance.

$\sigma\theta$ - Sigma theta is the standard deviation of the horizontal wind direction.

Silt - A rock or mineral particle having a diameter from 0.002 to 0.05 millimeters.

Site - The "...location of a significant event, a prehistoric or historic occupation or activity, or a building or structure, whether standing, ruined, or vanished, where the location itself maintains historical or archaeological value regardless of the value of any existing structure" (36 CFR 60, *National Register of Historic Places*, Section 3[1]).

GLOSSARY (Continued)

Site area emergency - Class of operational emergency that must be declared when events are in progress or have occurred and involve actual or potential major reductions in the safety of the shipment. Any release of hazardous material (radiological or nonradiological) is expected to exceed appropriate protective action guide (PAG) or emergency response planning guide (ERPG) exposure levels in the immediate vicinity of the accident or incident but is not expected to exceed the appropriate PAGs or ERPGs in a general public area. See also "operational emergency."

Snag - A standing dead tree.

Soil - A natural substance consisting of layers or horizons of mineral and/or organic constituents with variable thicknesses, which differ from the parent material (the unconsolidated material from which soil develops).

Soil horizon - A layer of soil that is distinguishable from adjacent layers by characteristic physical properties such as structure, color, or texture.

- Solid waste** - 1. In general, solid waste is nonliquid, nonsoluble discarded material ranging from municipal garbage to industrial waste that contains complex and sometimes hazardous substances. Solid waste includes sewage sludge, agricultural refuse, demolition waste, and mining residues.
2. For purposes of regulation under the *Resource Conservation and Recover Act*, solid waste is any garbage; refuse; sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility; and other discarded material. Solid waste includes solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities. Solid waste does not include solid or dissolved material in domestic sewage or irrigation return flows or industrial discharges which are point sources subject to permits under Section 402 of the *Clean Water Act*. Finally, solid waste does not include source, special nuclear, or byproduct material as defined by the *Atomic Energy Act*. A more detailed regulatory definition of solid waste can be found in 40 CFR 261.2. (See "hazardous waste.")

GLOSSARY (Continued)

Sonic boom - A noise caused by an atmospheric shock wave that emanates from an aircraft or other object traveling at or above the speed of sound, which is approximately 1,100 feet per second (333 meters per second) or 738 miles per hour.

Source material - In general, material from which special nuclear material can be derived. Under the *Atomic Energy Act* and Nuclear Regulatory Commission regulations, "source material" means uranium and thorium in any physical or chemical form, as well as ores which contain one-twentieth of one percent (0.05%) or more by weight of uranium or thorium. (See "special nuclear material.")

Special nuclear material (SNM) - A category of material subject to regulation under the *Atomic Energy Act*, consisting primarily of fissile materials. It is defined to mean plutonium, uranium-233, uranium enriched in the isotopes uranium-233 or -235, and any other material that the Nuclear Regulatory Commission determines to be special nuclear material, but it does not include source material.

Special siting zone - A zone where siting considerations must be given to existing facilities by neighboring facilities to prevent conflict with operations. Special siting zones are not a hazard to personnel, but may affect sensitive electrical equipment.

Species of concern - An unofficial designation of the U.S. Fish and Wildlife Service (USFWS) for species for which current evidence indicates that listing the species as threatened or endangered may be warranted, but insufficient data currently exists to conclusively support such listing.

Specific activity of a radioactive substance - Activity of a radionuclide per unit mass of that nuclide. Activity is usually measured in curies, a unit named for Marie and Pierre Curie, who separated and characterized radium in 1898. The curie is defined as that amount of radioactivity that has the same disintegration rate as one gram of radium-226, or 3.7×10^{10} disintegrations per second. The specific activity of any radioactive material is considered to be uniformly distributed throughout its mass.

Spp. - Term used as the specific epithet with a genus name to designate multiple species of that genus.

GLOSSARY (Continued)

State historic preservation officer - "...The official appointed or designated pursuant to Section 101(b)(1) of the [National Historic Preservation] Act to administer the state historic preservation program" (36 CFR 800, *Protection of Historic and Cultural Properties*, Section 2[n]).

Strata - A series of single beds or layers of rock, typically sedimentary, regardless of thickness.

Stratigraphy - That branch of geology which deals with the formation, composition, sequence, and correlation of stratified rocks.

Strike - The course or bearing of the outcrop of an inclined bed or structure on a level surface.

Succession - The natural process by which an ecological community changes with time toward a self-sustaining "climax community," typically following disturbance.

Survey report - A type of cultural resource report that documents the methods, findings, and any other important information about an archaeological survey.

Thermal - A rising column of warm air, caused by the uneven heating of the earth or sea by the sun.

Threatened species – Any plants or animals that are likely to become endangered species within the foreseeable future throughout all or a significant portion of their ranges and which have been listed as threatened by the U.S. Fish and Wildlife Service or the National Marine Fisheries Service following the procedures set out in the *Endangered Species Act* and its implementing regulations (50 CFR 424). (See "endangered species.") The lists of threatened species can be found in 50 CFR 17.11 (wildlife), 17.12 (plants), and 227.4 (marine organisms).

Threshold limit value-time-weighted average - Time-weighted average concentration for a normal 8-hour workday and a 40-hour work week to which nearly all workers may repeatedly be exposed, day after day, without adverse effect.

GLOSSARY (Continued)

TNT equivalent - A measure of the energy that is released in the detonation of an explosion, expressed in terms of the weight of trinitrotoluene (TNT) that would produce the same amount of energy when exploded.

Toxic pollutant - Material that may cause death, disease, or birth defects in organisms that ingest or absorb them.

Traditional cultural properties - Places or objects that have religious, sacred, or cultural value for a particular cultural group, especially an Indian tribe or other Native Americans.

Transfer - The movement of a specific quantity of hazardous material transported from one location to another by means of a particular conveyance.

Transuranic (TRU) waste – Radioactive waste that is not classified as high-level radioactive waste and that contains more than 100 nanocuries (3,700 becquerels) per gram of alpha-emitting transuranic isotopes with half-lives greater than 20 years.

Trend - The direction or bearing of a geological feature, such as a fault, expressed on the land surface.

Trick tank - A device used to provide a semi-permanent or permanent source of drinking water to wildlife, typically consisting of a small, open reservoir fed by a larger reservoir through a low-flow (trickle) or float valve. Also called wildlife guzzlers or (traditionally) gallinaceous guzzlers, due to their early use to improve habitat for gallinaceous game birds, such as quail and partridges.

Turbulence - Frictionally-induced eddies.

Typical landscape - Refers to prevalent, usual, or widespread landscapes within a landscape province. It also refers to landscapes with ordinary and routine scenic attractiveness.

Understory - The layer of vegetation that is below the canopy in a forest or woodland, typically consisting of herbaceous plants and shrubs.

GLOSSARY (Continued)

Undertaking - "...Any project, activity, or program that can result in changes in the character or use of historic properties..." and is carried out "...under the direct or indirect jurisdiction of a federal agency or [is] licensed or assisted by a federal agency" (36 CFR 800, *Protection of Historic and Cultural Properties*, Section 2[o]).

Vascular plant - Plants with a vascular system, including ferns, horsetails, gymnosperms (cone-bearing plants), and flowering plants, and excluding "lower plants," such as algae, fungi, lichens, and mosses.

Very low scenic integrity - A level of scenic integrity meaning human activities of vegetative and landform alterations may dominate the original, natural landscape character but should appear as natural occurrences when viewed from background distances.

Visual resource - Aspect of an area or project that pertains to its appearance and the manner in which it is viewed by people. The visual resources of an area are determined through application of an accepted methodology which analyzes the appearance of the landscape and how it is viewed.

Waste Characterization Oversight Committee (WCOC) - Committee that develops requirements to complete the waste characterization documentation. The WCOC comprises members who possess expertise in the following special areas of waste characterization:

- RCRA experts
- Potential disposal site contacts
- Radioactive waste experts
- Analytical experts

Waters of the state - All interstate and intrastate waters including natural ponds and lakes, playa lakes, reservoirs, perennial streams and their tributaries, intermittent streams, sloughs, prairie potholes, and wetlands (20 NMAC 6.1).

Watershed area - The area upstream of a given point on a stream channel; from this area, all flows will pass by that given point, unless they infiltrate or evaporate.

Weathering - The set of all processes that decay and break up bedrock by a combination of physical fracturing and/or chemical decomposition.

GLOSSARY (Continued)

Wetlands – Those areas that are inundated by surface or groundwater with a frequency sufficient to support, and under normal circumstances do or would support, a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas (e.g., sloughs, potholes, wet meadows, river overflow areas, mudflats, natural ponds).

Jurisdictional wetlands are those wetlands protected by the *Clean Water Act*. They must have a minimum of one positive wetland indicator from each parameter (i.e., vegetation, soil, and hydrology). The U.S. Army Corps of Engineers requires a permit to fill or dredge jurisdictional wetlands.

Wildlife - Free-living vertebrates (fish, amphibians, reptiles, birds, and mammals) excluding man and domesticated animals.

Windrose - A diagram that shows for a particular place the frequency and intensity of wind from different directions.

Withdrawn Area - The land area comprising approximately 20,500 acres along the eastern boundary of Kirtland Air Force Base (KAFB), identified in separate memoranda between the U.S. Department of Agriculture (USDA), DOE, and the Department of Defense (DoD), that is used for various military and research programs. These lands are precluded from public use.

Woodland - A vegetation formation typified by a dominance of trees forming an open canopy.

FACILITIES CROSS-REFERENCE LIST

This table provides a cross-reference between the facility terms used in this document and the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document (F/SID)*. The table is not all-inclusive; only terms that vary between documents are listed.

EID Facility Term	F/SID Facility Term
Annular Core Research Reactor (ACRR) Facility	Annular Core Research Reactor (DP) and Annular Core Research Reactor (Moly-99)
Components Development Laboratory	Repetitive High Energy Pulsed Power Unit I (RHEPP I)
Electron Beam Fusion Facility	Z Machine
Hyper Velocity Gun Facility, the STAR Facility	Shock Thermodynamics Applied Research Laboratory
Isotope Production Facility	Annular Core Research Reactor (Moly-99)
Particle Beam Fusion Accelerator (PBFA) II	Z Machine
Particle Beam Fusion Lab	
Radiation Laboratory	Microelectronics Development Laboratory
Repetitive High-Energy Pulsed Power (RHEPP) I	Repetitive High Energy Pulsed Power Unit I
Repetitive High-Energy Pulsed Power (RHEPP) II	Repetitive High Energy Pulsed Power Unit II
Robotics Vehicle Range	Autonomous Land Vehicle Test Area (Robotic Vehicle Range)
Saturn Accelerator	Saturn
shock tube explosives testing facilities	Explosive Test Facility
shock tubes	
6000 Igloo Area	Explosives Storage Igloos (Bldgs 6001-6010)
6000 Igloo Complex	
6 MeV Van de Graff Generator	6 MeV Tandem Van de Graff Generator
TANDEM Accelerator	
Sled Track Facility	Sled Track Facility
10,000-Foot Sled Track	
2,000-Foot Sled Track	
Sol se Mete Aerial Cable Facility	Aerial Cable Facility
Solar Tower	National Solar Thermal Test Facility
Terminal Ballistics Facility	Terminal Ballistics Facility
Terminal Ballistics Complex	
TESLA (formerly MITE) Accelerator Facility	TESLA
TESLA Opening Switch Facility Accelerator	

CHAPTER 1 - GEOLOGY

Contents

EXECUTIVE SUMMARY	1-3
1.0 INTRODUCTION.....	1-5
1.1 Purpose.....	1-5
1.2 Scope.....	1-5
2.0 STRUCTURAL GEOLOGY	1-6
2.1 Regional Tectonic Setting	1-6
2.2 Local Faults.....	1-9
2.2.1 Sandia Fault	1-9
2.2.2 Hubbell Springs Fault	1-11
2.2.3 Tijeras Fault	1-11
2.2.4 Coyote Fault.....	1-11
3.0 SEISMOLOGY	1-12
4.0 STRATIGRAPHY	1-15
4.1 Stratigraphy in the Kirtland Federal Complex (KFC).....	1-15
4.2 Precambrian Basement Complex.....	1-17
4.3 Upper Paleozoic Strata.....	1-17
4.4 Paleogene Strata	1-18
4.5 Neogene/Quaternary Santa Fe Group Strata	1-21
4.6 Quaternary Post-Santa Fe Group Sediments	1-21
5.0 GEOMORPHOLOGY	1-22
5.1 Geomorphic Provinces and Subprovinces in the Kirtland Federal Complex (KFC) Region	1-22
5.2 Llano de Manzano Geomorphic Province	1-24
5.3 Llano de Sandia Geomorphic Province	1-24
5.4 Rio Grande Geomorphic Province.....	1-25
5.5 Rift-Margin Ranges Geomorphic Province	1-25
6.0 PALEONTOLOGY.....	1-25
7.0 ENGINEERING GEOLOGY	1-26
8.0 SOILS	1-26
8.1 Overview and Geomorphic Relations	1-26
8.2 Soil Series	1-28
9.0 REFERENCES.....	1-35
9.1 Regulations, Orders, and Laws	1-35
9.2 General References	1-35

LIST OF TABLES

1-1. Earthquake Magnitude Classes as Measured on the Richter Scale	1-12
1-2. Moderate Magnitude Earthquakes Reported in New Mexico	1-14
1-3. General Soils Classification for the Kirtland Federal Complex.....	1-28

LIST OF FIGURES

1-1. Regional Tectonic Setting of the Albuquerque Basin	1-7
1-2. Diagrammatic Geologic Cross-Sections of the Central Albuquerque Basin.....	1-8
1-3. Major Faults on the Kirtland Federal Complex	1-10
1-4. New Mexico Earthquakes of Richter Magnitude 3.5 or Larger.....	1-13
1-5. Generalized Stratigraphic Column and Time Scale	1-16
1-6. Generalized Surface Geology of Surveyed Areas of the Kirtland Federal Complex	1-19
1-7. Geomorphic Subprovinces	1-23
1-8. Major Soil Types at the Kirtland Federal Complex.....	1-31

EXECUTIVE SUMMARY

This chapter provides a summary of geology in the region of the Kirtland Federal Complex (KFC), including discussions on the following:

- Structural geology
- Seismology
- Stratigraphy
- Geomorphology
- Soils

The geologic setting provides an overall framework for a better understanding of the KFC hydrogeology (see Chapter 3, "Hydrology and Water Resources," for more information). The discussion of the expected magnitude of earthquakes that may occur in the region may be useful in analysis of beyond-design-basis phenomena. (See the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* [Sandia National Laboratories, 1999], for information on existing SNL/NM safety and hazard analysis documents, which contain analyses of accident scenarios with an earthquake as an initiating event.)

1.0 INTRODUCTION

1.1 Purpose

This chapter provides an overview of the geology of the Kirtland Federal Complex (KFC), including SNL/NM. This information may be of use in considering the likelihood and consequences of geologic phenomena such as earthquakes. Geological features, such as type of rock and presence of faults, are also important in affecting the direction and rate of flow of groundwater and the location of surface seeps and springs (for a more detailed discussion of water resources, see Chapter 3, "Hydrology and Water Resources").

1.2 Scope

This chapter presents a general discussion of geology at the Kirtland Federal Complex (KFC). For a detailed discussion of geology on the KFC, see the annual reports produced for the Sitewide Characterization Project at SNL/NM (Sandia National Laboratories, 1993, 1994, 1995, 1996). However, the *Conceptual Geological Model of the Sandia National Laboratories and Kirtland Air Force Base* (GRAM Incorporated and William Lettis & Associates Incorporated, 1995) is recommended for obtaining specific geological information.

This chapter discusses the following:

- Structural setting, including faults
- Earthquakes and seismology
- Stratigraphy
- Geomorphology
- Paleontology
- Engineering geology
- Soils

These topics are generally discussed for the KFC or the Albuquerque area with some information provided on a regional or state-wide basis, as appropriate. The term "Kirtland Federal Complex (KFC)" is used throughout this chapter to denote the physical complex that encompasses the Kirtland Air Force Base (KAFB), lands owned by DOE and used by both DOE and its affiliates (including SNL/NM), and portions of the Cibola National Forest that have been withdrawn from public use. (See Chapter 2, "Land Use," for a more detailed discussion of land use in and near the KFC.)

2.0 STRUCTURAL GEOLOGY

2.1 Regional Tectonic Setting

The Kirtland Federal Complex (KFC), including SNL/NM, is situated in the eastern portion of the Albuquerque Basin (see Figure 1-1). This basin is about 145 kilometers (90 miles) long and up to 48 kilometers (30 miles) wide. It is located along the Rio Grande Rift zone that lies within the northern portion of the Eastern Mexican Highlands section of the Basin and Range physiographic province (Fenneman, 1931). The Albuquerque Basin is bound by the Sandia Mountains and the Manzano Uplift to the east, the Lucero Uplift and Puerco Plateau to the west, and the Nacimiento Mountains and the Jemez Uplift to the north. The southern boundary is defined by the Socorro Basin. The basin is widest in the Albuquerque area and constricted to the south and north.

The Albuquerque Basin is bordered by major faults and bisected by the northeast-trending Tijeras Fault zone, forming two half-grabens (see Figure 1-2). The Tijeras Fault acts as a zone of strain accommodation between differential extension rates of the northern and southern subbasins (Russell and Snelson, 1990, 175-207; Lozinsky, Hawley, and Love, 1991, 157-162). The Albuquerque Basin has undergone several kilometers of east-west extension over the past 30 to 40 million years. Large-scale faulting, deepening of the basin, and uplift and tilting of the mountain areas occurred approximately 15 to 5.3 million years ago. Since then, basin deposits have been laid down in a complex sequence of sedimentary and volcanic rocks. Faults within and bordering the basin exhibit evidence of late Pleistocene and possibly Holocene displacement. Overall structural relief between the Precambrian strata within the inner trough to the top of the eastern margin uplift is about 10 kilometers (6 miles).

Figure 1-1. Regional Tectonic Setting of the Albuquerque Basin

Figure 1-2. Diagrammatic Geologic Cross-Sections of the Central Albuquerque Basin

2.2 Local Faults

The Kirtland Federal Complex (KFC) is located in a structurally complex area. A number of major regional faults intersect within the area, resulting in a diverse pattern of fault trends and displacements (Sandia National Laboratories, 1996). There is no record of movement on these faults in historic times. In fact, there is no evidence of movement on these faults during the last 10,000 years. The following subsections provide a detailed discussion of these faults.

Several major rift-bounding faults are present on and near the KFC (see Figure 1-3). These include northeast-trending faults along the base of the Manzanita and Sandia Mountains, such as the Sandia and Coyote Faults, and faults located west of the range front, such as the Hubbell Springs Fault. Generally, these faults are west-dipping normal faults that exhibit down-to-the-west displacement. In addition, the northeast-trending Tijeras Fault zone traverses the KFC and intersects or merges with the Sandia and Hubbell Springs Faults in the south-central part of the KFC. The following sections briefly describe the major faults on the KFC. A more detailed discussion of these and other faults appear in the following:

- *Sandia National Laboratories Site-Wide Hydrogeologic Characterization Project - Calendar Year 1995 Annual Report, Environmental Restoration Project* (Sandia National Laboratories, 1996)
- *Conceptual Geological Model of the Sandia National Laboratories and Kirtland Air Force Base* (GRAM Incorporated and William Lettis & Associates Incorporated, 1995)

2.2.1 Sandia Fault

The Sandia Fault is a north- to northeast-trending, west-dipping normal fault along the eastern margin of the Albuquerque Basin (Kelley and Northrop, 1975). The location and lateral continuity of the fault are poorly constrained. Field investigations in 1995 constrained the surface trace location of the Sandia Fault along the west side of the Four Hills (the Manzano Storage Bunker Area) (Sandia National Laboratories, 1996). The southern extent of the fault is difficult to ascertain because it intersects or merges with the Tijeras Fault zone and the Hubbell Springs Fault. An exposure in the Tijeras Arroyo shows Precambrian granitic rocks faulted against upper Santa Fe Group sediments (Lambert, Hawley, and Wells, 1982, 97-99). Kelley (1977) suggests that there has been late Quaternary displacement on the fault. Geophysical investigations along the west side of the Four Hills (Manzano Storage Bunker Area) support an interpretation of significant vertical offset on the Sandia Fault, and documented a western fault strand west of the widely recognized and mapped Sandia Fault trace (Sandia National Laboratories, 1996).

2.2.2 Hubbell Springs Fault

The Hubbell Springs Fault is a series of north-trending, west-dipping normal fault strands along the western margin of the Hubbell Bench, a feature which extends for a distance of 36 miles to the south from the southern part of the Kirtland Federal Complex (KFC), southeast of Tech Area III (see Figure 1-3). The fault intersects or merges with the Tijeras and Sandia Faults in the south-central part of the KFC. The Hubbell Springs Fault displays prominent geomorphic evidence of late Quaternary displacement and is a major potentially active fault along the eastern side of the Albuquerque Basin. Although there is ample evidence for fault movements during the Quaternary (1.6 to 0.01 million years ago), surficial mapping shows no evidence for displacement of Holocene deposits (deposits laid down in the last 10,000 years) (Sandia National Laboratories, 1996). The northern half of the Hubbell Springs Fault is known for its numerous fresh-water springs (for locations of springs on and near the KFC, see Figure 3-2 in Chapter 3, "Hydrology and Water Resources").

2.2.3 Tijeras Fault

The northeast-trending Tijeras Fault extends from the Kirtland Federal Complex (KFC) to the north-northeast through Tijeras Canyon, where it separates the Sandia and Manzanita Mountains, and to the south-southwest across the Rio Grande Rift, where it separates the northern and southern subbasins of the Albuquerque Basin (see Figures 1-2 and 1-3). The Tijeras Fault consists of a narrow region or zone containing several subparallel faults with near-vertical dips that exhibit evidence of normal and left-lateral displacement (Lisenbee, Woodward, and Connolly, 1979, 89-99; Maynard, Woodward, and Giles, 1991, 57-69). There is geologic evidence of multiple episodes of movement along the fault during the Precambrian, Paleozoic, and Quaternary, with each episode having a different sense of displacement (Lisenbee, Woodward, and Connolly, 1979, 89-99). Displacement of the Quaternary colluvium in Tijeras Canyon (Lisenbee, Woodward, and Connolly, 1979, 89-99) shows that the fault is a potentially active structure. However, recent geophysical surveys of the Tijeras Fault zone in the Arroyo del Coyote area do not show evidence of offset in the alluvium overlying bedrock in that area (Sandia National Laboratories, 1996).

2.2.4 Coyote Fault

The Coyote Fault is a north- to northwest-striking fault located along the base of the Manzanita Mountains in the southern part of the Kirtland Federal Complex (KFC) (see Figure 1-3). This fault forms the eastern margin of the Hubbell Bench and exhibits down-to-the-west or southwestern displacement. There is no data addressing possible late Quaternary activity on this fault (Sandia National Laboratories, 1996).

3.0 SEISMOLOGY

The City of Albuquerque is located in Seismic Risk Zone 2B (International Conference of Building Officials, 1994), which, by definition, is a region that can be expected to experience moderate earthquake effects corresponding to Intensity VII of the Modified Mercalli Intensity Scale of 1931. The Modified Mercalli Intensity Scale measures the amount of ground shaking and other effects observed during an earthquake. Intensity on the Modified-Mercalli Intensity Scale is reported as a number from I to XII. Intensity VII is defined as follows: "Everybody runs outdoors, damage to buildings varies depending on quality of construction; noticed by drivers of automobiles."

In 1935, the Richter method was developed, which measures earthquake magnitude on a scale in terms of energy released. The Richter method is now preferred to the more subjective Modified Mercalli Intensity Scale in measuring earthquakes. Table 1-1 summarizes earthquake magnitude classes according to the Richter Scale (U.S. Geological Survey, 1997).

Table 1-1. Earthquake Magnitude Classes as Measured on the Richter Scale

Richter Magnitude	Earthquake Magnitude Class
> 8	Great
7 to 7.9	Major
6 to 6.9	Strong
5 to 5.9	Moderate
4 to 4.9	Light
3 to 3.9	Minor

Tables of the locations and magnitudes of earthquakes recorded in New Mexico are available in the *Sandia National Laboratories/New Mexico Environmental Baseline Update-Revision 1.0* (IT Corporation, 1996) and in the 1977 environmental impact assessment for SNL/NM (U.S. Energy Research and Development Administration, 1977). Earthquake records are also available through the U.S. Geological Survey, National Earthquake Information Center (U.S. Geological Survey, National Earthquake Information Center, 1997). The records for New Mexico show fairly high frequency of minor and light earthquakes (U.S. Geological Survey, National Earthquake Information Center, 1997).

Figure 1-4 presents the epicenter location of earthquakes with a magnitude of 3.5 or larger reported in New Mexico from 1868 through 1992 (IT Corporation and Consensus Planning Incorporated/Zephyr Design, 1993). Table 1-2 lists earthquakes of moderate magnitude (all approximately 5.0 on the Richter scale) that were instrumentally recorded in New Mexico from 1966 through 1995. There have not been any earthquakes of greater than moderate

magnitude reported in New Mexico in this period (U.S. Geological Survey, National Earthquake Information Center, 1997).

Figure 1-4. New Mexico Earthquakes of Richter Magnitude 3.5 or Larger

Table 1-2. Moderate Magnitude Earthquakes Reported in New Mexico

Date	North Latitude of Epicenter	West Longitude of Epicenter	Nearest City
01/23/66	36.980	107.020	Dulce
12/10/67	36.680	107.210	Dulce
01/05/76	35.844	108.341	Gallup
01/02/92	32.335	103.101	Eunice*
* East of Carlsbad, near the Texas border.			

Analysis of 1,000 earthquakes revealed that most seismic activity in New Mexico occurs in three geographic areas: (1) the Socorro and Albuquerque areas of the Rio Grande Rift, (2) the Mount Taylor area, and (3) the Estancia Basin (Jaksha and Sanford, 1986).

This analysis indicates that moderate damage is a reasonable expectation, if an earthquake occurs, but earthquakes are rare. The largest shock predicted in New Mexico in a 100-year period would have a magnitude 6.0 on the Richter Scale (Sanford et al., 1972).

The earthquakes that have affected New Mexico the most in the past century are those of 1906 in Socorro, 1966 in Dulce, and 1971 in Albuquerque. A series of shocks occurred at Socorro almost daily from July 2, 1906, until well into 1907. On July 12, 1906, some adobe walls cracked and others fell down. A wave-like ground motion was seen, and there were fissures in the ground. A more severe shock on July 16, 1906, was felt at Raton, New Mexico, and in Douglas, Arizona, each over 320 kilometers (200 miles) from the origin, and a train was nearly derailed 16 kilometers (10 miles) west of Socorro. A November 15, 1906, shock at Socorro was felt over a region of about 260,000 square kilometers (100,000 square miles). The Socorro region shows frequent small earthquakes. In late 1989 and early 1990, the area near Socorro and Belen experienced several earthquakes of magnitudes less than 4.6 on the Richter Scale.

In January 1966, an earthquake measuring 5.1 on the Richter Scale (U.S. Geological Survey, National Earthquake Information Center, 1997), and smaller aftershocks, were centered near Dulce, New Mexico, near the Colorado border. Nearly every house in Dulce was affected. Porches were displaced from houses, walls and foundations cracked, water pipes were broken, fireplaces were cracked in half, a church roof partially collapsed, and people in houses were knocked down. Between January 23rd and 28th, 119 aftershocks were recorded at the Coast and Geodetic Survey observatory 225 kilometers (140 miles) to the south in Albuquerque (Lander, 1966).

An earthquake of magnitude 4.7 on the Richter Scale occurred in the City of Albuquerque on January 4, 1971 (U.S. Geological Survey, National Earthquake Information Center, 1997). The Bernalillo County jail, University of New Mexico, and West Mesa High School reported cracked walls, window breakage, and damage from fallen items (Lander, 1971). The records indicate

no appreciable or serious damage to SNL/NM buildings. Although cracks were observed in some buildings, there was no evidence that these cracks did not predate the earthquake. The cracks were noticed only after the event, when a search for possible damage was made (U.S. Energy Research and Development Administration, 1977).

Although it was only a magnitude of 4.7 on the Richter Scale, the 1971 earthquake was the worst of the century in the Albuquerque area. The Albuquerque area experienced another earthquake, with a magnitude of 4.5 on the Richter Scale, on November 23, 1970.

Noninstrumentally located earthquakes in the vicinity of Albuquerque reported in the 1930s include 10 small earthquakes, ranging in intensity from "slight" to intensity VI (U.S. Energy Research and Development Administration, 1977).

4.0 STRATIGRAPHY

4.1 Stratigraphy in the Kirtland Federal Complex (KFC)

The Albuquerque Basin is primarily filled with poorly consolidated sediments that have eroded from the surrounding mountain areas during the uplift of the Sandia, Manzanita, and Manzano Mountains, which started about 26 million years ago (GRAM Incorporated and William Lettis & Associates Incorporated, 1995). The upper part of the Albuquerque Basin fill is comprised of a complex sequence of gravel, sand, silt, clay, and caliche deposits known as the Santa Fe Group and post-Santa Fe deposits (see Figure 1-5). Underlying these deposits are Mesozoic and Paleozoic deposits of unknown thickness, although gravity and aeromagnetic mapping indicate that these rocks extend approximately 4,600 meters (15,000 feet) below ground level in the deepest portions of the basin (U.S. Energy Research and Development Administration, 1977). These sedimentary rocks overlie the Precambrian (590 million years and older) rocks that underlie the entire basin and that are uplifted to form the caprock of the eastern mountains. The Sandia Mountains are about 1,500 meters (5,000 feet) above the basin, giving a difference in elevation between the bedrock in the basin and the mountains of approximately 6,000 meters (20,000 feet) (U.S. Energy Research and Development Administration, 1977).

ERA/SYSTEM/SERIES			UNIT/FORMATION		STRAT. COLUMN	DESCRIPTION
C E N O Z O I C	N E O G E N E	Holocene to Middle Pleistocene	Surficial Units			Cross-bedded, fine- to medium-grained eolian sand Poorly-sorted silty sandy cobble to boulder gravel Poorly-sorted silty sandy cobble to boulder gravel with relict and buried soils <i>Unconformity</i>
		Early Pleistocene to Early Miocene	Santa Fe Group	Upper Santa Fe Unit		<u>Basinal</u> : coarse- to fine-grained sandstone; common buried soils <u>Marginal</u> : pebbles, cobbles in fine-grained matrix
				Middle Santa Fe Unit		<u>Basinal</u> : medium- to fine-grained sandstone and mudstone; common buried soils <u>Marginal</u> : conglomeratic sandstone to pebbles and cobbles; common buried soils
				Lower Santa Fe Unit		<u>Basinal</u> : medium- to fine-grained sandstone, sandy mudstones <u>Marginal</u> : conglomeratic sandstone and mudstone <i>Unconformity</i>
	P A L E O G E N E	Oligocene	Unit of Isleta #2 Well			Fine- to coarse-grained sandstone; claystone, silt beds; volcanic detritus and ash-flow tuffs
		Eocene to Paleocene	Baca/ Galisteo Formations			Sandstone, variegated mudstone, and conglomerate <i>Unconformity</i>
MESOZOIC		Upper Triassic	Santa Rosa Sandstone			<i>Unconformity</i> Buff brown sandstone, petrified wood
P A L E O Z O I C	Upper Permian	San Andres Formation			Gray limestone, separated by red shale <i>Unconformity</i>	
		Glorieta Sandstone			Medium- to coarse-grained yellowish gray sandstone	
	Lower Permian	Yeso Formation			<u>Upper</u> : gypsiferous sandstone, siltstone, and limestone <u>Lower</u> : fine-grained sandstone and siltstone	
		Abo Formation			Fine- to coarse-grained sandstone and conglomerate with interbedded siltstone	
		Madera Group	Bursum Fm.		Finely laminated silty mudstone	
	Upper to Middle Pennsylvanian		Wild Cow Formation		Rhythmically bedded sequence: conglomerate, sandstone, siltstone, shale, and limestone	
			Los Moyos Formation		Gray calcarenite with chert	
	Middle Pennsylvanian	Sandia Formation			Fining-upwards clastic sequence: conglomerate to calcareous siltstone <i>Unconformity</i>	
PRECAMBRIAN			Isleta Metasediments Tijeras Greenstone Complex Coyote Canyon Sequence Sandia Granite		Phyllite; meta-arkose; metaquartzite; greenstone; metarhyolite; quartzite; microcline and biotite granite	

Figure 1-5. Generalized Stratigraphic Column and Time Scale

Discussion of stratigraphic units is limited to those exposed on the surface and/or that occur in the subsurface on and in the vicinity of the Kirtland Federal Complex (KFC) (see Figure 1-5). For this chapter, they are grouped into the following six major categories, and described from oldest to youngest:

1. Precambrian basement complex
2. Upper Paleozoic strata
3. Upper Cretaceous strata
4. Paleogene strata
5. Neogene/Quaternary Santa Fe Group strata (late Oligocene through lower Pleistocene)
6. Quaternary Post-Santa Fe Group sediments (upper Pleistocene to Recent)

Figure 1-6 provides a generalized geologic map of the KFC. For a more detailed description of the various formations and lithologies, refer to *Sandia National Laboratories Site-Wide Hydrogeologic Characterization Project - Calendar Year 1994 Annual Report* (Sandia National Laboratories, 1995).

4.2 Precambrian Basement Complex

Surface exposures of basement complex on the Kirtland Federal Complex (KFC) consist of Precambrian igneous, metasedimentary, meta-igneous, and other metamorphic rocks (see Figure 1-5). The basement bedrock is exposed in the uplifted Four Hills (Manzano Area) and Manzanita Mountains, located in the eastern part of the KFC. The west-facing mountain fronts, which are coincident with north- and northwest-trending faults, expose Precambrian granite, metarhyolite, greenstone, quartzite, and minor gneiss and schist. These same rock types underlie late Paleozoic sediments throughout the western Manzanita Mountains, and also underlie the Albuquerque Basin fill immediately west of the mountains. Precambrian rocks in the KFC display fractures, faults, and other deformation features and fabrics.

4.3 Upper Paleozoic Strata

Upper Paleozoic (320 to 248 million years old) formations within the Albuquerque Basin include interstratified carbonates and clastics of both marine and non-marine origins (see Figure 1-5). The Sandia Formation and overlying Madera Group are prominently exposed in the Sandia and Manzanita Mountains. The Sandia Formation varies laterally, but primarily consists of

sandstone, shale, limestone, conglomerate, and siltstone. The Madera Group is subdivided into the following formations (Myers, 1973, 13):

- Basal Los Moyos Formation
- Middle Wild Cow Formation
- Capping Bursum Formation

The lower two formations are present on the Kirtland Federal Complex (KFC). The Madera Group includes calcarenite, conglomerate, sandstone, siltstone, shale, and limestone (GRAM Incorporated and William Lettis & Associates Incorporated, 1995).

The Abo and Yeso Formations are difficult to differentiate on the KFC (GRAM Incorporated and William Lettis & Associates Incorporated, 1995). These formations have been identified in the subsurface from wells east of the fault complex on the KFC. These formations consist of sandstones, siltstones, and limestones. Discontinuous beds of gypsum or gypsiferous siltstone occur near the top of the Yeso Formation. The Glorieta Sandstone crops out along the eastern side of the Sandia Mountains and is encountered in monitoring wells drilled along the southern boundary of the KFC.

The San Andres Formation consists of fine-grained limestone with some interstratified sandstone. The San Andres Formation has not been identified on the surface or in the subsurface at the KFC (GRAM Incorporated and William Lettis & Associates Incorporated, 1995).

4.4 Paleogene Strata

Mesozoic strata such as the Santa Rosa Sandstone are not found at the Kirtland Federal Complex (KFC). Although no Paleogene-Age outcrops are present on the KFC, they occur as subsurface units along the southern boundary of the KFC. Knowledge of the distribution and characterization of the properties of Paleogene strata is considered important for hydrogeological modeling efforts for the south-central portion of the KFC because these strata contain laterally extensive, permeable sandstone units, and their distribution is structurally controlled by north-south bounding faults (GRAM Incorporated and William Lettis & Associates Incorporated, 1995).

4.5 Neogene/Quaternary Santa Fe Group Strata

Santa Fe Group strata comprise the principal fill of the Albuquerque Basin. The Santa Fe Group consists of complexly interstratified gravels, sands, silts, and clays. These sediments were deposited either as alluvial fans derived from the nearby mountains, as fluvial deposits transported by rivers from source areas outside the basin, or as locally thick playa-lake and eolian deposits (Kelley, 1977; Lozinsky, 1988, 298; Hawley and Haase, 1992). Buried soil horizons are common within this group. The Santa Fe Group is over 4,420 meters (14,500 feet) thick in the center of the rift, which is located near the western margin of the Kirtland Federal Complex (KFC). Hawley and Haase (1992) subdivided the group into lower, middle, and upper hydrostratigraphic units based on depositional environments and age (see Figure 1-5).

The Lower Santa Fe Unit (Hawley and Haase, 1992) is dominated by interfingering piedmont-slope alluvial fan, eolian, and fine-grained basin-floor deposits. The deposits range in age from approximately 30 to 15 million years and represent deposition in an internally drained basin.

The Middle Santa Fe Unit (Hawley and Haase, 1992) was deposited between approximately 15 and five million years ago, when tectonism was most active in the rift. Piedmont-slope sediments continued to be deposited at the margins of the Albuquerque Basin, but major fluvial systems from the north, northeast, and southwest were also transporting sediments into the basin. These fluvial systems probably terminated in playa lakes in the southern part of the basin (Lozinsky and Tedford, 1991, 35).

About five million years ago, a through-flowing ancestral Rio Grande system developed (Lozinsky, Hawley, and Love, 1991, 157-162), forming a large aggradational plain in the central basin area. The upper Santa Fe Group (Hawley and Haase, 1992) was deposited from about five to one million years ago. It is characterized by intertonguing piedmont-slope deposits (alluvial and debris-flow) and cross-stratified ancestral river basin-floor deposits (thick clean sand and pebble gravel). Fine- to medium-grained overbank sediments were deposited in areas where major river systems merged and in basin-floor and piedmont-slope transition zones.

4.6 Quaternary Post-Santa Fe Group Sediments

Post-Santa Fe Group units include alluvial fan, fluvial, eolian, playa, colluvial, and floodplain deposits (Lambert, 1968; Hawley and Haase, 1992). These sediments reflect deposition in the area between the Manzanita Mountains and the Rio Grande within the last one million years. For the past 10,000 to 15,000 years, there has been a rate of sedimentation that has exceeded the ability of the drainages to remove sediments (GRAM Incorporated and William Lettis & Associates Incorporated, 1995). See Chapter 7, "Cultural Resources," for more information.

Multiple alluvial fans are present throughout much of the Kirtland Federal Complex (KFC) and are derived from the Four Hills (Manzano Area) and Manzanita Mountain range fronts and drainages. Several fluvial terraces are inset into older alluvial fans along major drainages and interfinger with younger alluvial fans. Eolian deposits include active and stabilized dunes as well as sheets that cover and modify alluvial deposits. Colluvium is present within the steep terrain of the range block, and playa deposits are present in topographic and structural depressions in the western-most part of the KFC. Buried soils are common within these surficial deposits. These deposits have been mapped and are discussed in the following documents:

- Annual reports produced for the Sitewide Hydrogeologic Characterization Project at SNL/NM (Sandia National Laboratories, 1994, 1995, 1996)
 - *Conceptual Geological Model of the Sandia National Laboratories and Kirtland Air Force Base* (GRAM Incorporated and William Lettis & Associates Incorporated, 1995)
-

5.0 GEOMORPHOLOGY

5.1 Geomorphic Provinces and Subprovinces in the Kirtland Federal Complex (KFC) Region

The Kirtland Federal Complex (KFC) encompasses parts of the following four distinct geomorphic provinces (see Figure 1-7) (GRAM Incorporated and William Lettis & Associates Incorporated, 1995):

- Llano de Manzano
- Llano de Sandia
- Rio Grande
- Rift-Margin Ranges

Figure 1-7. Geomorphic Subprovinces

Variations in the geomorphic landforms, depositional environments, and type of bedrock distinguish each province. The Rio Grande geomorphic province encompasses the Rio Grande Valley, which contains alluvium deposited by the Rio Grande. The Llano de Sandia and Llano de Manzano geomorphic provinces are broad piedmonts between the Rio Grande Valley to the west and the Sandia and Manzanita Mountains to the east. The piedmonts are composed primarily of alluvial-fan deposits shed from the flanks of the adjacent mountains. The Sandia and Manzanita Mountains are within the Rift-Margin Ranges geomorphic province and contain alluvial deposits with intermontane drainages and colluvial deposits on interfluvial slopes. Each of the four geomorphic provinces is subdivided into several subprovinces based on the number and types of landforms, the source of surficial deposits, and types of surficial processes.

The following subsections summarize the characteristics of landforms and surficial deposits within each of these geomorphic provinces. In general, multiple, Late Quaternary geomorphic surfaces and complex, laterally discontinuous surficial deposits characterize the KFC. For a detailed discussion of geomorphology and the relationship of geomorphology to the hydrology of the KFC, see the annual reports produced for the Sitewide Hydrogeologic Characterization Project (Sandia National Laboratories, 1993, 1994, 1995, 1996).

5.2 Llano de Manzano Geomorphic Province

The Llano de Manzano geomorphic province includes the Upper Llano de Manzano and McCormick Ranch subprovinces. The Upper Llano de Manzano subprovince encompasses the broad, west-sloping piedmont flanking the western margin of the Manzanita Mountains south of and including the Arroyo del Coyote (see Figures 1-6 and 1-7). The Arroyo del Coyote, the Hells Canyon Wash, and associated piedmont tributaries moderately dissect this province. Surficial alluvial fan sediments in this subprovince are derived primarily from metamorphic and sedimentary rocks in the Manzanita Mountains. The McCormick Ranch subprovince is a flat area containing numerous closed depressions, and is dominated by eolian deposits (GRAM Incorporated and William Lettis & Associates Incorporated, 1995).

5.3 Llano de Sandia Geomorphic Province

The Llano de Sandia geomorphic province contains the Tijeras Arroyo and Eldorado subprovinces. Broad, west-sloping alluvial fan deposits formed by the ancestral Tijeras Arroyo and the modern 50-meter (165-feet) deep Tijeras Arroyo characterize the Tijeras Arroyo subprovince. Surficial deposits derived from the Tijeras Arroyo drainage contain granitic and sedimentary clasts from the Sandia Mountains and sedimentary and metamorphic clasts from the Manzanita Mountains. The Eldorado subprovince lies north of the Kirtland Federal Complex (KFC). It is a moderately dissected piedmont containing coalescent alluvial fans derived from the western escarpment of the Sandia Mountains. Surficial deposits in this subprovince contain

primarily granitic clasts from the Sandia Mountains (GRAM Incorporated and William Lettis & Associates Incorporated, 1995).

5.4 Rio Grande Geomorphic Province

The Rio Grande geomorphic province lies west of the Kirtland Federal Complex (KFC) and consists primarily of the Rio Grande Valley floor. It contains floodplain and sediments deposited by the Rio Grande. These deposits are distinct from deposits in other geomorphic provinces because they derived from the many volcanic, igneous, metamorphic, and sedimentary rock sources in the headwaters of the Rio Grande in northern New Mexico and southern Colorado (GRAM Incorporated and William Lettis & Associates Incorporated, 1995).

5.5 Rift-Margin Ranges Geomorphic Province

The Rift-Margin Ranges geomorphic province includes the Manzano Area (Four Hills), Manzanita Mountains, and Sandia Mountains subprovinces. Substantial topographic relief and narrow valleys characterize this subprovince. The Manzanita Mountains subprovince includes the headwaters of Arroyo del Coyote and smaller ephemeral drainages, and contains surficial deposits derived from the metamorphic and sedimentary rocks in the Manzanita Mountains. The Sandia Mountains subprovince lies to the northeast of the Kirtland Federal Complex (KFC). The Manzano Area (Four Hills) subprovince includes a series of four northeast-trending granitic hills surrounded by a moderately dissected piedmont. Surficial deposits within the Manzano Area (Four Hills) subprovince are derived from granitic rocks within the area.

6.0 PALEONTOLOGY

Few fossils have been discovered in the vicinity of SNL/NM. Lambert (1968) describes fossil vertebrate remains approximately 2.4 kilometers (1.5 miles) west of the Kirtland Air Force Base (KAFB) western boundary. Vertebrate fossils were also collected in a quarry near the mouth of the Tijeras Arroyo.

According to Lambert (1968), the formation containing the fossils consists of stream deposits, interbedded with sediments that were deposited on the basin floor and arroyo bottoms. The high-energy environments associated with the formation suggest that, although the formation may not extend beneath SNL/NM, the fossils may have been transported varying distances from their original source. It is possible that fossils are present at SNL/NM, but are buried by the alluvial fan deposits from the Sandia Mountains.

7.0 ENGINEERING GEOLOGY

DOE-owned tech areas used by SNL/NM (see Chapter 2, "Land Use," for more information) are located on gently sloping alluvial fan deposits, so slope stability is not usually of concern in building design or construction. The tech areas are also located to the northwest of the faults that run through the Kirtland Federal Complex (KFC) (see "2.2 Local Faults" for more information). Some SNL/NM facilities located on lands used under permit from the U.S. Air Force (USAF) and on the Withdrawn Area may be on or near faults, or in areas with steep topography.

SNL/NM constructs new buildings according to the specifications of Seismic Risk Zone 2B, as specified in the *Uniform Building Code (UBC)* current at the time of design (International Conference of Building Officials, 1994). In response to Executive Order 12941, *Seismic Safety of Existing Federally Owned or Leased Buildings*, the SNL/NM Facilities Development Center is preparing a report on the seismic adequacy of SNL/NM buildings. For more information on SNL/NM buildings, see the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* (Sandia National Laboratories, 1999).

8.0 SOILS

8.1 Overview and Geomorphic Relations

Surface soils at the Kirtland Federal Complex (KFC) are developed in fluvial, alluvial-fan, colluvial, and eolian surficial deposits. Variations in soil properties reflect differences in sediment characteristics, length of exposure to surficial weathering, and local climate.

Soils within the Llano de Manzano geomorphic province are developed primarily in:

- Alluvium derived from schist, greenstone, sandstone, siltstone, and limestone in the Manzanita Mountains.
- Granitic alluvium derived from the Manzano Area (Four Hills).
- Eolian deposits in the McCormick Ranch subprovince.

In general, soils developed on middle- to late-Pleistocene alluvial fans in the Upper Llano de Manzano and Manzano Area (Four Hills) subprovinces and on thin pediment deposits in the Tijeras Arroyo subprovince contain well-developed argillic (clay-rich) and calcic (calcium

carbonate-rich) horizons. These horizons probably influence rates of infiltration and the geochemistry of percolating water. There is a moderate possibility of surface erosion of these soils, which primarily include the:

- Tijeras gravelly, fine sandy loam
- Wink fine sandy loam
- Madurez loamy fine sand, and the Latene sandy loam (U.S. Department of Agriculture, 1977)

In the Upper Llano de Manzano and Manzano Area (Four Hills) subprovinces, soils in Holocene deposits are less developed than those on older surfaces. For example, soils developed on younger fans derived from the western side of Manzano Area (Four Hills) include the Embudo gravelly fine sandy loam and the Tome very fine sandy loam (U.S. Department of Agriculture, 1977). Moderately developed calcic horizons in these soils influence rates of infiltration and the geochemistry of percolating water. Areas underlain by the Embudo-Tijeras complex in this area contain Embudo soils in drainages and Tijeras soils on ridges, which is a result of erosion of the Tijeras soils. The heterogeneity of this complex shows that the locations and rates of infiltration, potential for surface erosion, and geochemical interactions between soils and percolating water may vary substantially in this part of the KFC.

Soils associated with the Tijeras Arroyo and Arroyo del Coyote valley floors are generally well drained, have moderate permeability, and have high potential for surface erosion. The Gila fine sandy loam is associated with the floors of large, active arroyos, such as the Tijeras Arroyo (U.S. Department of Agriculture, 1977). This poorly developed soil lacks evidence of substantial clay or salt accumulation and likely allows for rapid percolation of surface water. Escarpments flanking the large arroyos in the western part of the KFC are associated with poorly developed soils, such as the Bluepoint-Kokan association (U.S. Department of Agriculture, 1977). Areas underlain by this soil series, however, locally contain well-developed calcic horizons, which are remnants of the Tijeras, Wink, and Madurez soils originally developed on older surficial deposits. The Bluepoint-Kokan soils reflect erosion of older soils and therefore are characterized by discontinuous soil horizons. This heterogeneity strongly influences the location and rates of infiltration and geochemical interactions between surface soils and percolating water.

Soils developed in the bedrock uplands and small valleys in the eastern part of the KFC (for example, the Manzanita Mountains subprovince) are heterogeneous, consisting of the poorly developed soils of the Rock Outcrop-Orthids complex, the moderately developed Salas complex, and the moderately developed Tesajo-Millet series. The Rock Outcrop-Orthid soils

are formed in limestone, sandstone, and schist bedrock and are characterized by substantial variation in carbonate content (U.S. Department of Agriculture, 1977). The Salas complex contains well-drained soils developed in residuum derived from schist bedrock and characterized by moderate amounts of clay and carbonate accumulation. The Tesajo-Millet soils are formed in alluvium on valley floors and low terraces. These three soil complexes differ substantially in properties that probably influence interactions between surface and vadose water.

Soils are developed in silty, sandy surficial deposits in the McCormick Ranch subprovince, in contrast to the coarse-grained deposits of the Upper Llano de Manzano subprovince. Eolian influx into surficial deposits and soil horizons is probably substantial in this subprovince. It is likely that the eolian dunes and eolian-modified alluvium are a substantially different parent material than that for limestone- and sandstone-rich alluvium in the Upper Llano de Manzano subprovince. At present, these possible differences are poorly characterized.

8.2 Soil Series

Table 1-3 summarizes general information on soils. Figure 1-8 shows the major soils on the Kirtland Federal Complex (KFC). Minor amounts (less than 30%) of other soils may be present within each map unit shown in Figure 1-8.

Table 1-3. General Soils Classification for the Kirtland Federal Complex (KFC)

Series	Type	% Slope	Runoff	Soil and Water Erosion Potential	Use
Bluepoint	Bluepoint loamy fine sand	1-9	Slow	Severe	Range, watershed, wildlife habitat, recreation, and community development
	Bluepoint-Kokan association	5-40	Slow	Water erosion-moderate to severe	Range, watershed, wildlife habitat, recreation, and community development
Cut and Fill	Cut and fill land	1-25	Slow to Rapid	Slight to severe	Community development and watershed
Embudo	Embudo gravelly fine sandy loam	0-5	Medium	Water erosion-moderate	Watershed, wildlife habitat, and community development
	Embudo-Tijeras complex	0-9	Medium	Water erosion-moderate	Community development, watershed, wildlife habitat, and range
Gila	Gila fine sandy loam	0-0.5	Slow	Water erosion and soil blowing-moderate	Wildlife habitat, watershed, and community development
Ildefonso	Ildefonso gravelly sandy loam	1-9	Medium	Water erosion-moderate	Range, watershed, and wildlife habitat
Laporte	Laporte-Rock Outcrop- Escabosa complex	5-20	Moderate	Moderate	Watershed, wildlife habitat, community development, and recreation

**Table 1-3. General Soils Classification for the Kirtland Federal Complex (KFC)
(Continued)**

Series	Type	% Slope	Runoff	Soil and Water Erosion Potential	Use
Latene	Latene sandy loam	1-5	Medium	Water erosion and soil blowing-moderate	Range, watershed, wildlife habitat, and community development
Madurez	Madurez loamy fine sand	1-5	Slow	Soil blowing-severe	Range, wildlife habitat, watershed, and community development
	Madurez-Wink association	1-5	Slow	Soil blowing-moderate to severe	Range, wildlife habitat, watershed, and community development
Nickel	Nickel-Latene association	5-30	Rapid	Water erosion-moderate to severe	Range, watershed, and wildlife habitat
Pino	Pino-Rock Outcrop association	3-15	Medium	Water erosion-moderate	Range, timber, recreation, wildlife habitat, and watershed
Rock Outcrop	Rock Outcrop-Laporte complex	30-80	Rapid	Water erosion-slight	Watershed, wildlife habitat, and range
	Rock Outcrop-Orthids complex	40-80	Rapid	Water erosion-moderate	Watershed, recreation, and wildlife habitat
	Rock Outcrop-Ustolls complex	15-70	Rapid	Water erosion-moderate	Range, wildlife habitat, recreation, and watershed
Salas	Salas complex	20-80	Rapid	Water erosion-moderate	Wildlife habitat, watershed, and recreation
Seis	Seis very cobbly loam	0-15	Medium	Water erosion-moderate	Range, recreation, wildlife habitat, watershed, and limestone quarrying
	Seis-Silver complex	10-40	Medium-rapid	Water erosion-moderate to severe	Range, wildlife habitat, and watershed
	Seis complex	30-80	Rapid	Water erosion-severe	Wildlife habitat, watershed, recreation, and range
Silver	Silver and Witt soils	5-9	Rapid	Water erosion moderate to severe	Range, watershed, wildlife habitat, and community development
Source: U.S. Department of Agriculture, U.S. Soil Conservation Service and Forest Service, and U.S. Department of the Interior, Bureau of Indian Affairs and Bureau of Land Management in cooperation with the New Mexico Agricultural Experiment Station, 1977.					

The Bluepoint Series consists of deep, somewhat excessively drained loamy fine sand on alluvial fans and terraces. Elevations range from 1,478 to 1,824 meters (4,850 to 6,000 feet) with 1% to 15% slopes. Bluepoint soils are associated with Kokan, Latene, Madurez, and Wink soils (U.S. Department of Agriculture, 1977).

The Embudo Series consists of deep, well-drained gravelly fine sandy loam that formed from weathered granitic rocks on old fan-shaped deposits. Elevations range from 1,525 to 1,980 meters (5,000 to 6,500 feet) with slopes of up to 5%. Tijeras and Wink soils are associated with the Embudo Series (U.S. Department of Agriculture, 1977).

The Gila Series consists of deep, well-drained loamy soils that formed in and at the mouth of the Tijeras Arroyo. Elevations range from 1,478 to 1,829 meters (4,850 to 6,000 feet) with slopes of up to 2%. Small areas of Embudo, Bluepoint, and Glendale soils are mapped with this unit (U.S. Department of Agriculture, 1977).

The Ildefonso Series consists of gravelly sandy loam that is found in areas near the Hells Canyon Wash and west of the Manzano Mountains. Elevations range from 1,829 to 2,133 meters (6,000 to 7,000 feet) with 1% to 9% slopes. A small percentage of Latene soils are mapped with this unit (U.S. Department of Agriculture, 1977).

The Laporte-Rock Outcrop-Escabosa complex contains 35% Laporte loam with 20% Rock Outcrop and 15% Escabosa loam. The Laporte loam is a very shallow to shallow soil derived from weathered limestone from the mountain foothills. The Rock Outcrop is limestone, while the Escabosa loam is a moderately deep, weathered soil that formed from the weathered limestone of the Rock Outcrop. Elevations range from 1,980 to 2,286 meters (6,500 to 7,500 feet) with 5% to 20% slopes. Approximately 20% of the Ildefonso, Manzano, Silver, and Witt soils are included in this mapping unit (U.S. Department of Agriculture, 1977).

The Latene Series consists of deep, well-drained, loamy to fine sandy soils. Elevations range from 1,500 to 1,929 meters (5,000 to 6,000 feet) with 1% to 5% slopes. Wink and Madurez soils make up about 15% of the unit (U.S. Department of Agriculture, 1977).

The Madurez Series consists of deep, well-drained, fine sandy loam that formed on piedmonts in old, unconsolidated alluvium modified by wind. Elevations range from 1,500 to 1,800 meters (4,900 to 5,900 feet) with 1% to 5% slopes. Limited amounts of Bluepoint, Latene, and Wink soils are associated with the Madurez Series (U.S. Department of Agriculture, 1977).

The Nickel-Latene association is approximately 50% gravelly, fine sandy loam (Nickel) with 40% sandy loam (Latene). The remaining 10% is composed of Rock Outcrop. Elevations range from 1,600 to 1,800 meters (5,200 to 5,800 feet), with 1% to 30% slopes. These soils are associated with Latene, Tome, and Wink soils (U.S. Department of Agriculture, 1977).

The Pino-Rock Outcrop association is about 40% silt loam. The Rock Outcrop (30%) is limestone with minor amounts of sandstone outcrops. Elevations range from 2,250 to 2,440 meters (7,400 to 8,000 feet) with 3% to 15% slopes. Escabosa and Laporte soils are included in this mapping unit (U.S. Department of Agriculture, 1977). Sandstone, limestone, or basalt exposed through faulting or stream channel erosion compose 90% of the Pino-Rock Outcrop. Elevations range from 1,829 to 3,050 meters (6,000 to 10,000 feet) with 25% to 80% slopes. The remaining 10% of the unit is composed of gravelly, stony debris found at the base of the moderately to very steep slopes (U.S. Department of Agriculture, 1977).

The Salas complex is composed of very gravelly loam with the remaining 30% stony soils. Elevations range from 1,829 to 2,150 meters (6,000 to 7,000 feet) with 20% to 80% slopes. Laporte soils and Pino-Rock Outcrop make up the remaining 15% of the mapping unit (U.S. Department of Agriculture, 1977).

The Seis Series formed moderately deep, well-drained, very cobbly loam, very stony clay loam, and very stony light clay loam composed of weathered limestone from the mountains. Elevations range from 1,829 to 2,400 meters (6,000 to 7,800 feet) with slopes of up to 60%. These soils are mapped with minor amounts of Ildefonso and Silver soils (U.S. Department of Agriculture, 1977).

Fifty-five percent of the Silver and Witt soils are deep, well-drained, very fine sandy loam derived from sedimentary rocks, and 25% is the very fine sandy loam of the Witt soils derived from mixed rocks. Silver soils are dominant south of Interstate 40, and Witt soils dominate north of Interstate 40. Elevations range from 1,950 to 2,286 meters (6,400 to 7,500 feet), with slopes of up to 15%. Manzano and Laporte soils are found within this mapping unit (U.S. Department of Agriculture, 1977).

The Tesajo-Millet series is a stony sandy loam. Elevations range from 1,829 to 2,133 meters (6,000 to 7,000 feet), with 3% to 20% slopes. The Rock Outcrop Series composes 20% of this unit where the surface is covered with boulders (U.S. Department of Agriculture, 1977).

The Tijeras Series is yellowish-brown, gravelly fine sandy loam. Elevations range from 1,524 to 1,980 meters (5,000 to 6,500 feet), with 1% to 5% slopes. Embudo, Madurez, and Latene soils comprise 20% of this unit (U.S. Department of Agriculture, 1977).

The Tome Series is very fine sandy and silt loam derived from limestone and shale. Elevations range from 1,460 to 1,705 meters (4,800 to 5,600 feet), with slopes of up to 2%. Madurez and Wink soils make up 15% of this mappable unit (U.S. Department of Agriculture, 1977).

The Wink Series consists of brown, well-drained, fine sandy and sandy loam. Elevations range from 1,524 to 1,829 meters (5,000 to 6,000 feet) with slopes of up to 7%. Wink soils are associated with Madurez, Latene, Bluepoint, and Embudo soils (U.S. Department of Agriculture, 1977).

The Cut and Fill Series land consists of sandy loam and very gravelly sand that has been mixed for residential, industrial, and business developments. It is on high terrace breaks of the Rio Grande Valley, primarily within the City of Albuquerque. Elevations range from 1,494 to 1,829 meters (4,900 to 6,000 feet) with 1% to 25% slopes. Minor pockets of Bluepoint, Kokan, and Wink soils are associated with Cut and Fill land (U.S. Department of Agriculture, 1977).

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CHAPTER 2 - LAND USE

CONTENTS

EXECUTIVE SUMMARY	2-5
1.0 INTRODUCTION	2-7
1.1 Purpose	2-7
1.2 Scope	2-7
1.3 Regulatory Setting	2-8
2.0 DESCRIPTION OF THE KIRTLAND FEDERAL COMPLEX (KFC)	2-12
3.0 HISTORY OF LAND USE AT KIRTLAND AIR FORCE BASE (KAFB) AND DOE FACILITIES	2-12
3.1 Land Use Prior to Establishment of SNL/NM	2-12
3.2 Historical Development of SNL/NM	2-14
3.2.1 Tech Area I	2-14
3.2.2 Tech Area II	2-15
3.2.3 Tech Area III	2-15
3.2.4 Tech Area IV	2-16
3.2.5 Tech Area V	2-16
3.2.6 Development of the Kirtland Federal Complex (KFC)	2-17
4.0 CURRENT KIRTLAND FEDERAL COMPLEX (KFC) LAND USE	2-19
4.1 General Land Use and Land Use Planning	2-19
4.2 Land Owned by DOE	2-25
4.2.1 Tech Area I	2-26
4.2.2 Tech Area II	2-31
4.2.3 Tech Area III	2-33
4.2.4 Tech Area IV	2-33
4.2.5 Tech Area V	2-38
4.2.6 Other DOE-Owned Land	2-38
4.3 Land Owned by the U.S. Air Force (USAF) and Permitted to DOE for Use by SNL/NM	2-39
4.4 U.S. Forest Service (USFS) Land Withdrawn by DOE	2-39
4.5 U.S. Forest Service (USFS) Land Withdrawn by the U.S. Air Force (USAF) and Permitted to DOE for Use by SNL/NM	2-40
4.6 U.S. Forest Service (USFS) Land Withdrawn by the U.S. Air Force (USAF) and Used Under a Joint Operating Agreement Between the USAF and DOE	2-40
4.7 Utility Easement and Right-of-Way Permits to DOE for SNL/NM Facilities	2-45
4.8 Land Leased to DOE	2-47

5.0 SURROUNDING LAND USE	2-49
5.1 Current Adjacent Land Use	2-49
5.2. Land Ownership	2-49
5.3 Land Coverage	2-51
5.4 Agricultural Land and Rangeland	2-51
5.4.1 16-Kilometer (10-Mile) Radius	2-51
5.4.2 80-Kilometer (50-Mile) Radius	2-52
5.5 Residential and Commercial Land Use	2-52
5.5.1 16-Kilometer (10-Mile) Radius	2-52
5.5.2 80-Kilometer (50-Mile) Radius	2-52
5.6 Industrial Land Use	2-58
5.6.1 16-Kilometer (10-Mile) Radius	2-58
5.6.2 80-Kilometer (50-Mile) Radius	2-58
5.7 Public Lands	2-59
5.7.1 16-Kilometer (10-Mile) Radius	2-59
5.7.2 80-Kilometer (50-Mile) Radius	2-60
5.8 Native American-Owned Lands	2-63
5.8.1 16-Kilometer (10-Mile) Radius	2-63
5.8.2 80-Kilometer (50-Mile) Radius	2-63
6.0 REFERENCES	2-66
6.1 Regulations, Orders, and Laws	2-66
6.2 General References	2-66
ATTACHMENTS	
2-1 - Proposed Future Land Use Recommendations	2-73
2-2 - Memorandum of Understanding (MOU) Between the U.S. Department of Agriculture (USDA) and DOE	2-89
2-3 - Memorandum of Agreement (MOA) Between the U.S. Department of Agriculture (USDA) and the U.S. Air Force (USAF)	2-95

LIST OF TABLES

2-1. Land Ownership for the Kirtland Federal Complex	2-19
2-2. Kirtland Federal Complex Land Use Jurisdiction by Acreage	2-20
2-3. DOE Affiliates on the Kirtland Federal Complex	2-25
2-4. DOE Fee-Owned Land on the Kirtland Federal Complex	2-26
2-5. Tech Area I Activities	2-26
2-6. Permitted Utility and Right-of-Way Easements	2-45
2-7. Cities and Towns in the 80-Kilometer Radius Area of SNL/NM	2-53
2-8. Industrial Employers in Albuquerque	2-58
2-9. Native American Populations Within an 80-Kilometer Radius of SNL/NM	2-64

LIST OF FIGURES

2-1. Kirtland Federal Complex Land Use.....	2-9
2-2. General Land Use and Jurisdictions.....	2-11
2-3. 1929 Aerial View to the East of Oxnard Field	2-14
2-4. 1947 Aerial View of Sandia Base	2-15
2-5. 1962 Aerial View of KAFB including Tech Area I.....	2-18
2-6. Quantity Distance Safety Zones and Ordnance Impact Areas of the KFC.....	2-23
2-7. DOE-Owned Land Within the Kirtland Federal Complex	2-28
2-8. Tech Area I	2-29
2-9. Tech Area II	2-32
2-10. Tech Area III	2-35
2-11. Tech Area IV	2-37
2-12. Tech Area V	2-41
2-13. U.S. Air Force Land Permitted to DOE for Use by SNL/NM	2-42
2-14. U.S. Forest Service Land Withdrawn by the U.S. Air Force and DOE	2-43
2-15. U.S. Forest Service Land Withdrawn by the U.S. Air Force and Used Under a Joint Operating Agreement Between the USAF and DOE	2-44
2-16. U.S. Air Force Land Permitted to DOE for SNL/NM Utility and Right-of-Way Easements	2-46
2-17. Land Leased to DOE as Buffer Zones	2-48
2-18. Land Ownership Within the 80-Kilometer Radius of SNL/NM.....	2-50
2-19. Land Coverage Within the 80-Kilometer Radius of SNL/NM	2-54
2-20. Land Coverage Within the 16-Kilometer Radius of SNL/NM	2-55
2-21. Agricultural Land and Rangeland Within the 80-Kilometer Radius of SNL/NM	2-56
2-22. Residential and Commercial Land Use Within the 16-Kilometer Radius of SNL/NM	2-57
2-23. Public Lands Within the 80-Kilometer Radius of SNL/NM	2-61
2-24. Native American-Owned Lands Within the 80-Kilometer Radius of SNL/NM.....	2-65

EXECUTIVE SUMMARY

This chapter describes SNL/NM land use in the context of the complex land ownership and use agreements that define jurisdictions and land use areas within the Kirtland Federal Complex (KFC). These ownership and agreement designations provide a framework for summarizing SNL/NM land use and land use planning in its current and historical context. History of land use is described particularly as it applies to tech areas and other land areas used by SNL/NM within the KFC.

SNL/NM land use areas are categorized according to ownership and use jurisdictions within the KFC. This chapter generally describes land use within each jurisdiction, and contains information about current SNL/NM activities on land within the KFC and any known fiscal year 1997 (FY1997) actions. For specific program information, including environmental restoration (ER) sites and issues, and for information on facility descriptions, see the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* (Sandia National Laboratories, 1999). SNL/NM uses its planning process to evaluate each proposal involving land use considerations in terms of laws and regulations applicable to that proposal.

This chapter also discusses surrounding land uses within 80-kilometer (50-mile) and 16 kilometer (10-mile) radii. Specific land uses and their significance to the area include agricultural, residential and commercial, industrial, institutional, and public. Land use descriptions include land coverage characteristics and land ownership. In addition, this chapter describes the relationship of Native American-owned lands to an 80-kilometer (50-mile) radius around SNL/NM.

1.0 INTRODUCTION

1.1 Purpose

This chapter describes the complex land ownership and use agreements that define jurisdictions and land use areas within the Kirtland Federal Complex (KFC). These ownership and agreement designations provide a framework for summarizing SNL/NM land use and land use planning in its current and historical context. Description of land use within 80-kilometer (50-mile) and 16-kilometer (10-mile) radii from the KFC provides information useful for considering potential effects of SNL/NM activities on areas surrounding the KFC and for future land use planning.

1.2 Scope

The scope of the chapter summarizes historical land use and describes existing SNL/NM land uses within the Kirtland Federal Complex (KFC), including use of DOE lands and facilities, permitted lands and facilities, and U.S. Forest Service (USFS) land withdrawn from public use. Current land use areas within the KFC according to ownership and use jurisdictions appear in Figure 2-1. This chapter also describes land use by the U.S. Air Force (USAF) on Kirtland Air Force Base (KAFB), and management plans of the USAF and USFS as they affect SNL/NM land use planning.

SNL/NM land use areas are categorized in this chapter according to ownership jurisdictions within the KFC. This includes information about current SNL/NM activities on land within the KFC and known fiscal year 1997 (FY1997) actions. For major SNL/NM facility descriptions, see the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* (Sandia National Laboratories, 1999).

This chapter also describes general land uses within 80-kilometer (50-mile) and 16-kilometer (10-mile) radii shown in Figure 2-2. Land use descriptions include land coverage characteristics and land ownership. In addition, this chapter identifies Native American-owned lands to an 80-kilometer (50-mile) radius around SNL/NM. The specific categories of land uses discussed include the following:

- Agricultural
- Residential and commercial

- Industrial
- Institutional
- Public

1.3 Regulatory Setting

Each SNL/NM proposal involving land use considerations must meet applicable laws and regulations. The SNL/NM land use planning process ensures that this occurs. Changes to land use activities and proposals for new SNL/NM activities must be evaluated under the *National Environmental Policy Act (NEPA)* process, and other federal environmental laws. State and local entities, including several divisions within the New Mexico Environment Department (NMED), have regulatory authority delegated by the U.S. Environmental Protection Agency (EPA) for some environmental requirements. The NMED cooperates with the federal government in the administration of environmental laws and regulations through the:

- Environmental Improvement Board (EIB)
- Water Quality Control Commission (WQCC)
- Occupational Health and Safety Review Commission (OHSRC)
- Radiation Technical Advisory Council (RTAC)

For information on state laws and regulations that interrelate with federal laws and that may influence land use considerations, see Chapter 13, "Regulatory Requirements."

Proposed environmental restoration (ER) activities of the SNL/NM ER Project comply with federal, state, and local laws and regulations to protect air, water, and other environmental resources. Several of the proposed ER remedial options could potentially increase land use options by removing contaminated soils from ER sites and replacing them with clean or treated backfill (U.S. Department of Energy, Kirtland Area Office, 1996).

LAND USE CLASSIFICATION KEY

- DOE Fee Owned
- DOE Withdrawn from U.S. Forest Service (USFS)
- DOE Leased (State of New Mexico and Bureau of Indian Affairs)
- U.S. Air Force Permitted to DOE
- U.S. Air Force Withdrawn from U.S. Forest Service Permitted to DOE
- U.S. Air Force Fee Various Structures Within This Area Permitted to DOE, SNL, TSD, CTA and Support Agreement Between U.S. Air Force and DOE for Various Facilities (Marzano Area)
- U.S. Air Force Withdrawn from U.S. Forest Service Joint Operating Agreement Between DOE, SNL, and PHILLIPS
- U.S. Air Force Fee Joint Operating Agreement Between DOE, SNL, and PHILLIPS
- U.S. Air Force Permitted to Others
- DOE Outgranted or Permitted to U.S. Air Force
- DOE Outgranted or Permitted to Others
- Private Property
- Bureau of Land Management

LEGEND

- Kirtland Air Force Base Boundary
- U.S. Forest Service Withdrawn Area Boundary
- Paved Roads
- Unpaved Roads and Trails

SCALE 1: 84000

Planimetry compiled by photogrammetric methods from aerial photography dated March 1983, March 1988, September 1991, and July 1992.

Transverse Mercator Projection, New Mexico State Plane Coordinate System, Central Zone, 827 North American Horizontal Datum, 829 North American Vertical Datum

U.S. DEPARTMENT OF ENERGY	
KIRTLAND AIR FORCE BASE EAST	MANAGEMENT SUPPORT DIVISION ALBUQUERQUE, NEW MEXICO
Sandia National Laboratories Facilities Development Center	
ALBUQUERQUE, NEW MEXICO; LIVERMORE, CALIFORNIA; TONOPAH, NEVADA	
Facilities Geographic Information System	
Figure 2-1. Kirtland Federal Complex (KFC) Land Use	
Electrical & Architectural System Engineering Department 7821	
Date: 11/098	Map ID #: 980091

Figure 2-2. General Land Use and Jurisdictions

2.0 DESCRIPTION OF THE KIRTLAND FEDERAL COMPLEX (KFC)

The term Kirtland Federal Complex (KFC) refers to the lands that encompass Kirtland Air Force Base (KAFB), lands owned by DOE, including SNL/NM, and portions of the Cibola National Forest withdrawn from public entry by the U.S. Air Force (USAF) and DOE. The KFC covers approximately 51,559 acres of high desert land southeast of Albuquerque, New Mexico. It is geographically bound by the Manzanita Mountains (foothills of the Manzano Mountains) to the east, the Pueblo of Isleta to the south, the Albuquerque International Sunport and lands held in trust by the State of New Mexico to the west, and the City of Albuquerque to the north.

The Rio Grande flows from north to south approximately five miles to the west of the KFC. Most of the KFC lands are relatively flat, sloping gently westward toward the Rio Grande. However, the eastern portion of the KFC extends into the canyons of the Manzanita Mountains, which are precipitous and traversed by numerous arroyos (Keystone Environmental & Planning Incorporated, 1995a).

Figure 2-2 provides a general picture of land ownership and use jurisdictions within 80-kilometer (50-mile) and 16-kilometer (10-mile) radii of the KFC.

3.0 HISTORY OF LAND USE AT KIRTLAND AIR FORCE BASE (KAFB) AND DOE FACILITIES

3.1 Land Use Prior to Establishment of SNL/NM

The Kirtland Federal Complex (KFC) has developed over the last 50 years as a multi-user industrial research and development complex. Simultaneous growth and development of Albuquerque and other areas within the region of influence (ROI) have also affected SNL/NM activities and continue to contribute to consideration of options for future use of DOE land and facilities used by SNL/NM within the KFC.

The land along Tijeras Canyon, in the foothills of the Manzano Mountains and extending westward across the area within the KFC, was inhabited by Hispanic communities and individuals under Spanish land grants for approximately 300 years. Tijeras Canyon was a major artery connecting the High Plains with the Rio Grande Valley. However, the land grant rights failed to be confirmed beginning in 1890, and in the 1930s grant heirs lost their grazing rights and forest lands to the Cibola National Forest (IT Corporation, 1996).

Industrial land use within the KFC began in 1928 with construction of Albuquerque's first airport, known as Oxnard Field, on 140 acres of homestead land near the current site of the National Atomic Museum (see Figure 2-3 [Sandia National Laboratories, Corporate Archives, 1997]). In the late 1930s, the City of Albuquerque constructed a new airport approximately four miles west of Oxnard Field, using municipal and Works Progress Administration (WPA) funds (Alberts, 1987).

In 1941, the Albuquerque Army Base was at the east end of the airport. It was renamed Kirtland Field in February 1942. In 1942, an additional 11,000 acres of land at the east boundary of Kirtland Field, including the old Oxnard Field, were condemned for the construction of the Albuquerque Air Depot Training Station (Alberts and Putnam, 1982). Because Kirtland Field was the closest airport facility to Los Alamos, its runways and a bomb loading pit were used to support the Manhattan Project during 1944 and 1945. A few months prior to the successful completion of the Trinity Project (test detonation of the first atomic bomb) and of the Alberta Project (delivery of the first airborne atomic weapon), J. Robert Oppenheimer, Director of Los Alamos Scientific Laboratory, and his technical advisor, Hartly Rowe, began looking for a new site convenient to Los Alamos for the continuation of weapons development, especially the nonnuclear aspects. They believed that a separate division would best fulfill these functions (IT Corporation, 1996).

Jurisdiction of Kirtland Field was transferred from the U.S. Army Air Corps to the U.S. Army Service Forces Chief of Engineer District and thereafter assigned to the Manhattan Engineer District. In July 1945, the forerunner of Sandia Laboratory, known as "Z" Division, was established at Kirtland Field to handle future weapons development, testing, and bomb assembly for the Manhattan Engineer District (IT Corporation, 1996).

By the end of the war, Kirtland Field had not only become important to the military community, but also to the local community and economy. It was the site for 402 buildings, 82 of which were wartime housing units that had been transferred to Kirtland's jurisdiction in November 1943 (IT Corporation, 1996). Albuquerque, located several miles from Kirtland Field at that time, had a population of approximately 65,000 people. The city served as a railroad shipping center for ranchers and farmers (Johnson, 1997).

The "Z" Division facilities, which originally housed the laboratory, consisted of wooden sheds and buildings. However, the Manhattan Engineer District authorized construction of guard, storage, administrative, and laboratory facilities for "Sandia Base" soon after its establishment. This use of the term "Sandia Base" appears to be the first official use of that name. Congress designated Sandia Laboratory as a national laboratory in 1979 and it was renamed Sandia National Laboratories.

Figure 2-3. 1929 Aerial View to the East of Oxnard Field
Reprinted with permission from Sandia National Laboratories, Corporate Archives.

3.2 Historical Development of SNL/NM

3.2.1 Tech Area I

To separate the "Z" Division facilities from ongoing aircraft storage and salvage operations, a fenced area for classified activities was required. This site became Tech Area I of Sandia Laboratory. At that time, Tech Area I included some of the older, temporary buildings and additional wood-frame buildings that provided space for personnel and work functions. Construction of more permanent buildings for an expanded facility began in 1948 (IT Corporation, 1996). Weapons research and development operations at Tech Area I began in 1946. Current operations and associated light industrial land use are much the same in nature as those activities begun in 1946 (see Figure 2-4 [Sandia National Laboratories, Corporate Archives, 1997]).

Figure 2-4. 1947 Aerial View of Sandia Base

Reprinted with permission from Sandia National Laboratories, Corporate Archives.

3.2.2 Tech Area II

Early activities at Sandia Laboratory included the assembly of weapons, requiring the development of a separate area, located approximately 0.5 mile south of Tech Area I, for the handling and incorporation of explosives into the weapons. Construction of this area, which became Tech Area II, was initiated in 1948 (IT Corporation, 1996). Facilities completed in 1949 included two identical (mirror image) assembly buildings and a control building.

3.2.3 Tech Area III

The increasing use of missiles as delivery systems necessitated full-scale environmental testing of weapons (with and without explosives, but not including nuclear detonations). As a result,

there was a need for complex equipment and specialized engineers to analyze the test results. A decision was made to centralize a group of test devices which resulted in planning for Tech Area III, located approximately 11.3 kilometers (7 miles) south of Tech Area I. Work on this tech area began in 1952. Construction of the first group of facilities, consisting of a centrifuge, a rocket-sled, a vibration testing facility, and an instrument control center, was completed in 1953. Additional Tech Area III test facilities were constructed between 1954 and 1960 (IT Corporation, 1996).

3.2.4 Tech Area IV

Construction of Tech Area IV, which was developed as the test location for x-ray, gamma-ray, and particle-beam fusion accelerators, began in 1979. It is located south of Tech Area II. Major existing Tech Area IV facilities include the Saturn x-ray facility, the High Energy Radiation Megavolt Electron Source (HERMES) III gamma-ray facility, and the Particle Beam Fusion Accelerator II (PBFA II). Other, smaller facilities in Tech Area IV that support various technologies include the Rocket systems and Flight Dynamics Laboratory, the Payload and Satellite Processing Facility, the Parallel Computing Science laboratory, the Robotics Laboratory, and several small accelerators.

3.2.5 Tech Area V

In 1957, construction of a nuclear reactor facility was proposed. The site of the reactor was to become Tech Area V (IT Corporation, 1996). Currently, the area is completely enclosed by two standard security chain-link fences, except for a single office/light laboratory building. Tech Area V contains several major facilities, small research laboratories, machine shops, plant support facilities, and office for facility operational personnel. Major facilities located within the area include the following:

- Annular Core Research Reactor (ACRR) - Originally designed to support weapons programs by producing radioisotopes generated during the fission process, this facility will be modified to provide continued support to the weapons program and to support the production and shipment of the medical isotope molybdenum-99.
- Gamma Irradiation Facility (GIF) - The GIF was designed to store high activity cobalt and cesium sources used in gamma-irradiation experiments.
- Hot Cell Facility (HCF) - This research laboratory was constructed to allow safe remote handling of nuclear and radioactive material during its microscopic, radiological, and chemical analyses.

Most activities conducted in Tech Area V include research and testing of various materials, such as electronics, in a nuclear environment provided by low-power nuclear reactors.

3.2.6 Development of the Kirtland Federal Complex (KFC)

In the 1960s, as new weapons were developed, additional laboratory space became necessary and new environmental testing facilities were required. The need for test sites grew beyond the capacity of Atomic Energy Commission (AEC)-owned lands and the first use permits were acquired from the U.S. Air Force (USAF) to obtain land now known as the Coyote Test Field (CTF). Sandia Laboratory and facility construction continued at an average rate of about 50,000 square feet per year until 1963 (IT Corporation, 1996) (see Figure 2-5 for an aerial view of KAFB including Tech Area I [looking south] [Sandia National Laboratories, Corporate Archives, 1997]). The areas permitted by the USAF served as locations for new facilities as well as testing areas.

Both Kirtland Air Force Base (KAFB) and Sandia Base were primarily known as weapons testing and development facilities in the 1960s. Sandia Laboratory was responsible for "weaponizing" the many components needed to fabricate deliverable weapons, including the bomb case, arming, fuzing, and firing mechanisms, and weapon safety and security systems.

The Air Force Weapons Laboratory (AFWL) was established at KAFB in 1963 to undertake weapons research and to develop simulation techniques. Its facilities were constructed to simulate nuclear blast effects, including transient radiation, x-rays, and electromagnetic pulses. The AFWL became part of the Air Force Research Lab in December 1990.

The KAFB airfield, taxiways, and attendant properties were sold to the City of Albuquerque in 1966 to become the Albuquerque International Airport (renamed the Albuquerque International Sunport). A lease arrangement between KAFB and the City of Albuquerque allows the USAF to conduct military flying operations from the airfield.

During the 1970s, KAFB continued to evolve as a research and development base, hosting other military organizations. Research and development activities focused primarily on nuclear weapons blast effects, electronics, lasers, and explosives. However, activities have not been limited to industrial land uses. The cantonment area of KAFB, in the northwest portion of the Kirtland Federal Complex (KFC), is the site of KAFB housing and related commercial facilities, schools, a hospital, and recreational and open space areas.

Figure 2-5. 1962 Aerial View of KAFB including Tech Area I (Looking South)
Reprinted with permission from Sandia National Laboratories, Corporate Archives.

American Telephone & Telegraph (AT&T) was asked to manage Sandia as a separate laboratory by President Truman in 1949. AT&T continued to operate SNL/NM for DOE until 1992 (IT Corporation, 1996). That year, Sandia Corporation, the operating corporation of SNL/NM, became a wholly owned subsidiary of the Martin Marietta Corporation, which became the Lockheed Martin Corporation in March 1995. SNL/NM continues to be one of DOE's most

diverse laboratories and one of the nation's largest research and development facilities. SNL/NM's primary mission focuses on national security programs in defense and energy, with emphasis on nuclear weapons research and development. The labs also conduct work for the Department of Defense (DoD) and other federal agencies.

4.0 CURRENT KIRTLAND FEDERAL COMPLEX (KFC) LAND USE

4.1 General Land Use and Land Use Planning

Land use on the Kirtland Federal Complex (KFC) results from Kirtland Air Force Base (KAFB) activities of the U.S. Air Force (USAF) and other agencies, including SNL/NM. Land use planning for the various ownership and use jurisdictions within the KFC is accomplished by the USAF, SNL/NM (in cooperation with DOE), and U.S. Forest Service (USFS) planning efforts. The following sections describe SNL/NM land use within the KFC according to current ownership, jurisdiction, and/or permit status of the various areas used by SNL/NM. Table 2-1 lists ownership of land on the KFC and approximate acreage owned and/or withdrawn by each of the federal agencies assigned custody and accountability for land on the KFC. Table 2-2 describes jurisdictions by approximate acreage resulting from the acquisition of land use permits.

Table 2-1. Land Ownership for the Kirtland Federal Complex (KFC)

KFC Land Ownership	Acreage
DOE fee land	2,963
USAF fee land	24,148
USFS land withdrawn by DOE	4,595
USFS land withdrawn by USAF	15,891
Bureau of Land Management (BLM) land withdrawn by USAF	2,549
Land donated to KAFB by the City of Albuquerque	1,344
USAF perpetual easement	82
USAF general use permits	12
Total KFC acreage	51,559
Source: Carlos Valdez, 1997.	

SNL/NM describes its land use planning process in *Sandia National Laboratories 1997-2017 Sites Comprehensive Plan* (Sandia National Laboratories, 1996), which was prepared in response to DOE 430.1, *Life Cycle Asset Management*. This document, to be published annually by the Sites Planning Department at SNL/NM, replaces SAND94-2173, *Site Development Plan* (Sandia National Laboratories, 1995).

Table 2-2. Kirtland Federal Complex (KFC) Land Use Jurisdiction by Acreage

KFC Land Use Jurisdictions	Acreage
DOE fee used by SNL/NM (Tech Areas I through V)	2,841
Other DOE fee (DOE/AL, Coronado Club, and Eubank Boulevard)	96
DOE fee permitted to USAF	26
KAFB land for use by USAF and USAF tenants	28,041
USAF fee permitted to DOE for SNL/NM use	3,892
USAF fee permitted to DOE for use by other DOE affiliates	362
USFS land withdrawn by DOE	4,595
USFS land withdrawn by USAF and permitted to DOE for SNL/NM	2,051
USFS land withdrawn by USAF under joint use agreement between the USAF and DOE	1,921
Sources: Carlos Medrano, 1997; Camille Reyes, 1997a.	

SNL/NM has also used the planning process to work with DOE in response to DOE's Future Use Initiative. DOE's Future Use Logistics and Support Working Group, with participation from SNL/NM, the USAF, the U.S. Forest Service (USFS), and other DOE affiliates operating within the KFC, proposed risk-based future use designations for SNL/NM land use areas based on current and projected SNL/NM programs and activities and proposed environmental restoration (ER) cleanup levels. Four workbooks (Keystone Environmental & Planning Incorporated, 1995b, 1995c, 1996a, and 1996b) describing programs and ER Project activities in seven management areas were presented to the Citizens' Advisory Board (CAB) for Sandia National Laboratories/DOE (formerly known as the Sandia National Laboratories/Inhalation Toxicology Research Institute [ITRI] CAB) for consideration. Attachment 2-1 includes proposed future use recommendations.

Current use of land within the KFC by SNL/NM is generally described in the following sections. Activities requiring industrial use of land by SNL/NM include:

- Process development
- Radiation research
- Microelectronics research and production
- Science-based weapons stockpile stewardship
- Environmental testing
- Scientific computing
- Energy programs
- Technology transfer

Over the last 40 years, SNL/NM's mission has expanded from nuclear weapons research and development to include research on other advanced military technologies, energy programs, arms verification, control technology, and applied research in numerous scientific fields, including an extensive program in material research. Energy program efforts include research into combustion, integrated geosciences, solar energy, and wind power.

SNL/NM environmental projects include programs in waste reduction and research to develop environmentally conscious manufacturing. SNL/NM is a leader in scientific computing, especially in massive parallel processing, and it maintains an extensive semiconductor research and development program. SNL/NM is also working to transfer commercially valuable technologies developed by SNL/NM to U.S. industries.

Although not all SNL/NM facilities are strictly industrial in nature (e.g., administrative and office buildings), several factors contribute to a general designation of "industrial" in describing land use by SNL/NM on the KFC. For example, all aspects of SNL/NM activities, including research and development, administrative, and assembly operations occur within mixed-use areas that have limited area for development. Testing activities occur in areas contiguous to research and development facilities. Some past research and testing activities have resulted in some ER sites and associated remediation efforts.

In addition to the land bounded by Tech Areas I, II, and IV, DOE owns 282 acres of land within the Tijeras Arroyo drainage area. This land is currently undeveloped, but is not used as recreational space. Some of the ER sites that occur along the outfalls from Tech Areas II and IV have undergone remediation, and proposals for no further action (NFA) have been submitted to the New Mexico Environment Department (NMED) for approval.

Land use by the USAF within the 10,000-acre KAFB cantonment area includes a broader range of uses than those occurring as a result of the research and development and testing activities of other agencies (including DOE and SNL/NM) operating within the KFC. The cantonment area does not include the Manzano Area, the Withdrawn Area, or the southern portion of KAFB. Air Force land use designations include the following areas (Richardson, 1997):

- Community
- Outdoor recreation and training
- Mission (aircraft operations or weapons storage)
- Medical
- Base support and industrial activities (transportation, civil engineering, communications)
- Airfields (runways, taxiways, aprons)
- Tenant land use (land leased by other agencies)

- Administrative and research activities (specifically Air Force Research Lab)
- Open space

The USAF and USFS have also completed resource management plans that include the entire KFC (U.S. Air Force, 1995). The goal of the plan is to “consolidate and integrate all management activities in a manner to restore, sustain, and promote ecosystem health and integrity at KAFB,” while the USFS *Environmental Analysis Ecosystem Management Plan for National Forest Lands in and Adjacent to the Military Withdrawal* (U.S. Department of Agriculture, U.S. Forest Service, 1996) focuses on the USFS Withdrawn Area.

Large areas of land within the KFC, particularly in the Withdrawn Area, provide safety buffer areas for USAF and SNL/NM testing activities.

Jurisdictional boundaries are important in determining additional sites for development. However, siting of future DOE facilities within the KFC can also be affected by other constraints, including:

- Land slopes greater than 25%
- Known geologic faults
- Aircraft clear zone
- Department of Defense (DoD) and DOE quantity distance (QD) safety zones

The area and configuration of QD safety zones is determined based on the types of explosives or testing involved, the quantities of explosives used in tests, and the land uses or types of facilities that are adjacent to the testing area. Existing QD safety zones and ordnance impact areas appear in Figure 2-6. SNL/NM and USAF testing and military training exercises over the last 50 years have resulted in ordnance impact areas, mostly within the Withdrawn Area, Coyote Test Field (CTF), and the area including the land leased by DOE from the State of New Mexico and Mesa del Sol to the west. Explosives hazard zones designated as “concentrated,” “scattered,” or “possible” have been identified based on the likelihood of hazard. Although in the past, live artillery shells from testing done 20 to 30 years ago have been found in these areas, they have been searched, and most of the surficial unexploded ordnance (UXO) has been removed. However, the mountainous terrain of the Withdrawn Area makes recovery of all UXO and testing debris difficult (Sandia National Laboratories, 1989). The hatched areas in Figure 2-6 indicate the possible range within which UXO could exist. As with the QD safety zones, possible UXO areas are considered when addressing land use and development options.

In addition to SNL/NM, DOE supports other facilities and programs within the KFC. Table 2-3 describes the roles of other DOE affiliates.

Table 2-3. DOE Affiliates on the Kirtland Federal Complex (KFC)

DOE Affiliate	Role
Safeguards & Security Central Training Academy (S&SCTA)	Ensure efficient and effective training of safeguards and security personnel throughout DOE.
Transportation Safeguards Division (TSD)	<ul style="list-style-type: none"> ● Plan, coordinate, implement, and operate DOE Safeguards Program for strategic quantities of government-owned special nuclear material. ● Coordinate with DoD on weapons distribution from the KFC. ● Coordinate special nuclear material shipments for all other DOE field offices. ● Administer DOE courier forces and supporting electronic systems.
Allied Signal Federal Manufacturing & Technologies/New Mexico	Research, design, fabricate, and test electro-optic and recording systems for capturing fast transient signals.
Ross Aviation	Provide DOE's air cargo and transportation service support between Albuquerque and Los Alamos and between production plants, national laboratories, test sites, and military facilities.

4.2 Land Owned by DOE

DOE owns approximately 2,938 acres of land within the KFC. The five SNL/NM tech areas, as they are currently defined, cover approximately 2,841 acres of this land. Historically, tech area boundaries were described by their secured perimeters. In recent years, as SNL/NM facilities have expanded and fewer activities have required strict security, the general boundaries associated with each tech area have also expanded.

Table 2-4 lists the acreage of the original secured boundaries of each tech area and the total acreage currently attributed to each area (Reyes, 1997a, 1997b). Tech Areas I, II, and IV cover approximately 926 acres, although 282 acres of this area is located within the drainage area of the Tijeras Arroyo and is not considered part of the Tech Area IV boundary. Tech Areas III and V encompass approximately 1,915 acres. DOE also owns 10 acres comprising the DOE/Albuquerque Area Office (DOE/AL) and Coronado Club sites and 86 acres bordering Eubank Boulevard north of SNL/NM. Figure 2-7 shows these areas (Sandia National Laboratories, Space and Real Estate Department, 1997). Development of the five tech areas has occurred incrementally with the ever-widening research and development missions of SNL/NM.

Table 2-4. DOE Fee-Owned Land on the Kirtland Federal Complex (KFC)

Area Reference	Approximate Acreage	
	Secured	Total
Tech Area I	110	353
Tech Area II	46	208
Tech Area III	1,890	1,890
Tech Area IV	19	83
Tech Area V	25	26
Tijeras Arroyo drainage area	N/A	282
DOE/AL and Coronado Club	N/A	10
Eubank Boulevard development area	N/A	86
Total DOE-fee land	1,990	2,938
Sources: Carlos Medrano, 1997; Camille Reyes, 1997a.		

4.2.1 Tech Area I

Tech Area I is situated near the northern edge of the Kirtland Federal Complex (KFC), bounded by Wyoming Boulevard on the west and Eubank Boulevard on the east. F and G streets form the northern border, and Hardin Boulevard defines the southern boundary of the approximate 353 acres in Tech Area I. The original fenced, or secured, portion of Tech Area I includes approximately 110 acres. It is the most developed and populated of the tech areas at SNL/NM, with an employee population of approximately 6,633 (Reyes, 1997a). Figure 2-8 includes a site map of Tech Area I.

SNL/NM facilities in Tech Area I are tasked with the research, design, and development of nuclear weapons systems and components, weapons protection, energy systems, and nuclear safety. Table 2-5 summarizes specific activities in Tech Area I.

Table 2-5. Tech Area I Activities

Type of Activities	Activity Description	Resulting Land Use
Nonnuclear weapons work	<ul style="list-style-type: none"> • Military research • Alternative energy research • Arms verification • Material science • Systems evaluations • Instrumentation testing • Component fabrications • Waste management • Environmental restoration 	Light industrial

Table 2-5. Tech Area I Activities (Continued)

Type of Activities	Activity Description	Resulting Land Use
Technical support activities	<ul style="list-style-type: none">● Administration● Library and computing services● Planning● Military liaison● Shipping and receiving● Health and safety	Commercial and light industrial

Special research and development facilities include wind tunnels, high-altitude chambers, plasma arc jets, lasers, metallurgy and other specialty laboratories, and special fabrication shops for various materials, including toxic substances. Descriptions of specific, notable facilities and projects appear in the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* (Sandia National Laboratories, 1999). Figure 2-8 indicates the locations and names of these notable facilities. Other important buildings and facilities within Tech Area I are shown as primary buildings (Reyes, 1997c).

The density and variety of research and development functions that occur in Tech Area I have increased dramatically over the years. However, the light industrial nature of land use has been consistent throughout its 50-year history. Environmental restoration (ER) sites have resulted from research and development programs, but remediation of the sites is ongoing.

Figure 2-7. DOE-Owned Land Within the Kirtland Federal Complex (KFC)

4.2.2 Tech Area II

Tech Area II is located between Tech Area I to the north and Tech Area IV directly to the south. The overall area encompasses approximately 208 acres, including the original fenced (secured) area of approximately 46 acres. Figure 2-9 illustrates Tech Area II. The original area is diamond-shaped, approximately 1,450 feet per side, and distinguished by a 10-foot-high chain link fence with a guarded security gate. The current boundaries were established within the last few years for planning purposes (Reyes, 1997b). Work conducted in Tech Area II has involved development and testing of explosives and explosive devices since approximately 1959. Current activities focus on accelerated aging and development and testing of explosive components. In 1997, approximately 440 people worked at facilities in Tech Area II (Reyes, 1997b; Tooley, 1997).

Completion of the Explosive Components Facility (ECF) in 1995 has resulted in abandonment of the extensive operational quantity distance (QD) safety zones and commencement of remediation of environmental restoration (ER) sites that had limited further development of land within Tech Area II. SNL/NM plans to construct new laboratory facilities for Tech Area II, including more site services and low-height, low-density facilities. Assessment of the condition and remaining useful life of Tech Area II facilities is currently underway. However, no historical significance has been established to date, and it is expected that Tech Area II facilities will be demolished within the next ten years, pending funding for decommissioning and demolition (Reyes, 1997b). Suitable facilities may be reapplied to warehousing or other limited occupancy uses until the area is redeveloped. For more information on redevelopment plans, see the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* (Sandia National Laboratories, 1999). However, the industrial nature of land use in this area is expected to continue in the foreseeable future.

ER sites have resulted from Tech Area II development and testing programs, but remediation of the sites is ongoing. Many of the sites have been proposed for no further action (NFA) status following remediation efforts. The Classified Waste Landfill and the Radioactive Waste/Chemical Disposal Pit are undergoing voluntary corrective measures prior to submittal of NFA proposals (Aamodt, 1997).

4.2.3 Tech Area III

Tech Area III is located approximately five miles south of Tech Area I within the Kirtland Federal Complex (KFC). The approximately 1,890-acre area is bordered on the west by U.S. Air Force (USAF) land permitted to DOE and land leased to DOE by the State of New Mexico as a buffer area (see Figure 2-10).

Approximately 224 people work in Tech Area III (Reyes, 1997a). Nineteen extensive test facilities are used for testing and simulating a variety of natural and induced environments, many of which replicate extreme conditions. Land use in Tech Area III has been primarily industrial from its earliest development in 1952. However, an administrative building and mobile office trailers provide space for administrative, office, and light laboratory functions. Figure 2-10 indicates notable facilities and primary buildings located in Tech Area III (March, 1997; Reyes, 1997c). Because of restrictions associated with quantity distance (QD) safety zones, the tech area is considered fully developed. Many QD safety zones overlap, requiring coordination of testing facilities' operations. In addition, lack of utilities, emergency access, adequate facilities, and transportation issues currently limit further development of Tech Area III.

Tech Area III is also the site of the Design, Evaluation, and Test Technology (DETT) Center, a testing complex for weapons systems and their components. In April 1997, SNL/NM's environmental assessment (EA) analyzing the effects of a proposal to continue operating the DETT Center at Tech Area III, to institute changes to shock tube explosives testing facilities at the 10,000-Foot Sled Track, and to construct a central command and control facility with associated infrastructure received a finding of no significant impact (FONSI) by DOE.

Tech Area III testing activities require buffer areas adjacent to the boundaries of Kirtland Air Force Base (KAFB). The areas leased for this purpose include approximately 6,346 acres of the Pueblo of Isleta and approximately 2,747 acres of land held in trust for the University of New Mexico (UNM) by the State of New Mexico (see "4.8 Land Leased to DOE").

Past Tech Area III research and testing programs have resulted in some environmental restoration (ER) sites. Characterization and remediation of the sites is ongoing. Based on the existing data and knowledge of the operations at each site in Tech Area III, any contamination is assumed to be confined to the surface and shallow subsurface soils.

4.2.4 Tech Area IV

Tech Area IV is located south of Tech Area II on approximately 83 acres, 19 of which are fenced for security (see Figure 2-11). Tech Area IV can be accessed from 9th Street. The working population of Tech Area IV is approximately 546 (Reyes, 1997a).

Tech Area IV is a research site for pulsed-power sciences, such as x-ray, gamma-ray, and particle-beam fusion accelerators, all of which are used to simulate nuclear weapons effects and to conduct research on inertial-confinement fusion and particle-beam weapons. This tech area, too, is used industrially, as a research and development area primarily for accelerator facilities. Some of the major facilities include the following:

- High-Energy Radiation Megavolt Electron Source (HERMES) III
- Saturn Accelerator
- Repetitive High-Energy Pulsed Power Unit (RHEPP) I
- RHEPP II
- Particle Beam Fusion Accelerator (PBFA) II
- Sandia Accelerator & Beam Research Experiment (SABRE)
- Short-Pulse High-Intensity Nanosecond X-Radiator (SPHINX)
- High-Power Microwave Laboratory
- TESLA Opening Switch Facility Accelerator
- Advanced Pulsed-Power Research Module (APPRM)

Figure 2-11 indicates notable facilities and primary buildings located within Tech Area IV (March, 1997; Reyes, 1997c). Land for construction of new SNL/NM facilities is available.

Environmental restoration (ER) sites have resulted from past Tech Area IV research and testing programs. Most of the sites are related to storm drain system outfalls into the Tijeras Arroyo. The sites have been stabilized and no further action (NFA) proposals have been submitted subsequent to investigation, sampling, and remediation.

Legend

- Notable, Selected, or Infrastructure Facilities
- Buildings
- Road
- Chainlink Fence
- Barbedwire Fence
- Tech Area Boundary

SCALE 1"=1500'

Key Map

Figure 2-10. Tech Area III

Date: 08/01/99

Map ID #: 980096

Figure 2-11. Tech Area IV

4.2.5 Tech Area V

Tech Area V is located on approximately 25.5 acres adjacent to the northeast corner of Tech Area III (Figure 2-12). Approximately 159 personnel work in this tech area (Reyes, 1997a).

Tech Area V is a relatively small research area where experimental and engineering nuclear reactors and some particle accelerators are located. The Technology Support Center, which functions as office and light laboratory space, is the primary research and development building in the tech area. The reactor facility used for operation of the Medical Isotope Production Program, described in the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* (Sandia National Laboratories, 1999), is also located in Tech Area V. Figure 2-12 indicates other notable facilities and primary buildings located in Tech Area V (March, 1997; Reyes, 1997c).

In addition to DOE-owned lands within Tech Area V, approximately 6.2 acres are permitted from the U.S. Air Force (USAF) in support of security enhancement. The site proposed for a new Gamma Irradiation Facility (GIF) is currently under construction within this permitted area.

4.2.6 Other DOE-Owned Land

Other DOE-owned land includes portions of the Coronado Club site, the DOE/Albuquerque Operations Office (AL) main complex, and approximately 86 acres along the west side of Eubank Boulevard.

Portions of the Coronado Club site that include the swimming pool and parking lot areas have historically been permitted to DOE by the U.S. Air Force (USAF). However, a current DOE proposal would transfer ownership of the permitted areas of the Coronado Club site from the USAF to DOE (Garcia, 1997a).

A similar proposal involving transfer of ownership from the USAF to DOE of land to the north and south of the DOE/AL complex is under consideration. The current DOE/AL site consists of approximately 19 acres, including DOE-fee and USAF-fee portions of the site (Garcia, 1997a).

Approximately 26 acres of the 86-acre tract on Eubank Boulevard is permitted by DOE to the USAF. This acreage includes the Eubank Boulevard Gate to Kirtland Air Force Base (KAFB) and the USAF Inspection Safety Center. The remainder of the 86 acres is currently being studied for future development as a technology research park (Garcia, 1997a).

4.3 Land Owned by the U.S. Air Force (USAF) and Permitted to DOE for Use by SNL/NM

The main body of land that comprises the Kirtland Federal Complex (KFC) is owned by the U.S. Air Force (USAF) Base and has been used industrially by the USAF for weapons testing and development facilities since the 1950s. Various SNL/NM programs and facilities operate within areas of KAFB land permitted to DOE by the USAF (see Figure 2-13). These areas are generally permitted by the USAF for five-year periods, with renewals, although a few areas are permitted for 25-year periods. However, real estate permits are not necessarily terminated when a program or testing is completed. For instance, if SNL/NM facilities or environmental restoration (ER) sites exist on permitted areas, they must be decommissioned and demolished and or remediated and removed from the *Hazardous and Solid Waste Amendments (HSWA)* (42 U.S.C. §6901 et seq.) permit and the area accepted by the USAF before the real estate permit can be terminated. Therefore, some real estate permits are maintained only because of the existence of ER sites and are not actively used by SNL/NM. A process for closing out permits has not been fully developed between the USAF and DOE (Garcia, 1997a).

KAFB land permitted over the last 30 years to DOE for SNL/NM has primarily been used for testing weapons and weapon components and is considered industrial in nature. More specific information about current permits and their status and programs and facilities that operate within active permit areas appears in the *Sandia National Laboratories/New Mexico Facilities and Safety Information Document* (Sandia National Laboratories, 1999).

4.4 U.S. Forest Service (USFS) Land Withdrawn by DOE

DOE has withdrawn approximately 4,595 acres of public land administered by the U.S. Forest Service (USFS) from the Cibola National Forest (see Figure 2-14). In January 1987, DOE and the USFS updated their memorandum of understanding (MOU) for the joint administration of the Withdrawn Area (see Attachment 2-2) and reiterated in further detail the intent of Public Land Order 4569, withdrawing the land from public use. In addition to its use as the surface danger zone for the Lurance Canyon Burn Site at SNL/NM, other DOE programs, including Safeguards & Securities Central Training Academy (S&SCTA) and the Transportation Safeguards Division (TSD), also use this area. A cooperative process between the USFS and DOE will return approximately 199 acres of land withdrawn by DOE as a perpetual easement pending the revocation action by the USFS (Garcia, 1997b).

4.5 U.S. Forest Service (USFS) Land Withdrawn by the U.S. Air Force (USAF) and Permitted to DOE for Use by SNL/NM

Approximately 15,891 acres of U.S. Forest Service (USFS) land has been withdrawn from public use by the U.S. Air Force (USAF). Four areas of this withdrawal, encompassing a total of approximately 2,051 acres, were permitted to DOE by the USAF for use by SNL/NM (Medrano, 1997) (see Figure 2-14). They are used for various SNL/NM testing and research programs. Four other areas were permitted to DOE by the USAF for use by the S&SCTA and TSD.

In May 1989, the USFS and the USAF signed a memorandum of agreement (MOA) updating their joint responsibilities in the administration and management of Public Land Order 995 (see Attachment 2-3). In the MOA, both parties agreed to abide by the research and development purposes for which the land was set aside and the laws governing the protection of national forest resources.

4.6 U.S. Forest Service (USFS) Land Withdrawn by the U.S. Air Force (USAF) and Used Under a Joint Operating Agreement Between the USAF and DOE

A portion of land in the southwest part of the U.S. Air Force (USAF) Withdrawn Area is used under a joint operating agreement between the USAF and DOE (see Figure 2-15). The Starfire Optical Range, located in this jointly operated area, was established in 1976 to test new high-energy lasers. Work requiring industrial use of the land focuses on field experiments and analyses that enable laser technologies to be used in applications such as optical communications with satellites. In addition to its primary research charter, the Starfire Optical Range also supports field experiments by other groups in and outside of the Air Force Research Lab.

The Starfire Optical Range and other Air Force Research Lab groups are also engaged in research with SNL/NM to develop adaptive optics and laser technologies for laser-power beaming to satellites. This research is making possible the transfer of technology to practical and productive civilian applications (Keystone Environmental & Planning Incorporated, 1995b).

Figure 2-12. Tech Area V

Figure 2-13. U.S. Air Force (USAF) Land Permitted to DOE for Use by SNL/NM

Figure 2-14. U.S. Forest Service (USFS) Land Withdrawn By the U.S. Air Force (USAF) and DOE

Figure 2-15. U.S. Forest Service (USFS) Land Withdrawn by the U.S. Air Force (USAF) and Used Under a Joint Operating Agreement Between the USAF and DOE

4.7 Utility Easement and Right-of-Way Permits to DOE for SNL/NM Facilities

Table 2-6 lists permitted SNL/NM utility and right-of-way easements on U.S. Air Force (USAF) land. Currently, the process for returning land permitted to DOE by the USAF for the railroad right-of-way is still pending final completion (Medrano, 1997).

Table 2-6. Permitted Utility and Right-of-Way Easements

Permit Name	Use	Location Reference
Right-of-way to Electron Beam Fusion Facility	Vehicular access from Wyoming Boulevard to Tech Area IV	Figure 2-16 (A)
Electrical power line and amendments	Overhead power line; amended in 1993 for fiberoptic bank and in 1995 for 14-inch water line	Figure 2-16 (B)
Roadway permit	Access road between the 9920 Complex and the 9940 Complex	Figure 2-16 (C)
Underground electrical distribution and telephone easement	High-voltage cables between Building 9927 and the 9940 Complex	Figure 2-16 (D)
Solar facility utility easements (3)	Water lines (2) to the Solar Tower area and overhead 46-kilovolt service	Figure 2 -16 (E)
Access road to Building 9925	Access roads to Building 9925 and Lovelace Inhalation Research Institute (LIRI), formerly known as the Inhalation Toxicology Research Institute (ITRI)	Figure 2-16 (F)
Electro-Explosives Research Facility and utility easement	Overhead electrical power line and underground telephone line	Figure 2-16 (G)
Underground cable system	Underground communication cable system supporting Coyote Test Field (CTF)	Figure 2-16 (H)
Railroad right-of-way	Abandoned railroad spur	Figure 2-16 (J)
12-kilovolt power line to Madera and Lurance canyons	12-kilovolt power line for SNL/NM and DOE programs in the Withdrawn Area	Figure 2-15
Source: Keystone Environmental & Planning Incorporated, 1996a, 1996b.

Figure 2-16. U.S. Air Force (USAF) Land Permitted to DOE for SNL/NM Utility and Right-of-Way Easements

4.8 Land Leased to DOE

DOE leased approximately 9,093 acres of buffer zones located adjacent to the boundaries of Kirtland Air Force Base (KAFB) (see Figure 2-17). These buffer zones are located to the west and south of KAFB. Two areas comprise a unified buffer zone but are separate and distinct because of their ownership and the nature of the individual arrangements between the landowners and DOE and the U.S. Air Force (USAF).

Since September 1979, DOE has leased approximately 2,747 acres of land held in trust for the University of New Mexico (UNM) by the Commissioner of Public Lands. The land is part of the area known as Mesa del Sol. It is being used as a buffer zone for SNL/NM sled track operations. The land is located west of the KAFB boundary, adjacent to an area permitted to DOE by the USAF for the sled track. Currently, DOE is negotiating with the State Land Office for a short-term lease pending acquisition of the land by DOE (Garcia, 1997a).

DOE maintains a second lease agreement with the Pueblo of Isleta for approximately 6,346 acres extending south and west of KAFB southern boundary. The lease is necessary to ensure an adequate safety buffer zone to provide for the physical protection of the public from the testing activities that occur at SNL/NM's 10,000-Foot Sled Track.

The sled track buffer zone is a necessary buffer from high-speed sled-track tests that are conducted approximately 12 times per year. Examples of high-speed tests include parachute systems, sensor and sensor-fused weapon systems, and reverse ballistic impact using high-performance rocket motors.

To prepare for testing, SNL/NM personnel enter the buffer zone to set up appropriate buffer zone boundary markers and to ensure that no persons are in the area. The lease also provides for access to investigate damage or destruction. No known SNL/NM environmental restoration (ER) sites exist in either of the leased areas.

Figure 2-17. Land Leased to DOE as Buffer Zones

5.0 SURROUNDING LAND USE

5.1 Current Adjacent Land Use

The City of Albuquerque has experienced steady and dramatic growth in the last 50 years. Residential and commercial development has expanded toward the large employment bases within the Kirtland Federal Complex (KFC), as SNL/NM and U.S. Air Force (USAF) installations have expanded research and development capacities and employed more people. The once-isolated Kirtland Air Force Base (KAFB) is now a southern extension of Albuquerque and is adjacent to the Albuquerque International Sunport on the west. Much residential development has also occurred in the Manzanita Mountains to the east of the Withdrawn Area.

The following sections describe land use outside of the KFC in both a 16-kilometer (10-mile) radius area and an 80-kilometer (50-mile) radius area emanating from Tech Area V at SNL/NM. The 80-kilometer (50-mile) radius area covers approximately 20,106 square kilometers (7,854 square miles) and includes all of Bernalillo and Valencia counties and portions of Sandoval, Tarrant, Socorro, Santa Fe, Cibola, and McKinley counties. It represents a broad view of land uses surrounding SNL/NM, while the 16-kilometer (10-mile) radius area provides a more detailed view of the Albuquerque metropolitan statistical area (MSA) and the immediate areas surrounding and including SNL/NM and the KFC. Land use descriptions include land coverage and land ownership characteristics. For more information on the Albuquerque MSA, see Chapter 9, "Socioeconomics and Community Services."

The 16-kilometer (10-mile) radius area emanating from Tech Area V covers approximately 804 square kilometers (314 square miles). The KFC (including the Withdrawn Area of Cibola National Forest) represents approximately 26% of the land within this radius area. The KFC is roughly bordered on the north and west by Albuquerque, on the east by the Manzanita Mountains, and on the south by the Pueblo of Isleta.

5.2. Land Ownership

Land ownership in the 80-kilometer (50-mile) radius area of SNL/NM appears in Figure 2-18 (New Mexico Resource Geographic Information System [RGIS] Clearinghouse, 1996). Land ownership categories include:

- Public lands (Bureau of Land Management [BLM] land and wilderness areas; national forests, parks, refuges, and wilderness areas; and U.S. Fish and Wildlife Service [USFWS] refuges and wilderness areas)

Figure 2-18. Land Ownership Within the 80-Kilometer (50-Mile) Radius of SNL/NM

- State lands
- Military reservations
- Native American-owned lands
- Privately owned lands

5.3 Land Coverage

The predominant physical characteristic of a geographic area determines its land coverage designation. Land coverage within the 80-kilometer (50-mile) radius area of SNL/NM consists primarily of rangeland and U.S. Forest Service (USFS) land in the outlying and urban areas in the City of Albuquerque. Residential, commercial, industrial, and institutional land uses comprise the urban or built-up areas. These areas represent a relatively small percentage of the total land area within the 80-kilometer (50-mile) radius. Most commercial, residential, industrial, and institutional land uses are associated with the towns of the region. Albuquerque is the largest urban area within the radius. The majority of urban-related land use is concentrated in the greater Albuquerque area and consists predominately of residential and commercial uses.

Land use associated with land coverage within the 80-kilometer (50-mile) radius area of SNL/NM appears in Figure 2-19 (New Mexico Resource Geographic Information System [RGIS] Clearinghouse, 1996). Pasture and cropland is distinguished from mixed rangeland based on irrigation practices. Evergreen forest areas and deciduous forest areas are also indicated as unique areas. The built environment (urban and metropolitan areas) includes residential, commercial, and service uses.

Figure 2-20 (New Mexico Resource Geographic Information System [RGIS] Clearinghouse, 1996) shows more specific categories of land coverage occurring within the 16-kilometer (10-mile) radius area of SNL/NM.

5.4 Agricultural Land and Rangeland

5.4.1 16-Kilometer (10-Mile) Radius

Agricultural land use within the 16-kilometer (10-mile) radius area is limited to gardens and small farms and orchards located along the Rio Grande. The Rio Grande provides water for irrigating these agricultural lands.

5.4.2 80-Kilometer (50-Mile) Radius

Most agricultural land use in the 80-kilometer (50-mile) radius area of SNL/NM occurs in the Estancia Valley, east of the Manzano Mountains. Figure 2-21 illustrates this agricultural land use (New Mexico Resource Geographic Information System [RGIS] Clearinghouse, 1996). The Torrance County Farm Service Agency reports that crops grown in the Estancia Valley include corn, wheat, beans, and rye. Irrigation is used, but dry farming is also done. One dairy is located in the Estancia area. Cattle ranching also occurs on the rangeland of the Estancia Valley and east and west of the Rio Grande within the 80-kilometer (50-mile) radius south of the Kirtland Federal Complex (KFC) (Chavez, 1997).

5.5 Residential and Commercial Land Use

5.5.1 16-Kilometer (10-Mile) Radius

Figure 2-22 indicates residential and commercial land use in the 16-kilometer (10-mile) radius of SNL/NM (New Mexico Resource Geographic Information System [RGIS] Clearinghouse, 1996). Residential and commercial uses are predominant in the urban expansion that has extended toward the Kirtland Federal Complex (KFC). As Albuquerque has grown, residential and commercial infill development has extended to the northern boundary of the once-isolated KFC. The Withdrawn Area to the east extends for most of the 16-kilometer (10-mile) radius from SNL/NM, separating east mountain residential areas from SNL/NM facilities and activities. Similarly, residential or commercial development does not occur on the portion of the Isleta Reservation that borders the KFC to the south. Land to the west of the KFC includes the Albuquerque International Sunport and Mesa del Sol, an area of approximately 12,400 acres of land held in trust for the University of New Mexico (UNM) by the Commissioner of Public Lands. A DOE buffer zone comprised for approximately 2,747 acres of Mesa del Sol, is currently under negotiation acquisition for a perpetual easement of 99 years by DOE (Garcia, 1997a). Proposed future development of Mesa del Sol includes residential, commercial, industrial, institutional, and recreational uses.

5.5.2 80-Kilometer (50-Mile) Radius

Albuquerque is the center of population for the state and the largest population area in the 80-kilometer (50-mile) radius area surrounding SNL/NM. The intersection of Interstate 25 and Interstate 40 occurs in Albuquerque. Interstate 25 roughly parallels the Rio Grande through Albuquerque and southward; numerous small communities are located in this corridor. Table 2-7 identifies cities and towns with populations greater than 5,000 in 1995.

Table 2-7. Cities and Towns in the 80-Kilometer (50-Mile) Radius Area of SNL/NM

City or Town	Estimated 1995 Population
Albuquerque	418,000
Belen	6,900
City of Rio Rancho	43,800
Town of Bernalillo	7,000
Village of Corrales	6,600
Village of Los Lunas	8,000
Source: Middle Rio Grande Council of Governments of New Mexico, 1996.	

The east mountain area south of Interstate 40 in Tijeras Canyon, including the villages of Tijeras and Chilili, is mostly rural. Much of the land coverage consists of evergreen forest areas bisected by New Mexico Highway 337. The population in 1995 was estimated to be approximately 6,689 (University of New Mexico, Bureau of Business and Economic Research, 1996). The built environment consists predominantly of single family residences.

The east mountain area north of Interstate 40 is bound on the west by the Sandia Mountains and includes Cedar Crest. Land coverage is predominately evergreen forest areas. The built-up area roughly follows New Mexico Highway 14 to the north. Commercial services are located in small strip centers along this route. Commercial growth has occurred in the last few years to serve a fast-growing residential population. The population of the northeast mountain area within Bernalillo County was approximately 8,741 in 1995 (University of New Mexico, Bureau of Business and Economic Research, 1996).

Most of the commercial development in the 80-kilometer (50-mile) radius area occurs in the Albuquerque metropolitan statistical area (MSA). Commercial areas in Albuquerque are centralized in the downtown business district, at major shopping centers and malls, and in the developing Journal Center area on the north side of the city along Interstate 25. Commercial strip development also occurs along major streets, particularly in the northeast quadrant of Albuquerque.

Figure 2-19. Land Coverage Within the 80-Kilometer (50-Mile) Radius of SNL/NM

Figure 2-20. Land Coverage Within the 16-Kilometer (10-Mile) Radius of SNL/NM

Figure 2-21. Agricultural Land and Rangeland Within the 80-Kilometer (50-Mile) Radius of SNL/NM

Figure 2-22. Residential and Commercial Land Use Within the 16-Kilometer (10-Mile) Radius of SNL/NM

5.6 Industrial Land Use

5.6.1 16-Kilometer (10-Mile) Radius

The Kirtland Federal Complex (KFC), with activities of both the U.S. Air Force (USAF) and SNL/NM, is the largest industrial area in the 16-kilometer (10-mile) radius area of SNL/NM. Related commercial and industrial uses have developed in close proximity to the KFC and the Albuquerque International Sunport to the north and northwest of the KFC. Table 2-8 lists the largest industrial employers within the 16-kilometer (10-mile) radius of SNL/NM.

Table 2-8. Industrial Employers in Albuquerque

Company Name	Number of Employees	Product Type
Intel	5,100	Semiconductor components
Motorola	1,800	Ceramic products
Phillips	1,430	Semiconductor components
Honeywell	1,466	Building and avionic systems
General Electric*	925	Jet aircraft engine components
Levi Strauss	602	Men's blue jeans
Ethicon*	548	Surgical sutures
Elastimold	370	High-voltage electrical parts
Sunsoft*	250	Contact lenses
Traiser-Miller Technologies	239	Video games
SP Pharmaceuticals*	150	Pharmaceutical and biological products
Source: Guy Dameron, 1997.		
* Indicates industrial employers also located within the 16-kilometer (10-mile) radius of SNL/NM.		

The Albuquerque International Sunport, the state's largest airport, is located on approximately 1,436 acres adjacent to the northwest boundary of the KFC. Its runways are shared with the USAF. According to data produced by the Aviation Department at the Albuquerque International Sunport, 13 passenger airlines and five cargo carriers operate from the airport, which serviced approximately 6.6 million passengers in 1996 (Smith, 1997).

5.6.2 80-Kilometer (50-Mile) Radius

Small private commercial and industrial employers in the 80-kilometer (50-mile) radius of SNL/NM are located in predominantly light industrial parks in Albuquerque, and larger industrial employers operate from individual plants or manufacturing facilities. Table 2-8 lists the largest private commercial and industrial employers in Albuquerque (University of New Mexico, Bureau of Business and Economic Research, 1996).

Other airports servicing private aircraft in the 80-kilometer (50-mile) radius include the following:

- Coronado Airport, located adjacent to I-25 in north Albuquerque
- Double Eagle II Airport, on the west side of Albuquerque
- Moriarty Municipal Airport in Moriarty
- Sandia Airpark in Edgewood

5.7 Public Lands

5.7.1 16-Kilometer (10-Mile) Radius

Albuquerque city parks are distributed throughout the city. Approximately 2,125 acres are included in 255 neighborhood, community, and regional parks throughout the Albuquerque area (Martinez, 1997). In addition to public parks, the Open Space Division of the City of Albuquerque owns approximately 22,000 acres of designated open space in the Albuquerque area and manages a total of approximately 27,000 acres. The Albuquerque parks and open space areas are not all within the 15-kilometer (10-mile) radius area, but are located in the greater urban area (Linderoth, 1997).

A portion of the Cibola National Forest located in the Manzano Mountains is also within the 16-kilometer (10-mile) radius area. Approximately 20,000 acres of this forest land has been withdrawn from public use by DOE and the U.S. Air Force (USAF). See the following sections of this chapter for information on land use in the Withdrawn Area of the KFC:

- “4.3 Land Owned by the U.S. Air Force (USAF) and Permitted to DOE for Use by SNL/NM”
- “4.4 U.S. Forest Service (USFS) Land Withdrawn by DOE”
- “4.5 U.S. Forest Service (USFS) Land Withdrawn by the U.S. Air Force (USAF) and Permitted to DOE for use by SNL/NM”
- “4.6 U.S. Forest Service (USFS) Land Withdrawn by the U.S. Air Force (USAF) and Used Under a Joint Operating Agreement Between the USAF and DOE”

5.7.2 80-Kilometer (50-Mile) Radius

Public lands within the 80-kilometer (50-mile) radius of SNL/NM appear in Figure 2-23. Public lands have historically been considered as those administered by the Bureau of Land Management (BLM). However, publicly used lands have been included as public land in this discussion of land use and categorized as follows:

- U.S. Forest Service (USFS) land and wilderness areas
- National parks or monuments
- U.S. Fish and Wildlife Service (USFWS) refuges and wilderness areas
- State parks and monuments
- BLM-administered land

Portions of the Cibola National Forest and the Santa Fe National Forest are within the 80-kilometer (50-mile) radius of SNL/NM. The Sandia and Manzano Mountains, to the east of Albuquerque and the Kirtland Federal Complex (KFC), are within the Cibola National Forest. The Sandia Mountain Wilderness contains 37,232 acres, and the Manzano Mountain Wilderness covers approximately 36,970 acres. Both the Sandia and Manzano areas of Cibola National Forest are used extensively for public recreation, including hiking, bicycling, cross-country skiing, camping, picnicking, and enjoyment of the natural setting. Forest products, such as firewood, poles, posts, vigas, and latillas are available to the public by special permit from wildlife habitat restoration and fuels reduction projects (Etherton, 1997).

Stewardship efforts of the Sandia Ranger District include fuels management projects conducted to simulate the natural role fire has played in the vegetation types present. Vegetation types are resilient and contain a diversity of vegetative species and age classes. Watersheds in the area are stable and sustainable and runoffs are clean and gradual. Drainages are stable with little evidence of soil movement. Historic gully action has been stabilized and restored. Riparian areas are stable (Etherton, 1997).

Figure 2-23. Public Lands Within the 80-Kilometer (50-Mile) Radius of SNL/NM

Petroglyph National Monument is the only National Park Service area in the 80-kilometer (50-mile) radius area. The national monument was established by Congress in 1990 to protect more than 15,000 petroglyphs. It is jointly administered and managed by the National Park Service and the City of Albuquerque Open Space Division. Petroglyph National Monument is located on the 17-mile-long lava escarpment of the mesa west of Albuquerque. Not all of the monument is currently in public ownership. As land is acquired, rangers open more areas to the public (Broersma, 1997).

A portion of the USFWS Sevilleta National Wildlife Refuge is located in the southern portion of the 80-kilometer (50-mile) radius of SNL/NM. This refuge was a gift from the Campbell Family Foundation to the USFWS, to be managed as naturally as possible and to permit research by both individuals and institutions nationwide. The refuge hosts long-term ecological research by the University of New Mexico (UNM). It contains approximately 229,700 acres and provides refuge for 230 bird species, 70 mammal species (including the Mexican wolf), and 1,500 plant species (Stans, 1997).

Currently, data describing BLM land and state land is evolving as a result of a land exchange program involving transfer of land between the BLM and the State of New Mexico in order for the state to acquire more contiguous pieces of land. State land was originally acquired to be held in trust for the public school system and, therefore, consists of small one-section parcels scattered across the state (Alm, 1997). State parks within the 80-kilometer (50-mile) radius area include the following:

- Rio Grande Nature Center State Park, Bernalillo County
- Rio Grande Valley State Park, Bernalillo County
- Coronado State Park, Sandoval County
- Senator Willie M. Chavez State Park, Valencia County

The Rio Grande Nature Center State Park is a 170-acre parcel of land bordering the Rio Grande that was donated by the estate of Mr. Hugh Woodward. The mission of the nature center is "to manage and protect the unique environment along the Rio Grande and to educate the public about Rio Grande ecosystems and positive human interactions with those ecosystems" (Mauro, 1997).

The Rio Grande Valley State Park consists of approximately 5,000 acres of bosque land extending from the Sandia Reservation southward to the Isleta Reservation. The City of Albuquerque Open Space Division manages this state park (Linderoth, 1997).

Coronado State Park is located in Sandoval County, west of the Town of Bernalillo on New Mexico Highway 44. The park covers approximately 42 acres. It was instituted through the state legislature for recreational use and consists primarily of camp sites. Vegetation includes many types of trees and native grasses (Padilla, 1997).

Senator Willie M. Chavez State Park, in Belen, is located near Interstate 25 and New Mexico Highway 47 on approximately 27 acres of bosque land. Five acres are state-owned and 22 acres are leased by the State of New Mexico from the Middle Rio Grande Conservancy District (Clarence Valdez, 1997).

5.8 Native American-Owned Lands

5.8.1 16-Kilometer (10-Mile) Radius

A portion of the Pueblo of Isleta is located within the 16-kilometer (10-mile) radius area of SNL/NM. Located adjacent to the southern boundary of the Kirtland Federal Complex (KFC), Isleta is the only Native American-owned land within the 16-kilometer (10-mile) radius area. The Pueblo of Isleta, the more densely populated area of the reservation, is partially located within the radius. The majority of reservation land consists of mixed rangeland. The Pueblo of Isleta built environment is predominantly residential, with minor commercial support services.

DOE maintains a lease agreement with the Pueblo of Isleta for approximately 6,346 acres extending south and west of the KFC southern boundary. As has been stated, the lease provides for an adequate safety buffer zone for the physical protection of the public from the testing activities that occur at the SNL/NM rocket sled track.

5.8.2 80-Kilometer (50-Mile) Radius

Portions of ten Native American reservations are located within the 80-kilometer (50-mile) radius of SNL/NM. All of the reservations in the larger radius area belong to Pueblo tribes except the Canoncito Reservation, which is Navajo. The closest in proximity to SNL/NM is the Isleta Reservation, located adjacent to the southern boundary of the Kirtland Federal Complex (KFC). Reservations and their populations in 1990 appear in Table 2-9. Figure 2-24 indicates the geographical relationship between SNL/NM and each reservation. See Chapter 9, "Socioeconomics and Community Services," for more information.

**Table 2-9. Native American Populations Within an 80-Kilometer (50-Mile)
Radius of SNL/NM**

Reservation Name	1990 Population
Canoncito Reservation	1,189
Cochiti Reservation	1,342
Isleta Reservation and Trust Lands	2,915
Jemez Reservation	1,750
Laguna Reservation and Trust Lands	3,731
Sandia Reservation	3,971
San Felipe Reservation	2,434
Santa Ana Reservation	593
Santo Domingo Reservation	2,979
Zia Reservation	637
Source: Timothy Cohen and Denise R. Bleakly, 1997.

Figure 2-24. Native American-Owned Lands Within the 80-Kilometer (50-Mile) Radius of SNL/NM

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ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS

This attachment includes future land use recommendations of the Future Use Logistics and Support Working Group contained in the future use workbooks and corresponding recommendations from the Citizens' Advisory Board (CAB) for Sandia National Laboratories/DOE, formerly known as the Sandia National Laboratories/Inhalation Toxicology Research Institute (ITRI) CAB.

6.0 FUTURE USE RECOMMENDATIONS FOR MANAGEMENT AREA 1

Recommendations for future use of the land within Management Area 1, the Withdrawn Area, have been developed by the Future Use Logistics and Support Working Group for the SNL ER Project, with cooperative input of the EPA and NMED. These recommendations were determined as an interim decision-making tool for ongoing ER Project operations. The recommendation process considered the probability that future missions are likely to be associated with long-term institutional controls which will remain in place for the foreseeable future. The Working Group also took into account the existing known ER sites within the Withdrawn Area and their current status in terms of permitting, characterization, and cleanup efforts. Costs and technologies associated with cleanup levels were also considered.

Management Area 1, which includes all the of DOE and USAF Withdrawn Area, is located within the Cibola National Forest. The area has been used by the DOE and the USAF primarily for weapons testing, but land withdrawn by the DOE is also used for research and development missions and training. The USAF also maintains testing and training activities in the Withdrawn Area. The execution of past and present missions within the area have resulted in ER sites and in UXO of unknown quantities throughout a large ordnance impact zone of primarily WWII vintage.

The Future Use Logistics and Support Working Group recommends classification of Management Area 1 as recreational for purposes of future use planning and determination of appropriate cleanup levels. It assumes less exposure to users of the area than the residential or industrial cleanup levels because people do not spend as much time in recreational settings as they do in residential or industrial settings.

It is important to note certain recreational activities carry a greater potential for exposure because of the nature of the activity. Motorized trail vehicles, such as four-wheelers or dirt bikes, disturb the soil and potentially increase airborne contaminants through dust clouds. Uses that would be less likely to increase exposure hazard would be hiking or equestrian trails.

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

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Page 1 of 4

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Department of Energy
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P.O. Box 5400
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Re: Future Use Management Area 1,
Section "P" The Withdrawn Area

Dear Mr. Zamorski:

The Citizens' Advisory Board (CAB) reached a consensus recommendation on the Future Use Management Area 1, Section "P" The Withdrawn Area at the June 19, 1996 CAB meeting.

Recommendation for Future Land Use

Management Area 1, Section "P", The Withdrawn Area, should be classified Recreational for future land use only. The Committee does not include an approval for clean up level.

The committee has the following concerns:

The population of 15,430 residents in the East Mountain area is a significant factor. There are vehicles traveling throughout this area constantly. People are riding dirt bikes and horses, and hiking in parts of this area regularly. The recreational use cleanup level is based on an exposure risk of two weeks per year doing activities such as hiking and camping. This level might not be appropriate for all areas of the withdrawn area.

Currently, people use the area for frequent recreational use beyond two weeks per year, such as motor bike riders who compete and

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

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Inhalation Toxicology Research Institute

CITIZENS' ADVISORY
BOARD (CAB)

Mr. Michael J. Zamorski
June 20, 1996
Page 2 of 4

therefore practice frequently. Biking activities tend to aggravate the soil more than hiking or other recreational activities.

If the cleanup levels are recreational use levels there should be restrictions on the land now and in the future that accommodate for this level.

Restricted recreational use should be the future land use and that restricted recreational cleanup will be safe for this area, if people are infrequent visitors.

Dirt bike use should be restricted from the remaining withdrawn areas. The land should be limited to recreational use with total restriction of dirt bikes.

Concerning the risk to those who work near these sites, their contact with the remaining sites, should be restricted.

In light of our limited budget perhaps stronger measures should be taken to keep people off the contaminated areas.

The return of small sections of the Withdrawn Area, now considered, in the "Ecosystem Management Plan", is critical to logically connect trails. In the future, when any or all of the remaining withdrawn area returns to the Forest Service it should go through a public approval process as to the Forest Service's recommendation for its future. It should also go back through New Mexico Environmental Department and Environmental Protection Agency scrutiny.

There are two future land use scenarios: (1) the future use of the land while under the DOE and DOD control, (2) The future use of the land when returned to the United States Forest Service. Both

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

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CITIZENS' ADVISORY
BOARD (CAB)

Mr. Michael J. Zamorski
June 20, 1996
Page 3 of 4

future uses need to be considered when determining cleanup levels.

The following are concerns about future use of the land while under the control of the Department of Defense and Department of Energy.

1. Illegal access to the Withdrawn Area is a problem that should not be minimized.
2. Illegal access is a concern for public safety.
3. Enforcement of access control procedures should be adequate to protect the public.

Unexploded ammunition is a major concern. The whole area should be swept clean.

Lurance Canyon Burn Site produces air pollution that affects the East Mountain Area residents. There should be sufficient advance public notification, to the 15,000 residents, about the burnings.

The communication between the government agencies and residents of the east mountain areas should be enhanced. The black smoke is a public relations issue and potential health issue.

Currently, the open burn pit can only be used if the wind blows east over the mountain, thus going over two schools and making the residents unhappy. This needs to be looked into and an effort made to try and change it.

There are no defensible fuel fire breaks. The ones in place are not adequate.

**ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE
RECOMMENDATIONS (Continued)**

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Sandia National Laboratories and
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Mr. Michael J. Zamorski
June 20, 1996
Page 4 of 4

The Withdrawn Area is shared by both DOD and DOE therefore, both entities should receive any decision and recommendation given by the CAB.

This was a difficult issue, in part because it was not clear what the Department of Energy was asking of the Citizens' Advisory Board. The Future Land Use Committee met four (4) times to discuss Management Area 1, Section "P", The Withdrawn Area. The committee heard presentations which included information from Sandia National Laboratories, Department of Energy, Forest Service, East Mountain Alliance (TEMA). The committee also toured the area. The committee presented information about Management Area 1, Section "P", The Withdrawn Area, to the full Board at the April 17, and May 15, 1996 meeting.

Respectfully

Patrick J. Baca
Chair

YA:klb

cc: file
Jamie Welles

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

7.0 Future Use Recommendations For Management Area 2

Recommendations for future use of the land within Management Area 2 have been developed by the Future Use Logistics and Support Working Group for the SNL ER Project with cooperative input of the EPA and NMED. However, EPA and NMED do not currently support or reject these recommendations because appropriate public input has not yet been received. These recommendations were determined as an interim decision-making tool for ongoing ER Project operations. The recommendations consider the probability that future missions are likely to be associated with long-term institutional controls, which will remain in place for the foreseeable future. They also take into account the existing known ER sites within each of the two sectors in Management Area 2, and their current status in terms of permitting, characterization, and cleanup efforts. Costs and technologies associated with cleanup levels have also been considered.

The following sections include recommendations for each of the sectors in Management Area 2. Section 7.3 is included as a place for the CAB to address the perceptions and response generated by this document and the resulting future use recommendations.

7.1 Sector E

Sector E, which includes Areas I, II, and IV, is located on DOE land. These Areas were originally the site of intensive research and development in weapons design and development. Current missions include technology transfer and new technological research.

The Future Use Logistics and Support Working Group recommends classification of Sector E as Industrial for purposes of future use planning. This recommendation is based upon several factors, including the existence of structures and facilities suitable for industrial use and the high probability that they will continue to be used to support DOE missions. In addition to the current industrial use and presence of identified ER sites, the possibility exists that additional ER sites will be added as ongoing research projects end or facility uses change.

7.2 Sector G

Sector G is comprised of Areas III and V. Area III is used for testing and simulating a variety of natural and induced environments. Two rocket-sled tracks, centrifuges, and explosives testing sites make this area inappropriate for uncontrolled public access. Area V, which is adjacent to Area III, is the site of experimental and engineering nuclear reactors and some particle accelerators. Both of these areas are limited in terms of transportation and emergency access and utility service. Sector G differs from Sector E in that the projects of the two sectors require different facility types and development

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

densities. Although the density of development in Sector G is less, the nature of operations in this sector poses a special set of future use challenges.

The Future Use Logistics and Support Working Group recommends an Industrial classification for future use of Sector G. The presence of reactor facilities and special testing equipment (and their associated ER sites) supports the classification of this area for industrial use.

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

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March 22, 1996

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Acting Area Manager
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Albuquerque, New Mexico 87115

Re: Future Use Management Area 2
Sectors 2E and 2G, Areas I-V

Dear Mr. Zamorski:

The Citizens' Advisory Board (CAB) reached a consensus recommendation on the Future Use Management Area 2, Sectors 2E and 2G, Areas I-V at the March 20, 1996 CAB Public Meeting.

Recommendation for Future Land Use

The Citizens' Advisory Board, without limiting its right to future review of the issue, agrees with the recommendation for industrial use ; designation for sectors E and G, which consists of Areas I-V, as an "interim decision making tool" for the Environmental Restoration Project. When the institutional control by Kirtland Air Force Base ends further examination of future land use will be needed.

In this future examination it is probable additional clean up will be required to meet changing future land uses. The Citizens' Advisory Board feels the integrity of the Tijeras Arroyo needs to be preserved. The Board also feels the whole arroyo's future use should be examined, instead of looking at it in sections such as in Area IV.

The Citizens' Advisory Board recognizes that future use designations will affect the types and frequency of exposures that may occur as a result of any residual contaminate remaining on the site. In turn, this affects the nature of the remedy chosen.

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

CAB

CITIZENS' ADVISORY BOARD

Department of Energy
Environmental Management Site Specific Advisory Board
Sandia National Laboratories and
Inhalation Toxicology Research Institute

CITIZENS' ADVISORY
BOARD (CAB)

page 2
Mr. Mike Zamorski
March 22, 1996

Should land use change and should further cleanup be necessary to ensure protection of safety and health, the CAB wishes to be on record as stating that its agreement with an interim industrial use designation today also carries with it the meaning that DOE has a legal and moral obligation to cleanup any residual contaminations it has created with remedy selection for industrial use; that this is true even if there has been: (1) no failure in DOE remedial actions, (2) no discovery of new DOE contamination, and (3) no promulgation of new standards. Any action the CAB takes now that is deemed "reasonable" does not absolve DOE of its obligations to assist the Albuquerque community with any and all of its future use plans when base closure occurs and land conveyance to public or private users occurs.

Respectfully,

Patrick J. Baca

YA:kib

cc file
Jamie Welles

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

6.0 FUTURE USE RECOMMENDATIONS

The DOE has the responsibility for the determination of future land use at all SWMUs associated with the DOE or its affiliates. Establishment of future-use scenarios that include input of the public and regulators helps to assure reasonable cleanup goals and costs. The results of input from stakeholders about future-use scenarios at DOE ER sites will be provided to the EPA Region 6 and NMED as reference information. Future land uses that may be designated by the DOE include, but are not limited to, residential, industrial, and recreational.

6.1 Management Area 3, Sector B - Ross Aviation, Inc.

Ross Aviation, Inc., is an active site on KAFB land that is permitted by the DOE for use by Ross Aviation. It has no environmental statutory violations and/or cleanup agreements pending. All areas of hazardous waste activities have been evaluated for compliance with RCRA, and Ross Aviation completes an annual environmental report that includes self-assessment.

The Future Use Logistics and Support Working Group recommends classification of Management Area 3, Sector B as Industrial for purposes of future-use planning. This recommendation is based upon several factors, including the existence of structures and facilities suitable for industrial use and the high probability that the present land use will continue in the foreseeable future. No mission changes are proposed or planned at this time.

6.2 Management Area 4, Sector C - AlliedSignal Federal Manufacturing & Technologies/Albuquerque

AlliedSignal FM&T/NM is an active DOE affiliate located on KAFB land under permit to the DOE. As with other areas of KAFB, applicable environmental regulations include RCRA and Section 120 of CERCLA, which are administered by the EPA and NMED.

The Future Use Logistics and Support Working Group recommends classification of Sector C as Industrial for purposes of future-use planning. Similar to the Ross Aviation facilities, the recommendation is based on the suitability of the existing structures and facilities to industrial use and on the probability that the present land use will continue indefinitely for the existing AlliedSignal facilities and for the surrounding USAF land and facilities. No mission changes are proposed or planned at this time.

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

6.3 Management Area 5, Sector M - Manzano Administrative and Storage Area

The Manzano Administrative and Storage Area is located on KAFB land. Various structures within the area are permitted by the USAF to SNL and S&SCTA through the DOE. Some of the storage areas used by SNL are RCRA-permitted storage structures used for the storage of hazardous and mixed waste. However, there are no SNL ER sites in the Manzano Area. Therefore, it is the responsibility of the USAF to propose an appropriate future land-use classification for the Manzano Area.

6.4 Management Area 6, Sector A - Tijeras Arroyo and Arroyo del Coyote

Tijeras Arroyo and Arroyo del Coyote are the two primary surface water channels on KAFB. A number of KAFB and DOE facilities and test areas have been and continue to be located along these drainages. There are DOE ER sites associated with past disposal practices along the arroyo channels. Two of these have been described in Section 5.0 of this workbook. Others have been described in Section 4.0, Area IV, of *Workbook: Future Use Management Area 2, Sectors 2E and 2G*, as they are associated with storm drain system outfalls along the northern embankment of Tijeras Arroyo within Area IV.

The Future Use Logistics and Support Working Group recommends a Recreational classification for Sector A, Tijeras Arroyo. The basis for the recommendation is that due to the limitations on development of waterways, it is unlikely that the arroyos will ever be utilized for industrial purposes. Present and future use of the channels is expected to be limited to occasional recreational use.

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

Department of Energy

Albuquerque Operations Office

Kirtland Area Office

P.O. Box 5400

Albuquerque New Mexico 87115

APR 6 1997

Mr. Jesse Dompfeh, Chairman
Citizens' Advisory Board
2625 Pennsylvania, NE, Suite 400
Albuquerque, NM 87110

Re: Department of Energy Response to the CAB Recommendation for Future Use,
Management Areas 3, 4, 5, and 6

Dear Mr. Dompfeh:

At the March meeting of the CAB held on Wednesday March 19, 1997 the Future Land Use Subcommittee presented their recommendations on the future use of Management Areas 3, 4, 5, and 6. The full CAB approved the subcommittees recommendations. Based on the presentation the CAB approved the following recommendations:

- Area 3 - Ross Aviation Industrial future land use
- Area 4 - Allied Signal Industrial future land use
- Area 5 - Manzano Admin & Storage Area Industrial future land use
- Area 6 - Tijeras Arroyo & Arroyo Del Coyote Recreational future land use

The subcommittees recommendation included a condition on Area 6 that cleanup should be determined on a site by site recommendation and it is important to consider the areas around Tijeras Arroyo. As we've discussed previously, the designation of a land use (such as recreational or industrial) does not signify a cleanup level for any of the DOE/SNL sites within a designated area. Cleanup levels are established based on risk; human health and safety and ecological damage are considered. Only the regulatory authority (New Mexico Environment Department), after public comment, is authorized to approve a site for No Further Action (NFA) status based on a risk based clean up level.

The value of a predetermined, CAB-endorsed future use designation based on reasonable expectations for the foreseeable future (30-50 years) will help DOE/SNL better plan and implement the ER Project. Cleanup levels for designated future use scenarios will always assure acceptable protection for human health and the environment.

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

Jesse Dompree

-2-

This is the last set of areas for the Future Land Use Subcommittee to consider as part of DOE's site-wide future use study. I wish to thank the Future Land Use Subcommittee for their dedication and perseverance in completing the final recommendation for the Future Use Study presented by DOE.

If you have any questions please contact Mark Jackson at 845-6288 or me at 845-4094.

Sincerely,

Michael J. Zamorski
Acting Area Manager

cc:
D. Garcia, KAO
A. Stotts, OPA
W. Cox, 6681, MS 1147
W. Keener, 7500, MS 1054

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

11.0 MANAGEMENT AREA 7 FUTURE USE RECOMMENDATIONS

The DOE has the responsibility for determining the future use of lands associated with the DOE or its affiliates. Establishment of future-use scenarios that include input from the public and regulators helps to assure reasonable cleanup goals and costs. The results of input from stakeholders about future-use scenarios at DOE ER sites will be provided to the EPA, Region 6, and the NMED as reference information. Future land uses that may be designated by the DOE include, but are not limited to, industrial and recreational.

The majority of land encompassed by Management Area 7 is USAF-owned, with the exceptions of the Sled Track Buffer Areas (Sector F) and a strip of land adjoining the Pueblo of Isleta that was withdrawn by the DoD from the BLM. DOE use of the lands on KAFB has occurred through land use permits, described in the previous sections of this handbook. Prior to termination of permits and return of the land to the USAF, the DOE must ensure that permit areas are remediated to levels acceptable to the USAF, the regulators, and citizen stakeholders.

The Future Use Logistics and Support Working Group has considered a broad overview of current and past activities associated with DOE activities on KAFB, as well as scenarios for the future of the area. Testing, training, and research activities of both the DOE and USAF are ongoing and are expected to continue for the foreseeable future. Therefore, risk-based cleanup to an Industrial level is recommended for Management Area 7, with the exception of Sector F, DOE Buffer Zone, and Sector Q, ITRI. A Recreational level is recommended for Sector F because it is maintained for purposes of protecting the public and neither the USAF or SNL/DOE have active sites in the area.

Sector Q, comprised of the ITRI facility, has undergone cleanup to an Industrial level based on prior agreement with the EPA and NMED. Natural deterioration of the remaining contaminants, however, will result in Residential cleanup levels within 30 years.

Figure 11-1 illustrates the cleanup levels recommended by the Future Use Logistics and Support Working Group for all of the Management Areas and Sectors described in *Workbook: Future Use Management Area 1*, *Workbook: Future Use Management Area 2*, *Workbook: Future Use Management Areas 3, 4, 5, and 6*, and this document, *Workbook: Future Use Management Area 7*. The workbooks have been intended to provide the CAB an overview of the history, missions, and activities, both past and ongoing, that have affected the area within the Kirtland Federal Complex and that now influence remediation goals and efforts of the DOE and USAF.

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

CAB

CITIZENS' ADVISORY BOARD

Department of Energy
Environmental Management Site Specific Advisory Board
Sandia National Laboratories and
Inhalation Toxicology Research Institute

Page 1 of 2

October 29, 1996

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Mr. Michael J. Zamorski, Area Manager
Department of Energy
Albuquerque Operation Office/KAO
PO Box 5400
Albuquerque, NM 87115

Re: Future Use Management Area 7
Sectors D,F,H,J,K,L,N,Q

Dear Mr. Zamorski:

The Sandia/ITRI Citizens' Advisory Board reached a consensus recommendation on Future Use Management Area 7, Sectors D,F,H,J,K,L,N,Q at the October 16, 1996 CAB meeting.

COMMITTEE' CHARGE

To review and consider the recommendation given by the Department of Energy to the Citizens' Advisory Board. To advise, recommend, and comment on the DOE commendations, including concerns of the community for the current and long term site specific issues.

FACTORS TAKEN INTO CONSIDERATION IN THE DECISION MAKING PROCESS

- This is one step in a multi-step public review process.
- Future review by the Environmental Protection Agency, New Mexico Environment Department and other agencies will occur.
- Effort was made to consult with adjacent affected communities.
- Looked at process in two (2) stages; (1) the Department of Defense and the Department of Energy's current ownership, (2) and if there is land transfer.
- Members of CAB and the community will have the opportunity to comment on site by site recommendations.

ATTACHMENT 2-1 - PROPOSED FUTURE LAND USE RECOMMENDATIONS (Continued)

CAB

Page 2 of 2

CITIZENS' ADVISORY
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CITIZENS' ADVISORY BOARD

Department of Energy
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RECOMMENDATION FOR FUTURE USE MANAGEMENT AREA 7

SECTOR 7D	IGLOO AREA & TEST FACILITY	INDUSTRIAL
SECTOR 7H	TRAINING AREAS	INDUSTRIAL
SECTOR 7J	TEST SITES	INDUSTRIAL
SECTOR 7K	THUNDER RANGE	INDUSTRIAL
SECTOR 7N	COYOTE TEST FIELD	INDUSTRIAL
SECTOR 7Q	INHALATION TOXICOLOGY RESEARCH INSTITUTE	INDUSTRIAL
SECTOR 7L	PENDULUM SITE AREA	
	RECOMMENDATION FOR INDUSTRIAL FUTURE LAND USE BUT RESIDENTIAL RISK BASED CLEANUP LEVEL	

- *Not suitable for housing.*
- *Immediate proximity to new major housing developments.*
- *Comments from the affected community.*

SECTOR 7 DOE BUFFER ZONE
7Fa RECOMMENDATION FOR RISK-BASED
CLEANUP TO A RESIDENTIAL LEVEL
7Fb NO RECOMMENDATION

Sector 7Fa is the land leased from the New Mexico State Land Office. Sector 7Fb is the land leased from the Pueblo of Isleta. Because of the proposed future community development of land next to Sector 7Fa, risk-based cleanup to a residential level is recommended for this area. Because the Pueblo of Isleta is a Sovereign nation, we cannot make a recommendation for future use in area 7Fb.

Other Concerns

- Secure the boundaries for public safety.
- Unexploded ammunition.
- There is not a working relationship between the Department of Defense Environmental Working Group and the Department of Energy Citizens' Advisory Board.
- Groundwater protection is a major concern. DOE should be highly protective of the aquifer.
- DOE activities protect existing quality of the groundwater.

Respectfully,

Jesse D. Dompereh
CAB Chairman

ATTACHMENT 2-2 - MEMORANDUM OF UNDERSTANDING (MOU) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND DOE

Contract No. DE-GM04-87AL42885

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE UNITED STATES DEPARTMENT OF AGRICULTURE
AND
THE UNITED STATES DEPARTMENT OF ENERGY

This MEMORANDUM OF UNDERSTANDING (MOU) is entered into this 22nd day of January, 1987, by and between the UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE (hereinafter referred to as the SERVICE), represented by the Regional Forester, Region 3, and the UNITED STATES DEPARTMENT OF ENERGY (hereinafter referred to as the DOE), represented by the Manager of the Albuquerque Operations Office.

WHEREAS, the DOE is engaged in the conduct of energy research and development with associated security measures training; and

WHEREAS, the SERVICE has made available to the DOE the use of National Forest lands within the Cibola National Forest as needed for these purposes; and

WHEREAS, Public Land Order (PLO) 4569 dated January 16, 1969, and the proposed continuation thereof places surface management responsibilities with the Forest Service where said management does not conflict with the intent of the withdrawal; and

WHEREAS, the DOE and SERVICE agree to the continuation of the withdrawal for use under this MOU a total of 4594.63 acres of National Forest land described as:

T. 9 N., R. 4 1/2 E., NMPM

Section 12, Lots 3, 4, and SE1/4	215.87 acres
----------------------------------	--------------

T. 9 N., R. 5 E., NMPM

Section 3, S1/2NW1/4, SW1/4, S1/2SE1/4	320.00
4, S1/2, S1/2N1/2	480.00
5, S1/2, S1/2N1/2	480.00
6, Lots 15, 16, and 23	113.16
7, Lots 5, 6, 7, 9, 10 thru 21	524.58
8, All	640.00
9, All	640.00
10, All	640.00
11, W1/2NW1/4, SW1/4	240.00
17, Tracts A and B HES 414	148.45
18, Tracts A and B HES 413	152.57
Total	4594.63 acres

All in Bernalillo County, New Mexico; and

ATTACHMENT 2-2 - MEMORANDUM OF UNDERSTANDING (MOU) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND DOE (Continued)

Contract No. DE-GM04-87AL42885

WHEREAS, the SERVICE concurs with the existing withdrawal of the specified lands from all forms of appropriation under the public land laws, including the mining laws (30 U.S.C. 2) but not from leasing under the mineral leasing laws; and

WHEREAS, the original MOU required by PLO 4569 is inadequate to reflect current regulations and the Cibola Forest Plan; and

WHEREAS, this MOU supersedes the MOU between the Atomic Energy Commission and the Forest Service, U.S. Department of Agriculture, dated December 15, 1967.

Now, therefore, the parties hereto agree as follows:

A. The SERVICE will:

1. Recognize the rights of DOE as stated in PLO 4569 subject to valid claims, not excluded above, and the provisions of this MOU.

2. Retain all protection and management responsibilities as directed by PLO 4569, the Cibola Forest Plan, laws, regulations, and policy. In this regard, the SERVICE will continue to survey, inventory, and inspect all resources associated with the National Forest lands withdrawn for use under this MOU; to map, plan, and lay out conservation and protection projects; and to implement these planned projects insofar as they do not unreasonably interfere with the purposes for which the lands are used by DOE. When implementation of such projects are deemed, by DOE, to cause unreasonable interference, the SERVICE will consult DOE as early as practicable in an effort to mitigate impacts to the maximum extent practicable.

3. Provide consultation on the DOE's Five-Year Master Plan for site development. Consultation will also cover DOE current proposals for individual projects not dealt with in the plan that affect the National Forest, such as ground disturbing activities, manipulation of vegetation, and those that have potential major effects on air or water quality. SERVICE review will address advisable and/or required mitigation measures. Situations contrary to laws related to National Forest system land, and impacts which are unacceptable in implementing the project as proposed, will be corrected prior to implementation of the project.

4. Issue and administer any authorizations to occupy and use the land, taking into consideration DOE activities so that unreasonable interference does not result.

ATTACHMENT 2-2 - MEMORANDUM OF UNDERSTANDING (MOU) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND DOE (Continued)

Contract No. DE-GM04-87AL42885 -

5. Cooperate fully with the DOE in all matters relating to the use and administration of the lands for research and development purposes and for associated security training purposes. To facilitate this, the Forest Supervisor, Cibola National Forest, Albuquerque, New Mexico, is hereby designated to represent the SERVICE in matters pertaining to the administration of all National Forest land covered by this MOU. Day-to-day, on the ground administration is delegated, by the Forest Supervisor, to the District Ranger, Sandia Ranger District, Tijeras, New Mexico.

6. Legally close the area or parts of the area to public use as necessary and as authorized by applicable law and regulations.

7. Review and approve cultural resource surveys provided by the DOE. Projects can be implemented after consultation by the SERVICE with the State Historic Preservation Officer and clearance being granted by the Forest Supervisor.

8. Provide technical advice on matters relating to cultural resources.

9. Provide the DOE with a current list of cultural resources contractors that are approved and permitted to perform cultural resource related work on the Cibola National Forest.

B. The DOE will:

1. To the maximum extent practicable, construct all roads, trails, pads, ramps, experimental sites, and storage or auxiliary areas in accordance with the Cibola Forest Plan and the SERVICE's published standards, guidelines, and policies. When such standards cannot be fully satisfied, DOE will consult with the SERVICE in order to mitigate the construction impact to the maximum extent practicable.

2. Construct all sewage systems and potable water systems in compliance with applicable county, state, and federal standards.

3. Take all reasonable precautions to prevent and suppress forest fires and to exercise great care when conducting experiments involving open flame.

4. Assume complete responsibility for the prevention and/or control of radioactive contamination and contamination by other exotic agents resulting from DOE projects.

5. Prepare and issue passes, keys, identification cards, and other items or documents needed by SERVICE employees entering the area on official business.

ATTACHMENT 2-2 - MEMORANDUM OF UNDERSTANDING (MOU) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND DOE (Continued)

Contract No. DE-GM04-87AL42885..

6. Cooperate fully with the SERVICE in all matters relating to the use and administration of the National Forest System land described herein. To facilitate this, the Chief, Real Property Management Branch, Facilities and Construction Management Division, Albuquerque Operations Office, Albuquerque, New Mexico, is hereby designated to represent the DOE in all matters pertaining to the administration of all DOE activities covered by this MOU.

7. In conjunction with DOE's preparation of its Five-Year Master Plan for site development, provide the SERVICE ample time for consultation on the draft plan. Alert the SERVICE to current proposals for individual projects not dealt with in the plan that affect the National Forest, as described under item A.3. above, so as to normally provide 60 days for review and input from the SERVICE.

8. Provide archeological survey reports for all undertakings that have the potential to affect cultural resources, such as excavating trenches, scraping the earth's surface, digging, or drilling holes, penetrating the earth's surface, etc., to the SERVICE. The SERVICE will be provided a timely opportunity to review all cultural resource proposals and to concur with said proposal. To the extent possible, the SERVICE will be provided 45 days to review and provide comments or concurrence. All cultural resource contractors are required to be approved and permitted by the SERVICE prior to any activities. Cooperate with the SERVICE in obtaining full compliance with 36 CFR 800 and 36 CFR 296.

9. Provide the SERVICE, at the beginning of each fiscal year, with a list and description of its anticipated undertakings that may affect cultural resources.

10. Insure that all employees, contractors, subcontractors, etc. abide by the terms and conditions of this agreement.

11. DOE will provide all existing records relating to archeological surveys and cultural and archeological resources upon request by the SERVICE.

C. The SERVICE and DOE mutually agree that:

1. They will arrange and conduct an annual meeting of persons involved in the administration and use of lands under this MOU. The objective of the meeting will be to:

- a. Keep the lines of communication open.
- b. Review conflicts and problems and resolve them.

2. The SERVICE and DOE will jointly prepare an annual fire plan about February of each year.

ATTACHMENT 2-2 - MEMORANDUM OF UNDERSTANDING (MOU) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE AND DOE (Continued)

Contract No. DE-GM04-87AL42885

3. This MOU may be amended or modified at any time by mutual agreement of the parties by an exchange of correspondence. This MOU will be amended to reflect any change resulting from modifications of the Cibola Forest Plan where said modifications do not interfere with the intent of the withdrawal.

4. This MOU shall automatically terminate upon receipt by the SERVICE of written notice from the DOE that the land described herein is no longer needed. The DOE shall at that time request a revocation of the withdrawal.

5. Upon termination of this MOU, the DOE will remove all improvements except those identified as being beneficial to National Forest management. To the maximum extent practicable, the DOE will restore roads and experimental sites to prevent deterioration of the resources. Contaminated, toxic, or similar areas will be rendered safe for public entry prior to termination.

6. When a cultural resource mitigation plan is required, it will be prepared by the DOE, in consultation with the SERVICE, for review and approval by the Cibola Forest Supervisor. The financial responsibility for implementation of the mitigation plan will be borne by the DOE, unless otherwise agreed to by the Cibola Forest Supervisor.

In Witness Whereof, this MOU has been duly executed by the parties as of the day and year first above written.

United States Department of
Agriculture, Forest Service

United States Department of Energy

By: Thomas S. Sotero

By: Ronald W. Cochran

Name: Sotero Muniz

Name: R. G. Romatowski

Title: Regional Forester

Title: Manager, Albuquerque
Operations Office

Date: March 4, 1987

Date: January 22, 1987

ATTACHMENT 2-3 - MEMORANDUM OF AGREEMENT (MOA) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND THE U.S. AIR FORCE (USAF)

MEMORANDUM OF AGREEMENT

BETWEEN

THE UNITED STATES DEPARTMENT OF AGRICULTURE

AND

THE UNITED STATES AIR FORCE

This MEMORANDUM OF AGREEMENT (MOA) is entered into this 15th day of May, 19 89, by and between the UNITED STATES DEPARTMENT OF AGRICULTURE, FOREST SERVICE (hereinafter referred to as the SERVICE), represented by the Regional Forester, Region 3, and the UNITED STATES AIR FORCE (hereinafter referred to as the USAF), represented by the Commander, 1606 Air Base Wing, Kirtland Air Force Base, NM.

WHEREAS, the USAF is engaged in the conduct of military research, testing and development activities associated with national security and defense; and

WHEREAS, the SERVICE is willing to make available to the USAF the use of National Forest lands within the Cibola National Forest as needed for these purposes; and

WHEREAS, PLO 995 dated 19 August 1954 (as amended by PLO 5692 dated 28 January 1980), withdrew from all forms of appropriation under the public land laws including the mining and mineral leasing laws and reserved for use by the Department of the Army in connection with Sandia Base, New Mexico, now known as Kirtland Air Force Base, NM; and

WHEREAS, the original Memorandum of Understanding is inadequate to reflect current regulations and the Cibola Forest Plan; and

WHEREAS, this Memorandum of Agreement supersedes the Memorandum of Understanding between the Department of the Army (subsequently administered by the USAF) and the Forest Service, U.S. Department of Agriculture, dated 14 May 1954; and

WHEREAS, the USAF and SERVICE agree to the continuation of the withdrawal for use under this MOA a total of approximately 15,891.00 acres of National Forest land more particularly described as:

T.9 N., R. 41/2 E., NMPM,
Sections 13, 24, 25, and 36

T.8 N., R. 5 E., NMPM,
Sections 1 to 5 inclusive, those parts north
of Isleta Pueblo Grant, except 20.535 acres of
Moonray Patented mining Claim in Section 5.

ATTACHMENT 2-3 - MEMORANDUM OF AGREEMENT (MOA) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND THE U.S. AIR FORCE (USAF) (Continued)

T.9 N., R. 5 E., N-MPM,
Sections 14, 15, and 16 - All
Section 17 - N1/2, NW1/4, S1/2, SW1/4, E1/2
Section 18 - N1/2, SW1/4
Section 19-23, 26-35

Consisting of 15,891.00 acres, more or less, located in Bernalillo County, New Mexico.

WHEREAS, the SERVICE agrees with the existing withdrawal of the specified land from all forms of appropriation under the public land laws, including the mining laws (30 USC Ch 2), and the mineral leasing laws.

NOW, therefore, the parties hereto do hereby agree as follows:

A. The SERVICE will:

1. Recognize the rights of the USAF as granted in PLO 995, subject to valid claims and the provisions of this Agreement.

2. Retain protection and management responsibilities in compliance with the Cibola Forest Plan, laws, regulations, and policy. In this regard, the SERVICE will continue to survey, inventory, and inspect all resources associated with the National Forest land withdrawn for use under the MOA; to map, plan, and lay out conservation and protection projects; and to implement these planned projects insofar as they do not unreasonably interfere with the purposes for which the lands are used by the USAF. The SERVICE will consult with the USAF in an effort to determine impacts and the mitigation required to the maximum extent practicable prior to implementing the project.

3. Provide consultation on the USAF's Land Use Plan. Consultation will also cover USAF current proposals for individual projects not dealt with in the plan that affect the National Forest, such as ground disturbing activities, manipulation of vegetation, and those that have potential major effects on air or water quality. SERVICE review will address advisable and/or required mitigation measures, situations contrary to laws related to National Forest system land, and impacts which may appear unacceptable in implementing the project as proposed. The SERVICE will consult with USAF for possible correction prior to implementation of the project.

4. Issue and administer any authorizations to occupy and use the land, for non-DOD related activities through consultation and coordination with Kirtland AFB. The SERVICE will take into consideration Kirtland Air Force Base mission activities so that unreasonable interference does not result.

5. Cooperate fully with the USAF in all matters relating to the use and administration of the lands for research, testing and development purposes including the ongoing projects. To facilitate this, the District Forest Ranger, Sandia Ranger District, Tijeras, New Mexico, is hereby designated to represent the Forest Service in all matters pertaining to the administration of all National Forest lands covered by this MOA.

ATTACHMENT 2-3 - MEMORANDUM OF AGREEMENT (MOA) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND THE U.S. AIR FORCE (USAF) (Continued)

6. Recommend reasonable management alternatives for cultural resource management. Review and approve cultural resource surveys provided by the USAF. Projects can be implemented after consultation by the SERVICE with the State Historic Preservation office with clearance being granted by the Forest Supervisor, Cibola National Forest. The SERVICE will provide the USAF with a current list of suggested sources to augment the USAF source list for contractors to perform cultural resource related work. ^t

B. The USAF will:

1. To the maximum extent practicable, construct all roads, trails, pads, ramps, experimental sites, and storage or auxiliary areas in accordance with the Cibola Forest Plan and the SERVICE's minimum standards, guidelines and policies. When such standards cannot be fully satisfied, USAF will consult with the SERVICE in an effort to mitigate the construction impact to the maximum extent practicable.

2. Construct all sewage systems and potable water systems in compliance with applicable county, state, and federal standards.

~~A~~ 3. Take all reasonable precautions to prevent and suppress forest fires and to exercise great care when conducting experiments involving open flame.

4. Assume complete responsibility for the prevention and/or control of radioactive contamination and contamination by other exotic agents resulting from USAF projects.

5. Prepare and issue passes, keys, identification cards, and other items or documents needed by SERVICE employees entering the area on official business.

6. Cooperate fully with the SERVICE in all matters relating to the use and administration of the National Forest system land described herein. To facilitate this, the Director, Engineering, Construction and Development Directorate, Kirtland Air Force Base, New Mexico, is hereby designated to represent the USAF in all matters pertaining to the administration of all USAF activities covered in this MOA.

7. Provide the SERVICE ample time for consultation during the planning and drafting of the Land Use Plan for facilities and operations, and for consultation on the draft plan. Alert the SERVICE to current proposals for individual projects not dealt with in the plan that affect the National Forest, as described under item A.3. above, so as to provide ample time for review and input from the SERVICE.

8. Provide archaeological survey reports for all undertakings that could adversely affect cultural resources, such as excavating trenches, scraping the earth's surface, digging, or drilling holes, penetrating the earth's surface, etc., to the SERVICE. The SERVICE will be provided a timely opportunity to

ATTACHMENT 2-3 - MEMORANDUM OF AGREEMENT (MOA) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND THE U.S. AIR FORCE (USAF) (Continued)

review all cultural resource management proposals. To the extent possible, the SERVICE will be provided 45 days to review and provide comments or concurrence. All cultural resource contractors are required to be permitted by the SERVICE prior to any activities. Cooperate with the SERVICE in obtaining proper clearance.

9. Provide the SERVICE, at the beginning of each fiscal year, with a list and description of its anticipated undertakings that may affect cultural resources.

10. Invite the SERVICE to pertinent Environmental Protection Committee meetings for technical advice. The USAF will request the SERVICE act as a technical advisor to the Technical Advisory Subcommittee for issues involving the withdrawn land.

C. The SERVICE and USAF mutually agree that:

1. They will arrange and conduct an annual meeting of persons involved in the administration and use of lands under this MOA. The objective of the meeting will be to:

- a. Keep the line of communication open.
- b. Review conflicts and problems and resolve them.

2. The SERVICE and USAF will jointly prepare an annual fire plan about February of each year.

3. The MOA may be amended or modified at any time by mutual agreement of the parties by an exchange of correspondence. This agreement will be amended to reflect any change resulting from modifications of the Cibola National Forest Plan. This amendment will be accomplished through consultation with the USAF.

4. This MOA shall automatically terminate upon receipt by the SERVICE of written notice from the USAF that the land described herein is no longer needed. The USAF shall at that time request a revocation of the withdrawal.

5. Upon termination of this MOA, the USAF and the SERVICE shall meet and discuss the settlement and disposition of structures and improvements on the land. To the maximum extent practicable, the USAF will restore roads and experimental sites to prevent deterioration of the resources. Contaminated, toxic, or similar areas will be rendered safe for public entry prior to release.

6. When a cultural resource Mitigation Plan is required, it will be jointly prepared by the SERVICE and USAF. The financial responsibility will be borne by the USAF, unless otherwise agreed to by the Cibola National Forest Supervisor.

7. This Agreement may be terminated with 60 days notice by either party.

ATTACHMENT 2-3 - MEMORANDUM OF AGREEMENT (MOA) BETWEEN THE U.S. DEPARTMENT OF AGRICULTURE (USDA) AND THE U.S. AIR FORCE (USAF) (Continued)

In witness whereof, this Memorandum of Agreement has been duly executed by the parties as of the day and year first above written.

United States Department of
Agriculture, Forest Service

United State Air Force

By:

Title: Regional Forester
for Region 3

By:

Title: Director,
Engr, Const, Dev Directorate
Kirtland AFB, NM.

CHAPTER 3 - HYDROLOGY AND WATER RESOURCES

Contents

EXECUTIVE SUMMARY	3-5
1.0 INTRODUCTION.....	3-7
1.1 Purpose.....	3-7
1.2 Scope.....	3-7
1.3 Background Information and Data Sources.....	3-7
2.0 REGULATIONS FOR HYDROLOGY AND WATER RESOURCES USE	3-10
2.1 State and Local Regulations.....	3-10
2.1.1 New Mexico Underground Storage Tank (UST) Regulations.....	3-10
2.1.2 Water Quality Regulations.....	3-10
2.1.3 City and County Groundwater Protection Policy and Action Plan	3-11
2.1.4 City Sewer Use and Wastewater Control Ordinance	3-12
2.2 Federal Regulations	3-12
2.2.1 Clean Water Act (CWA)	3-12
2.2.2 Safe Drinking Water Act (SDWA).....	3-13
2.2.3 Discharge of Oil.....	3-14
2.2.4 Oil Pollution Prevention	3-15
2.2.5 General Environmental Protection.....	3-15
3.0 GROUNDWATER HYDROGEOLOGY.....	3-16
3.1 Overview	3-16
3.2 Hydrogeologic Setting	3-16
3.2.1 Geologic Setting.....	3-16
3.2.2 Hydrogeologic System.....	3-21
3.2.3 Groundwater System Characteristics	3-22
3.3 Hydrology.....	3-31
3.3.1 Meteorology and Groundwater Interactions.....	3-31
3.3.2 Arroyo-Groundwater Interactions.....	3-32
3.3.3 Vadose Zone Hydrology	3-33
3.3.4 Groundwater Hydrology.....	3-35
3.4 Groundwater Quality	3-44
3.4.1 Background Groundwater Quality.....	3-44
3.4.2 Groundwater Contamination at SNL/NM.....	3-47
4.0 SNL/NM SURFACE HYDROLOGY	3-49
4.1 Channels and Arroyos.....	3-49
4.1.1 Tijeras Arroyo.....	3-51
4.1.2 Arroyo del Coyote.....	3-51

4.1.3 Lurance Canyon	3-51
4.1.4 Madera Canyon	3-51
4.1.5 Sol se Mete Canyon	3-52
4.1.6 Upper Arroyo del Coyote	3-52
4.1.7 Lower Arroyo del Coyote	3-52
4.1.8 Drainages South of Arroyo del Coyote	3-52
4.1.9 Flow Data	3-52
4.2 Floodplains and Wetlands	3-58
4.2.1 Floodplains	3-58
4.2.2 Wetlands	3-62
4.3 Water Quality and Contamination Issues	3-62
5.0 SNL/NM DISCHARGES	3-73
5.1 Overview	3-73
5.2 Natural Discharges.....	3-73
5.2.1 SNL/NM Storm Water Drainage System	3-73
5.2.2 Meteorology.....	3-78
5.3 Process-Related Surface Discharges and Monitoring at the Tech Area IV Lagoons	3-79
5.3.1 Overview	3-79
5.3.2 Lagoon Discharge Plan for Tech Area IV	3-79
5.3.3 Runoff Collection System for the Lagoons.....	3-80
5.3.4 Summary of Analytical Results	3-80
5.4 Sanitary Sewer Discharges and Monitoring.....	3-82
5.4.1 Overview	3-82
5.4.2 Monitoring Stations.....	3-83
5.4.3 Permitting and Reporting.....	3-84
5.4.4 Tech Area V Radiological Screening	3-85
5.4.5 Sewer Wastewater Sampling	3-86
5.4.6 Wastewater Discharge Policy.....	3-86
5.4.7 Trend Data for Sanitary Sewer Discharges at SNL/NM	3-95
5.4.8 Summary of Monitoring Results.....	3-96
6.0 POTABLE WATER USE AT SNL/NM	3-96
6.1 Overview	3-96
6.2 Water Use Estimates	3-97
6.3 Adjustments to Metered Wastewater Flows	3-98
6.4 Water Conservation	3-98
6.4.1 Current Projects	3-99
6.4.2 Funded Future Water Conservation Projects.....	3-101
6.4.3 Proposed Project.....	3-102
7.0 REFERENCES.....	3-103
7.1 Regulations, Orders, and Laws	3-103

7.2 General References 3-104

LIST OF TABLES

3-1. Data Sources and Contents	3-8
3-2. Hydraulic Conductivity for Fluvial Facies of the Ancestral Rio Grande of the Santa Fe Group	3-24
3-3. Storage Coefficient Values from Aquifer Tests in the Santa Fe Group.....	3-27
3-4. Hydraulic Conductivity for Alluvial Fan Facies of the Santa Fe Group	3-28
3-5. Hydraulic Conductivity for Perched Aquifer Intervals in Alluvial Fan Facies of the Santa Fe Group	3-29
3-6. Shallow Alluvium and Bedrock Hydraulic Conductivity Data in Hydrogeologic Regions 2 and 3	3-30
3-7. Chloride Mass Balance Estimated Recharge Rates	3-35
3-8. Physical Characteristics of Groundwater at SNL/NM, March 1996.....	3-45
3-9. Major Ion Concentrations in Groundwater at SNL/NM, March 1996	3-46
3-10. Streamflow Data Collected from Four Local U.S. Geological Survey Gauges during Water Year 1994	3-53
3-11. Streamflow Data Collected from Four Site-Wide Hydrogeologic Characterization Gauges during Water Year 1995.....	3-54
3-12. Streamflow Data Collected from Three Storm Water Monitoring Stations in 1995 and 1996.....	3-57
3-13. 1995 Storm Water Sampling Results	3-64
3-14. 1996 Storm Water Sampling Results	3-68
3-15. Fiscal Year 1996 Surface Discharges Requests	3-74
3-16. Semiannual Water Quality Parameters, December 1996, Lagoons 1 and 2.....	3-80
3-17. Tech Area IV Water Levels Measured to Date	3-81
3-18. SNL/NM Wastewater Monitoring Station Characteristics.....	3-83
3-19. Primary Regulatory Drivers for the Wastewater Program.....	3-85
3-20. Examples of Sanitary Sewer Discharges FY1996	3-87
3-21. SNL/NM Daily Wastewater Discharge Volumes	3-97
3-22. Adjustments to Wastewater Flows	3-98

LIST OF FIGURES

3-1. SNL/NM Hydrogeologic Regions.....	3-19
3-2. Well and Spring Locations at the Kirtland Federal Complex.....	3-25
3-3. Potentiometric Surface for the Regional Groundwater System at SNL/NM and Kirtland Air Force Base	3-37
3-4. Annual Water-Level Elevation Declines in the Santa Fe Group Regional Aquifer System	3-38

3-5. Potentiometric Surface for the Perched Aquifer System Near Tijeras Arroyo.....	3-41
3-6. Remote Area Drainage Map.....	3-50
3-7. Storm Water Sampling Locations.....	3-55
3-8. Storm Water Drainages in Tech Areas I, II, and IV	3-59
3-9. 100- and 500-Year Floodplains	3-61
3-10. SNL/NM's Wastewater Monitoring Station Locations	3-84

EXECUTIVE SUMMARY

The groundwater system in the Albuquerque Basin is currently the sole source for drinking water for the Albuquerque metropolitan statistical area (MSA). Groundwater is being pumped from the aquifer system at a rate much greater than it is being replenished through recharge. The consequences of withdrawal that exceeds recharge are a rapidly declining water table and surface subsidence in the inner valley area. The short-term solution developed by the City of Albuquerque for this impending crisis is a program of water conservation with a goal of 30% reduction in water use by the year 2004. The long-term plan is the use of surface water from the San Juan River in northwest New Mexico, conveyed to Albuquerque through the Rio Chama and Rio Grande channel. This issue of future water availability has sensitized the local community to groundwater issues in the Middle Rio Grande Valley. SNL/NM, southeast and adjacent to the City of Albuquerque, overlies the eastern portion of the main aquifer of the Albuquerque Basin, and borders some of the most productive parts of the groundwater system. SNL/NM has instituted a management plan with matching water conservation goals.

Groundwater contamination at SNL/NM is associated with identified Environmental Restoration (ER) Project sites. Trichloroethylene, a commonly used solvent, is found in low concentrations but above regulatory maximums in groundwater at the Chemical Waste Landfill, located in Tech Area III, and also beneath Tech Area II. Nitrate concentrations above regulatory concentrations have been detected at the Lurance Canyon Burn Site Well, Tech Area V, and Tech Area II.

Environmental impacts on storm water at SNL/NM are difficult to assess. SNL/NM endeavors to limit exposure of stored chemicals and materials to storm water, but outdoor testing can disperse pollutants that may be transported by storm water. The semiarid climate with limited rainfall increases the potential to exceed discharge parameters. Weeks to months between storm events allows the accumulation of pollutants on surfaces such as parking lots. These pollutants are subject to transportation off site when runoff occurs.

It is the intent of SNL/NM to comply with all applicable environmental regulations and requirements and to minimize the potential for releases of toxic pollutants to the environment. Compliance is implemented by good engineering and best management practices.

1.0 INTRODUCTION

1.1 Purpose

This chapter characterizes the current state of water resources, environmental discharges, and potential water quality impacts at SNL/NM. The detail presented is necessarily limited to cover all the required areas of hydrology and water resources. Other documents that provide greater detail are cited in the chapter.

1.2 Scope

This chapter also summarizes SNL/NM historical environmental impacts on both surface water and groundwater and describes the programs that minimize the impact. SNL/NM programs that address water compliance issues are components of SNL/NM's total environmental management program. Some of the water protection programs routinely monitor water discharges and groundwater. Monitoring data is provided to help assess SNL/NM's effect on water quality. Primary water protection programs include the following:

- Sanitary Sewer Discharge Program
- Surface Discharge Program
- Spill Prevention Control and Countermeasures Program
- Underground Storage Tank Program
- Groundwater Protection Program
- Storm Water Monitoring Program

1.3 Background Information and Data Sources

Table 3-1 contains an annotated list of SNL/NM documents that provide the procedures required for water quality monitoring and sampling, sample documentation and handling procedures, analytical methods, quality assurance, quality control, reporting, and personnel qualifications at SNL/NM. Adherence to these documents provides sample results that are scientifically and legally defensible.

Table 3-1. Data Sources and Contents

Data Source	Contents
MN471001, <i>ES&H Manual</i> , ^a Chapter 10, Section F, "Oils, Greases, and Fuels"	Details process to prevent any discharge of oils, greases, or fuels from reaching any navigable waters of the United States or any tributaries of such waters
MN471001, <i>ES&H Manual</i> , ^a Chapter 10, Section H, "Discharges to the Sanitary Sewer System"	Documents guidance process for minimizing the discharge of pollutants into the sanitary sewer system and details reporting requirements
MN471001, <i>ES&H Manual</i> , ^a Chapter 10, Section K, "Underground Storage Tanks"	Outlines the SNL/NM process to manage and maintain underground storage tanks (USTs) in a manner that prevents releases and protects the environment from the harmful effects of leaks and discharges from USTs
MN471001, <i>ES&H Manual</i> , ^a Chapter 10, Section T, "Surface and Storm Water Discharges"	Directs minimization of the potential for discharges of pollutants into the storm drain system or onto the surface
Plan 90-11, <i>Spill Prevention, Control, and Countermeasure Plan</i> ^b	Defines SNL/NM's comprehensive plan to meet regulatory requirements for spill prevention, control, and countermeasures
<i>Sandia National Laboratories Facility Response Plan</i> ^c	Specifies available oil spill response resources
<i>SNL/NM Groundwater Protection Management Program Plan (GWPMPP)</i> ^d	<p>The plan is reviewed annually and updated triennially as needed. The plan also:</p> <ul style="list-style-type: none"> • Documents the SNL/NM Groundwater Protection Program as established by DOE 5400.1 requirements • Identifies federal, state, and local laws and regulations pertaining to groundwater at SNL/NM • Describes site hydrogeology and relevant groundwater processes • Identifies SNL/NM activities and facilities that utilize or store hazardous and/or radioactive materials • Evaluates the potential to contaminate groundwater; discusses Environmental Restoration (ER) Project activities relating to groundwater characterization and contamination remediation • Details groundwater protective measures, including monitoring well registration and oversight, groundwater monitoring plans, and activities
<i>SNL/NM Annual Site Environmental Reports (ASERs)</i>	<ul style="list-style-type: none"> • Presents summary environmental data to characterize site environmental management performance, confirm compliance with environmental standards and requirements, and highlight significant programs and efforts • Refers readers to other more comprehensive documents

Table 3-1. Data Sources and Contents (Continued)

Data Source	Contents
<i>SNL/NM Annual Groundwater Monitoring Report^e</i>	<p>This report is submitted to the DOE-Kirtland Area Office (KAO) for transmittal to the U.S. Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED). The report also:</p> <ul style="list-style-type: none"> • Describes data collection activities to characterize groundwater quality • Tabulates groundwater data for the SNL/NM Groundwater Protection Program and the ER Project for the preceding calendar year • Provides baseline information on groundwater quality and identifies groundwater contamination • Provides information on water level trends for the Kirtland Air Force Base (KAFB) area
<i>Plan 92-06, Wastewater Sampling and Analysis Plan^f</i>	<ul style="list-style-type: none"> • Documents SNL/NM's wastewater sampling and analysis procedures • Provides direction for sampling activities
<i>Handbook for Sampling and Sample Preservation of Water and Wastewater^g</i>	Details standard procedures to follow during field collection of liquid samples
<i>PG470187, Water Quality Program^h</i>	Defines responsibilities and procedures for meeting regulatory requirements
<i>Solvent Management and Discharge Control Planⁱ</i>	<ul style="list-style-type: none"> • Documents compliance with City of Albuquerque permit requirements • Addresses procedures SNL/NM follows to minimize introducing pollutants to the environment
<i>Wastewater Monitoring Program Monthly Report</i>	Documents results of monitoring activities and is used in trending analyses
<i>Semiannual Wastewater Monitoring Report</i>	Documents compliance with permit requirements and City of Albuquerque's Sewer Use and Wastewater Control Ordinance
<i>Plan 92-20, Septic System Monitoring Sampling and Analysis Plan^j</i>	Documents procedures for septic tank monitoring
<i>Plan FOP 92-05, Field Operating Procedures for Septic Tank Systems^k</i>	Provides direction on proper procedures for obtaining samples from septic systems
<p>Sources:</p> <p>^a Sandia National Laboratories, 1998.</p> <p>^b E. Park, 1992.</p> <p>^c J. Bonaguidi, 1997.</p> <p>^d Sandia National Laboratories, 1997a.</p> <p>^e Sandia National Laboratories, 1997b.</p> <p>^f Sandia National Laboratories, 1996a.</p> <p>^g U.S. Environmental Protection Agency, 1982.</p> <p>^h Sandia National Laboratories, 1994a.</p> <p>ⁱ A. Jones, 1995.</p> <p>^j IT Corporation, 1995a.</p> <p>^k IT Corporation, 1995b.</p>	

2.0 REGULATIONS FOR HYDROLOGY AND WATER RESOURCES USE

2.1 State and Local Regulations

Primary state and local regulations detail standards for the protection of existing and attainable uses of waters of the State of New Mexico. These regulations include:

- 20 NMAC 5, *New Mexico Underground Storage Tank (UST) Regulations*
- 20 NMAC 6, *New Mexico Water Quality Regulations*
- *Albuquerque/Bernalillo County Ground-Water Protection Policy and Action Plan* (Albuquerque City Council and Bernalillo County Board of County Commissioners, 1995)
- *City of Albuquerque Sewer Use and Wastewater Control Ordinance* ('74 Code, §8-9-1 and 8-944.H)

2.1.1 New Mexico Underground Storage Tank (UST) Regulations

New Mexico underground storage tank (UST) regulations (20 NMAC 5) apply to any owner and operator of a regulated UST system. The UST regulations have specific requirements for the installation, operation, maintenance, modification, and closure of a UST system.

2.1.2 Water Quality Regulations

20 NMAC 6, *New Mexico Water Quality Regulations* - These regulations address water quality protection of New Mexico interstate and intrastate streams, surface water, and groundwater. Notification to the Groundwater Protection and Remediation Bureau and/or the Surface Water Quality Bureau is required before any discharge that includes a new water contaminant. Notification to these bureaus is also required if the character or location of a discharge changes.

20 NMAC 6.1, *Standards for Interstate and Intrastate Streams* - These standards designate the uses for which surface waters of the State of New Mexico shall be protected. Established general standards include stream bottom deposits, floating solids, oil, grease, color, odor and taste of fish, plant nutrients, and toxic substances.

20 NMAC 6.2, *Water Quality, Groundwater and Surface Water Protection* - These regulations, consisting of five sections, are promulgated under the authority of the New Mexico Water-Quality Control Commission (NMWQCC). The regulations are administered by the NMWQCC with specific functions delegated to the New Mexico Environment Department (NMED) Groundwater Protection and Remediation Bureau and Surface Water Quality Bureau.

Section 1 establishes requirements for prior notification of any water contaminant discharge. A procedure for notification of any unauthorized discharges and subsequent corrective actions is defined.

Section 2 prohibits the discharge of effluents exceeding specified concentrations of biological oxygen demand (BOD), chemical oxygen demand (COD), settleable solids, fecal coliform bacteria, and pH. The standards for discharges to the water courses in the Rio Grande basin are further limited by more restrictive standards of the identified effluent parameters. This section also prohibits the disposal of refuse in a natural water course or a location where there is reasonable expectation that the refuse may be moved into a natural watercourse.

Section 3 defines groundwater standards and requires that a discharge plan be filed and approved prior to the discharge of any effluents or leachate that may directly or indirectly move to groundwater. Specific exemptions from the discharge plan are allowed. The Groundwater Protection Bureau has determined that, in the event that groundwater monitoring samples exceed the established groundwater standards, the notification and corrective actions procedure established in Section 1 is applicable under the presumption that a discharge has occurred.

Section 4 sets forth the requirements for the abatement of pollution of groundwater and surface water, in the event that the corrective actions proposed under the discharge notification requirements of Section 1 are not deemed appropriate in returning the water quality of the affected waters to their designated use for domestic or agricultural water supply.

Section 5 establishes regulations for effluent disposal wells and in situ extraction wells.

2.1.3 City and County Groundwater Protection Policy and Action Plan

The *Albuquerque/Bernalillo County Ground-Water Protection Policy and Action Plan* was adopted by Bernalillo County in 1993 and by the City of Albuquerque in 1994 (Albuquerque City Council and Bernalillo County Board of County Commissioners, 1995). The plan acknowledges that vast areas of groundwater within the city and the county are already contaminated and contains specific policies to prevent further contamination and remediate contaminated sites. To implement these policies, the plan includes three specific actions: (1) the establishment of a

groundwater protection ordinance and joint powers agreement, (2) the establishment of a groundwater protection board, and (3) the institution of a memorandum of understanding (MOU) with the federal government, which will allow city and county scrutiny of federal facility compliance with applicable laws and regulations.

Because groundwater from Kirtland Air Force Base (KAFB) flows toward city water supply wells, local government interest in SNL/NM groundwater protection policies and programs will increase as concern over groundwater quality and availability intensifies, and as the metropolitan area's population increases and water demand grows.

2.1.4 City Sewer Use and Wastewater Control Ordinance

Sanitary sewer discharges from SNL/NM are in compliance with the *City of Albuquerque Sewer Use and Wastewater Control Ordinance* ('74 Code, § 8-9-1 and 8-944.H; Ordinance 21-1985; Am. Ordinance 42-1996). The ordinance sets uniform requirements for users of the city's wastewater collection system and treatment works to enable the city to comply with provisions of the *Clean Water Act (CWA)*, and other applicable federal and state laws and regulations. The ordinance provides the means for determining wastewater volumes, constituents, and characteristics, and for the issuance of permits for system users. The ordinance also establishes effluent limitations and other discharge criteria to prevent the introduction of pollutants into the publicly owned treatment works (POTW).

2.2 Federal Regulations

The primary objective of all federal water quality regulations is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. This objective is achieved at SNL/NM through controls on discharges, surface water and groundwater monitoring, and an effective occurrence management system.

2.2.1 Clean Water Act (CWA)

The *Federal Water Pollution Control Act*, commonly known as the *Clean Water Act (CWA)*, dictates the regulation of industrial wastewater discharges to any waters of the United States. The CWA establishes and enforces regulations for industrial discharges and publicly owned treatment works (POTW). The CWA directed the U.S. Environmental Protection Agency (EPA) to develop guidelines and standards in 40 CFR 401-471, Subchapter N, *Effluent Guidelines and Standards*, which gives EPA the authority to enforce the National Pollutant Discharge Elimination System (NPDES).

The National Pollutant Discharge Elimination System (NPDES) Permit Program establishes the requirement of a permit to discharge storm water runoff from industrial sites into U.S. waters. There are currently three activities at SNL/NM that are classified as primary industrial activities, which require storm water discharge permitting and monitoring: (1) electronics manufacturing, (2) hazardous waste storage and shipping, and (3) scrap and waste recycling. On August 25, 1997, EPA Region VI issued SNL/NM NPDES Storm Water Multi-Sector General Permit Number NMR05A181.

Construction sites that disturb more than five acres of soil are also required to obtain a storm water runoff discharge permit. SNL/NM presently has a surface disturbance permit at one site. No significant variances were noted in 1996. Results from tests on 1996 storm water runoff samples showed that no analytes indicated the presence of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), organo-chlorinated pesticides, polychlorinated biphenyls (PCBs), and/or constituents from explosive and radiological testing. See "4.3 Water Quality and Contamination Issues" for analytical results from 1995 and 1996 storm water sampling.

A State Pollutant Discharge Elimination System (SPDES) permit, required in some states, is not required in New Mexico.

2.2.2 Safe Drinking Water Act (SDWA)

The *Safe Drinking Water Act (SDWA)*, established in 1976, was significantly amended in 1986. The law is being considered for reauthorization and likely will be amended again. The initial law was enacted to establish and maintain drinking water supplies at levels safe for human consumption. To that end, the SDWA authorizes the U.S. Environmental Protection Agency (EPA) to establish national drinking water standards. EPA has promulgated the *National Primary Drinking Water Regulations (NPDWR)* (40 CFR 141) that are based on health risks, and it has also established *National Secondary Drinking Water Regulations (NSDWR)* (40 CFR 143). The latter standards are based on aesthetic characteristics of water quality.

The primary standards are enforceable for public water supplies. States are required to adopt standards at least as stringent as primary standards. Drinking water at SNL/NM is supplied from Air Force-operated and -owned wells at Kirtland Air Force Base (KAFB). Responsibility for compliance with the standards has been assumed by the Air Force. The primary standards are also significant in that they have been incorporated into groundwater quality standards for the *Resource Conservation and Recovery Act (RCRA)* of 1976 and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)*. The impact of the primary standards on SNL/NM is through their RCRA implementation. Also included in the

law are requirements for EPA to establish protection programs and regulations for drinking water sources.

As the principal source of drinking water for 50% of the general and 90% of the rural population nationally, groundwater is the main focus of source protection. The EPA has developed three programs to address groundwater source protection. The most mature program is the Underground Injection Control Program. This program regulates the injection of potential contaminants into groundwater that may serve as a potential source of drinking water. In New Mexico, underground injection wells are regulated by the Water Quality Control Commission (20 NMAC 6).

The second program directed toward protecting groundwater sources through SDWA requirements is the Well Head Protection Program. EPA has requested states to submit Well Head Protection Program regulations for approval and has made funds available to the states for the development of the regulations. The Well Head Protection Program is not mandatory, and only 26 states have submitted regulations. New Mexico has not submitted a Well Head Protection Program to the EPA.

The final protective measure for groundwater drinking water authorized by the SDWA is protection of *Sole Source Aquifers* (40 CFR 149). States can nominate, and the EPA can designate, a groundwater system as a sole source aquifer if the system is the sole or principal drinking water source for an area and if its contamination would create a significant hazard to public health. The designation of sole source aquifer has two primary legal consequences: (1) it prevents federal financial assistance to projects that have the potential to contaminate the designated groundwater system; and (2) it qualifies local governments having jurisdiction for financial grants to assist in developing and implementing demonstration projects for management plans of the designated sole source aquifer. Congress has not appropriated funds to support the grant program.

Although EPA has designated 56 groundwater systems as sole source aquifers, the groundwater system supplying drinking water for the Albuquerque metropolitan area, including KAFB and SNL/NM, has not been submitted for sole source aquifer protection.

2.2.3 Discharge of Oil

Regulation 40 CFR 110, *Discharge of Oil*, prohibits the discharge of oil into navigable waters of the United States or adjoining shorelines.

2.2.4 Oil Pollution Prevention

Regulation 40 CFR 112, *Oil Pollution Prevention*, establishes procedures and requirements to prevent the discharge of oil from non-transportation-related onshore facilities into navigable waters of the United States.

2.2.5 General Environmental Protection

DOE 5400.1 establishes environmental protection program requirements, authorities, and responsibilities for DOE operations to ensure compliance with applicable federal, state, and local environmental protection laws and regulations, executive orders, and internal department policies. The order requires notification of the Headquarters Emergency Operations Center of the significant, nonroutine release of any pollutant or hazardous substance concurrent with notification to any regulatory agency. For all DOE facilities that have significant environmental protection programs, an annual site environmental report (ASER) is prepared to summarize environmental data that characterize performance of site environmental management, show compliance with environmental standards and requirements, and highlight significant programs and efforts.

In addition to the requirement of long-range environmental protection plans for each site, DOE 5400.1 specifies several special program plans, including the development of a Groundwater Protection Management Program Plan that contains the following:

- Documentation of the groundwater regime with respect to quantity and quality
- Design and implementation of a groundwater monitoring program to support resource management and comply with all applicable environmental laws and regulations
- A management program for groundwater protection and remediation, including specific *Safe Drinking Water Act (SDWA)*, *Resource Conservation and Recovery Act of 1976 (RCRA)*, and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)* actions
- A summary and identification of areas that may be contaminated with hazardous substances, and strategies for controlling these contaminants
- A remedial action program that is part of the site CERCLA program required by DOE 5400.4
- Decontamination and decommissioning (D&D) and other remedial programs

The order also requires the development of environmental monitoring programs, including a Groundwater Monitoring Program, for determining and documenting the effects of DOE operations on groundwater quality and quantity, and demonstrating compliance with DOE requirements and applicable federal, state, and local laws and regulations.

3.0 GROUNDWATER HYDROGEOLOGY

3.1 Overview

This section, a summary description of the current state of knowledge of the Kirtland Federal Complex (KFC) hydrogeologic system, integrates relevant information from existing reports, from ongoing environmental programs in the Albuquerque and Kirtland Air Force Base (KAFB) area, and from SNL/NM Environmental Restoration (ER) Project investigations. Descriptions in “3.2 Hydrogeologic Setting,” include structure, topography, and sedimentology as they pertain to groundwater occurrence and movement. Elements of the local hydrogeologic system, described in “3.3 Hydrology,” include meteorology, surface-water infiltration, the vadose zone, and the saturated zone. These elements are considered with geologic factors to detail the occurrence of groundwater including the depth to water at various locations, historical trends in water levels and water table declines, and the general direction and rate of groundwater movement. The last section, “3.4 Groundwater Quality,” addresses groundwater quality issues at SNL/NM. The geochemistry of groundwater is detailed, incorporating the spatial variation in water chemistry and the determinative factors of local mineralogy and sedimentology.

3.2 Hydrogeologic Setting

A description of the hydrogeologic setting provides a framework for better understanding of factors that affect the Kirtland Federal Complex (KFC) hydrogeology. Geologic factors can affect contaminant flow paths from the surface into and through the vadose zone, and ultimately into the saturated zone.

3.2.1 Geologic Setting

Several major rift-bounding faults present on the Kirtland Federal Complex (KFC) include north- and northeast-trending faults along the base of the Manzano Area and the Manzanita Mountains (e.g., Sandia and Coyote faults) and faults located west of the range front (e.g., Hubbell Springs fault and the West Sandia fault) (see Figure 3-1). They generally are west-dipping normal faults. The Tijeras fault zone, a major structural feature cross-cutting the Rio Grande rift, predates the development of the Albuquerque Basin. The term “zone” in this

context refers to the presence of several branching, subparallel fault strands with extensively sheared rock material between them. The faults in the zone demonstrate near-vertical dips with normal and extensive left-lateral displacement. On SNL/NM, the Tijeras fault zone extends from southwest of the Manzano Area, where it intersects or merges with the Sandia and Hubbell Springs faults, to the northeast through Tijeras Canyon, where it separates the Sandia and Manzanita Mountains.

The primary sedimentary structure of the Albuquerque Basin is collectively termed the Santa Fe Group. The Santa Fe Group consists of complexly interstratified gravels, sands, silts, and clays representing basin filling synchronous with basin rifting between approximately 30 and five million years ago. These sediments were deposited as alluvial fans derived from the nearby mountains, as sediments transported by rivers from source areas outside the basin, or as locally thick playa-lake and eolian deposits (Kelley, 1977; Lozinsky, 1988; Ingersoll et al., 1990, 1280-1296; Hawley and Haase, 1992). Buried soil horizons are common within these sediments. The Santa Fe Group is over 14,500 feet (4,421 meters) thick in the deepest part of the basin, near the western margin of the KFC. The basin-fill sediments have three major hydrostratigraphic divisions, based on depositional environment and age: the lower, middle, and upper Santa Fe Units. At the KFC, the basin-fill sedimentation history was directly controlled by the uplifted areas to the east. Rates of sedimentation were dictated by paleoclimatic conditions, effects of eastern mountain-front uplift, and the flow characteristics of the through-flowing ancestral Rio Grande as an aggradational source.

The lower Santa Fe Unit is not known at present to form a part of the Albuquerque Basin fresh-water aquifer system. The middle Santa Fe Unit forms a major part of the basin-fill aquifer system in the northern Albuquerque Basin, but only forms a minor portion of the aquifer system near the KFC. Primary water-bearing units near the KFC are the upper Santa Fe Unit and post-Santa Fe Group sediments.

Hawley and Haase (1992) divided the 1,200-foot (366-meter) thick upper Santa Fe Unit into three subunits based on sediment source terranes. Two of these subunits are significant parts of the stratigraphic framework within the eastern Albuquerque Basin area. One subunit associated with the KFC area contains coarse-grained, alluvial fan and piedmont-veneer facies extending westward from the bases of the Sandia, Manzanita, and Manzano uplifts. This facies is characterized by poorly sorted, weakly stratified sand and conglomerate, with an abundant silt and clay matrix. At its western extent, this facies is interlayered with a second subunit that includes cross-stratified, thick, clean sand and pebbly gravel deposits of the ancestral Rio Grande. Approximately five million years ago, a through-flowing river system was established in the basin (Lozinsky and Tedford, 1991). This system formed a large aggradational plain along the axis of the basin. Fine- to medium-grained overbank sediments were deposited in areas where major river subsystems merged, and in basin-floor and piedmont-slope transition

zones. Interfingering of these two subunits has been documented in the KFC area west of the fault complex. Differentiation of the two subunits is based, in part, on the presence of river-borne volcanic detritus in the ancestral Rio Grande facies. These deposits were derived, in part, from basalts, andesites, rhyolite flows, and pyroclastic units deposited in the northern portion of the Albuquerque Basin or brought into the basin by the river from what is now northern New Mexico.

Post-Santa Fe Group Units include alluvial fan, fluvial, eolian, playa, colluvial, and floodplain deposits (Lambert, 1968; Hawley and Haase, 1992). These sediments reflect deposition in the area between the Manzanita Mountains and the Rio Grande after the most recent period of down-cutting of the Rio Grande and partial backfilling episodes. For the past 10,000 to 15,000 years, the basinal areas have aggraded because of a relatively high rate of sedimentation compared to the ability of drainages to remove the sediments.

Multiple alluvial fans, present throughout much of the KFC, are derived from the Manzano Area and Manzanita Mountain range. Discontinuous fluvial terraces, inset into older alluvial fans along major drainages, interfinger with younger alluvial fans. Eolian deposits include active and stabilized dunes, and eolian sheets that cover and modify alluvial deposits. Colluvium is present within the steep terrain of the mountains, and playa deposits are present in topographic and structural depressions in westernmost KFC. Buried soils are common within many of these surficial deposits.

3.2.2 Hydrogeologic System

Kirtland Federal Complex (KFC) topography is characterized by a series of coalescing alluvial fans of Holocene age that extend from the base of the mountains to the east to terraces along the Rio Grande. The north- to south-striking Sandia fault enters the base from northwest of the Four Hills that comprise the Manzano Area uplift; almost co-linearly, the Hubbell Springs fault enters from the south, and the Tijeras fault cuts the base diagonally from the northeast. The fault system bisects the area occupied by the KFC. East of the Hubbell Springs and Sandia faults, the fan deposits rest on eroded pediment slopes with outcrops at various locations of Paleozoic and Precambrian rocks (Thorn, McAda, and Kernodle, 1993). West of the faults, the bedrock plunges into the basin, and the hydrogeologic setting consists of thick sedimentary deposits. Primarily on the basis of the complex fault structure, the local groundwater system can be divided into three distinct hydrogeologic regions: Hydrogeologic Region 1 (HR-1) is the region west of the fault system; Hydrogeologic Region 2 (HR-2) is associated with the fault system; and Hydrogeologic Region 3 (HR-3) is east of the fault system (Sandia National Laboratories, 1994b). Figure 3-1 shows the locations of the three hydrogeologic regions. Boundaries between these regions serve only to identify approximate geographic areas.

Hydrogeologic Region 1 - The uppermost aquifer underlying HR-1 is within the upper Santa Fe Group, and is an unconsolidated to partially indurated, porous-media aquifer. The upper Santa Fe Group sediments that provide the framework for this aquifer include a heterogeneous mixture of coarse- to fine-grained sands, silts, and clays that exhibit a complex structure, characterized by variability in bedding thickness, continuity, and connectivity. The complex sedimentary framework is reduced to two major subsets: the ancestral Rio Grande fluvial facies and the alluvial fan facies, extending westward from the highlands across the fault zone and into the basin. Their juncture is effected by mutual interfingering rather than a distinct, well-defined boundary. The fluvial facies includes thick, well-sorted, cross-stratified sand and pebbly gravel channel deposits, and fine- to medium-grained sand overbank deposits. This fluvial facies is characterized by well-developed bedding, with channel deposits generally oriented north-south. The alluvial fan facies is characterized by poorly sorted, weakly stratified sand and conglomerate with an abundant silt and clay matrix. In this facies, the bedding is less continuous, with channel deposits generally oriented east-west.

Hydrogeologic Region 2 - HR-2 straddles the Sandia/Tijeras/Hubbell Springs fault complex. The subsurface geology of HR-2 includes Santa Fe Group sediments to the south, a poorly-to-moderately cemented Tertiary conglomerate near the center, and Paleozoic/Precambrian bedrock to the north. The saturated zone hydrology is characterized by a flow system complicated by the juxtaposition of different stratigraphic units across one or more faults. The faults themselves also have a significant impact on groundwater flow. Appropriate documents related to the hydrogeologic framework in this region include

publications by SNL/NM (1994b, 1995a), Haneberg (1995, 1815-1820), the U.S. Geological Survey (USGS) (1992a), Lozinsky (1988), Grant (1982, 325-331), Riddle and Grant (1981), Kelley (1977), Kelley and Northrop (1975), and Titus (1963).

Hydrogeologic Region 3 - HR-3 is in the eastern portion of the area occupied by the KFC. The bedrock stratigraphy includes an unnamed, lower Tertiary unit; Paleozoic Yeso, Abo, Sandia, and Madera formations; and Precambrian igneous and metamorphic rocks. Faulting complicates this general stratigraphic framework. A thin veneer of alluvial material overlies portions of the bedrock. The saturated zone hydrology includes shallow, unconfined alluvial aquifers (especially in the foothill canyons) and confined bedrock aquifer systems. The bedrock aquifers include one or more confined porous-media aquifers in sandstones of the Paleozoic units (Yeso, Abo, and Sandia formations), and one or more confined fractured aquifers in the Paleozoic Madera limestone and Precambrian rocks. Appropriate documents related to the hydrogeologic framework for this region include publications by SNL/NM (1994b, 1995a), Calvin et al. (1982, 191-196), Titus (1980), Kelley (1977), Myers and McKay (1970, 1976), Kelley and Northrop (1975), and Reiche (1949).

3.2.3 Groundwater System Characteristics

Groundwater characteristics within the Kirtland Federal Complex (KFC) area vary among and within the three hydrogeologic regions previously defined as HR-1, 2, and 3. These characteristics include aquifer types (i.e., unconfined/confined, porous media/fractured rock, and regional/perched), hydraulic properties (hydraulic conductivity, storativity, and porosity), horizontal groundwater-flow directions, vertical hydraulic gradients, trends in water-level decline resulting from water supply pumping, and groundwater geochemistry. Many of these characteristics are directly related to the geologic media that provide the local framework for the regional aquifer. Aquifer types and associated hydraulic properties are discussed below. Groundwater flow directions, gradients, and water level trends are discussed in "3.3.4 Groundwater Hydrology." Groundwater geochemistry is discussed in "3.4 Groundwater Quality."

Aquifer Types - The regional aquifer underlying HR-1 and the southern portion of HR-2 is a porous media aquifer in the upper unit of the Santa Fe Group. In HR-1, this upper unit includes two depositional facies: a fluvial facies deposited by the south-flowing ancestral Rio Grande and an alluvial fan facies deposited into the basin from the eastern mountains. These two facies intertongue along a north-south trend that bisects the locale near SNL/NM Tech Area III and Tech Area V. In the alluvial fan facies, field data from boreholes drilled in 1992 at SNL/NM's Liquid Waste Disposal System (LWDS) site and the Mixed Waste Landfill (MWL) indicate that the uppermost part of the aquifer may be semiconfined (Sandia National Laboratories, 1993a).

Shallow groundwater above the regional aquifer has been identified near Tech Area II underlying a large area extending from the Tijeras Arroyo Golf Course northwest to the WYO-1 monitoring well location. Depth to groundwater in this perched zone ranges from 268 to 325 feet below ground surface (Sandia National Laboratories, 1996b). Based on a comparison of water level dynamics in wells completed in the shallow zone and the dynamics in nearby wells in the regional aquifer, the two aquifers appear to not be hydraulically connected. Furthermore, based on the analysis of core and geophysical well logs, the sediments between the two zones do not appear to be continuously saturated. Shallow saturation may exist at other areas where natural or induced recharge is concentrated.

The uppermost aquifer in HR-2 occurs in three very different types of geologic media. In the southern portion of HR-2, the uppermost aquifer is a porous media aquifer in the alluvial fan facies of the upper Santa Fe Group. In the central portion of HR-2, between the Tijeras and Hubbell Springs faults, the aquifer unit is a poorly-to-moderately well-cemented Tertiary conglomerate. A pilot borehole drilled at the Solar Tower West (STW) monitoring well location indicated the conglomerate extended to a depth greater than 500 feet (see Figure 3-2). Several instances of significant loss of drilling fluid circulation during drilling at the STW location suggest the conglomerate may be weakly cemented or significant fractures exist within the cemented conglomerate. Based on this interpretation, the aquifer in this segment of HR-2 may exhibit both porous media and fracture flow characteristics. The northern portion of HR-2 includes the area between the Sandia and Tijeras faults. In this area, the uppermost aquifer may be in the thin alluvial cover or in the underlying granitic bedrock. An aquifer present in the shallow alluvium is an unconfined, porous-media aquifer. Where the uppermost aquifer is present in granitic bedrock, it is typically confined and fractured.

In HR-3, the uppermost aquifer is in shallow alluvium, occurring locally in the foothill canyons and on the gently sloping piedmont surface in the southern part of the region and in various bedrock units. An aquifer present in the shallow, saturated alluvium is an unconfined porous-media aquifer. Groundwater occurrence in the bedrock aquifer includes both confined, porous-media aquifers in sandstone/siltstone units and confined, fractured-rock aquifers in limestone and igneous/metamorphic rock.

Hydraulic Properties - Hydraulic properties summarized in this subsection include conductivity, storativity, and porosity for the Santa Fe Group Units in HR-1 and HR-2, and shallow alluvium and bedrock units in HR-3. Figure 3-2 shows monitoring well locations where hydraulic conductivity has been estimated from aquifer pumping tests.

The surface of the regional aquifer of the uppermost Santa Fe Group (in HR-1 and HR-2) underlying the KFC area occurs in the fluvial facies of the ancestral Rio Grande to the west and in alluvial fan facies to the east. Based on an assessment of the ratio of (sand + gravel)/(silt +

clay) in various lithofacies of the Santa Fe Group, estimated hydraulic conductivities in the upper Santa Fe Group could range from less than 0.3 foot per day in alluvial fan facies to more than 30 feet per day in the fluvial facies (Hawley and Haase, 1992). However, more recent aquifer test data from Chemical Waste Landfill (CWL) wells and elsewhere shows that hydraulic conductivities range from less than 0.1 foot per day to more than 100 feet per day (Sandia National Laboratories, 1996c).

Hydraulic conductivity data for the fluvial facies of the ancestral Rio Grande is available from aquifer pumping tests performed on water supply wells. (These wells are generally screened over large intervals that include thick sections of the fluvial facies.) Slug tests and aquifer pumping tests in monitoring wells known to be completed in the fluvial facies also provide data. Table 3-2 summarizes hydraulic conductivity data obtained in wells completed in this facies.

Table 3-2. Hydraulic Conductivity for Fluvial Facies of the Ancestral Rio Grande of the Santa Fe Group

Data Type	Hydraulic Conductivity (Feet per Day)
Estimated for the fluvial facies ^a	> 30.0
Slug test analysis (KAFB IRP monitoring wells in fluvial facies) ^b	0.2 to 10.5
Pumping test analysis (Yale and Burton well fields) ^c	12.0 to 121.5
1995 pumping test analysis at PL-2 and MRN-1 ^d	46.6 to 147.1
1995 slug test analysis at PL-2 and MRN-1 ^e	0.26 to 2.6
Sources: ^a J. W. Hawley and C. S. Haase, 1992. ^b U.S. Geological Survey, 1993. ^c Groundwater Management Incorporated, 1988a. ^d Groundwater Management Incorporated, 1988b. ^e Sandia National Laboratories, 1996d.	

Comparison of the slug-test data-analysis results from the PL-2 and MRN-1 monitoring wells to the aquifer pumping-test data-analysis results shows that slug tests in this facies may yield data that significantly underestimates hydraulic conductivity. In general, aquifer test data obtained from pumping is more representative than slug tests, due to the larger volume of aquifer tested during the pumping tests.

Porosity data for the fluvial facies of the ancestral Rio Grande was derived empirically from grain-size distribution data (22 samples with approximate ranges of 0.26 to 0.45) (Sandia National Laboratories, 1995b). Storativity values for the fluvial facies were obtained from pumping tests in the City of Albuquerque's Ridgecrest well field (0.001) and data from TA2-NW1-595 in Tech Area II (0.00024) (see Table 3-3).

Table 3-3. Storage Coefficient Values from Aquifer Tests in the Santa Fe Group

Data Type	Storage Coefficient (Dimensionless)
Pumping test analyses (Ridgecrest well field) ^a	0.001
1995 pumping test at CWL (MW-5 [lower] and MW-6 [lower]) ^b	0.00017 to 0.000033
1995 analysis of drawdown-recovery data from TA2-NW1-595 (well response due to pumping at KAFB-11) ^c	0.00024
Sources: ^a Groundwater Management Incorporated, 1988c. ^b Sandia National Laboratories, 1995c. ^c Sandia National Laboratories, 1996d.	

The uppermost water-bearing unit in the alluvial fan facies south of Tijeras Arroyo consists of up to 50 feet of silty clay. Below this fine-grained unit is an interval of approximately 85 feet that includes several coarser-grained layers, each approximately 10 to 15 feet thick (Sandia National Laboratories, 1995b). Most monitoring wells are completed in the upper fine-grained unit, which generally has a low hydraulic conductivity. At several locations near Tech Area III and Tech Area V, monitoring wells have been completed in one or more of the underlying coarser-grained intervals. The hydraulic conductivity in these intervals is higher, while the hydraulic head is lower than the head in the overlying fine-grained unit. At the CWL, monitoring wells completed in a deeper, coarser-grained interval and separated by a horizontal distance of up to 300 feet responded similarly during an aquifer pumping test (MW-2B [lower], MW-5 [lower], and MW-6 [lower]). This similar response indicates that the coarser-grained intervals are relatively continuous at the scale of the CWL and suggests that these intervals are hydraulically connected to the fluvial facies to the west and could be more responsive to water supply pumping in the city well fields to the north. If this hypothesis is correct, it could explain the lower hydraulic head in these sand intervals.

Hydraulic conductivity data for the alluvial fan facies is available from aquifer pumping tests performed on water supply wells located east of the eastern limit of the fluvial facies. (These wells are screened over large intervals that may include intervals of fluvial facies that intertongue with the predominant alluvial fan facies.) Slug tests and aquifer pumping tests in monitoring wells known to be completed in this facies also provide data. Table 3-4 summarizes hydraulic conductivity data obtained in wells completed in this facies.

Table 3-4. Hydraulic Conductivity for Alluvial Fan Facies of the Santa Fe Group

Data Type	Hydraulic Conductivity (Feet per Day)
Slug test ^a	0.08 to 13.0
Pumping test (Ridgecrest well field) ^b	9.66 to 44.7
1990 pumping test at MW-2A ^c	0.39
1990 laboratory analysis of samples from MW-4 ^c	0.01 to 10.8
1985 slug tests at MW-1, MW-2, and MW-3 ^c	0.07 to 0.09
1994 slug tests at BW-3, BW-4, and BW-4A ^c	0.014 to 0.031
1995 slug tests in MW-1A, MW-2A, MW-3A, MW-5 (upper), and MW-6 (upper) ^c	0.02 to 0.33
1995 slug test in MW-2B (lower) ^c	6.74
1995 pumping tests in BW-4A ^c	0.01
1995 pumping tests in MW-2B (lower) ^c	21.6
Observation wells MW-5 (lower) and MW-6 (lower) during 1995 pumping test in MW-2B (lower) ^c	25.9 to 27.4
1994 pumping test in MW-4 (upper) ^d	0.072
1994 pumping test in MW-4 (lower) ^d	1.48
1995 slug tests at LWDS MW-01 and MW-02; TA5 MW-01 and MW-02 ^d	0.04 to 2.38
1994 pumping test at SFR-3P (HR-2) ^e	10.34
1995 slug test at KAFB-0311 ^e	6.15
1995 analysis of drawdown-recovery data from TA2-NW1-595 (well response due to pumping at KAFB-11) ^e	14.5
Sources: ^a U.S. Geological Survey, 1993. ^b Groundwater Management Incorporated, 1988c. ^c IT Corporation, 1985; Sandia National Laboratories, 1992a; Sandia National Laboratories, 1995b. ^d Sandia National Laboratories, 1996d. ^e Sandia National Laboratories, 1995a.	

A few aquifer tests have been conducted in perched aquifer intervals in the alluvial fan facies near Tijeras Arroyo. Table 3-5 summarizes hydraulic conductivity data obtained in wells completed in perched aquifer intervals.

Porosity data for the alluvial fan facies is available from eight SNL/NM environmental restoration (ER) sampling activities. Porosity values from 431 samples ranged from 0.17 to 0.64 (Sandia National Laboratories, 1995b, 1995c, 1995d, 1995e, 1995f, 1995g). Some samples were measured directly, and others were derived empirically from grain-size distribution data. Three samples collected and measured directly from locations along Tijeras Arroyo and Arroyo del Coyote had porosities ranging from 0.35 to 0.48 (Sandia National Laboratories, 1995e).

Storativity values for the alluvial fan facies ranging from 0.00017 to 0.000033 were obtained from pumping tests conducted at the CWL (see Table 3-3).

Table 3-5. Hydraulic Conductivity for Perched Aquifer Intervals in Alluvial Fan Facies of the Santa Fe Group

Data Type	Hydraulic Conductivity (Feet per Day)
Slug tests (KAFB IRP monitoring well KAFB-0310) ^a	34.9
1995 pumping test at TJA-2 (drawdown and recovery) ^b	17.6 to 50.2
1995 slug test at TJA-2 ^b	19.3
Sources:	
^a U.S. Geological Survey, 1993.	
^b Sandia National Laboratories, 1996d.	

Little data is available for the assessment of aquifer parameters in HR-2 and HR-3. Although boreholes have been drilled at numerous sites, hydrologic testing has been performed at only four locations. These locations include bedrock aquifer tests at test well TSA-1 in Lurance Canyon, and the Site-Wide Hydrogeologic Characterization (SWHC) Project bedrock monitoring wells SFR-3T and TRN-1 (see Figure 3-2 for well locations). In addition, multiple aquifer tests have been performed in the shallow alluvial aquifer underlying the Lovelace Inhalation Research Institute (LIRI) facility.

No aquifer testing has been done for several of the geologic units that contain the uppermost regional aquifer. Untested geologic units include the Tertiary conglomerate near the center of HR-2 (Travertine block), the granitic bedrock in northern HR-2 (Manzano block), the shallow portion of the lower Tertiary Unit in southern HR-3, and the Madera limestone in HR-3.

TSA-1 was drilled to a total depth of 300 feet in a combination of granite, quartzite, schist, and metamorphosed sedimentary rock (see Figure 3-2 for well location). An aquifer pumping test was conducted over a depth interval from 180 feet to 300 feet. The lithology in this depth interval was described as "fractured metamorphics." The transmissivity values obtained from this test ranged from 1,992 gallons per day per foot (drawdown phase) to 1,530 gallons per day per foot (recovery phase) (Geohydrology Associates Incorporated, 1987). Using an assumed aquifer thickness of 120 feet (the length of the well completion interval), these transmissivities were converted to hydraulic conductivity values that ranged from 1.70 feet per day to 2.22 feet per day.

In 1994, an aquifer pumping test was conducted in monitoring well SFR-3T. Although this well is located in HR-2, it was completed in a "lower Tertiary" sandstone/siltstone bedrock unit below a fault contact. Therefore, the test interval is within a bedrock unit that extends into HR-3. The estimated hydraulic conductivity from this test is 0.00317 foot per day (Sandia National Laboratories, 1995a).

In 1995, an aquifer pumping test was conducted in monitoring well TRN-1. This well is completed in the Permian Abo Formation, which, at the location of TRN-1, includes reddish-brown mudstone interbedded with lenticular sandstone beds. The estimated hydraulic conductivity from this test is 0.16 foot per day.

Pneumatic slug tests of five monitoring wells and aquifer pumping tests in monitoring well MW-10 were conducted at the LIRI facility. All the slug tests were performed in wells completed in alluvial material just above weathered Permian siltstone/sandstone units. The calculated hydraulic conductivities from these tests ranged from a low of 6.24 feet per day to a high of 147.10 feet per day (PRC Environmental Management Incorporated, 1990). The aquifer pumping tests were conducted in March and April 1993, in monitoring well MW-10, and included several observation wells. Analysis of the test data yielded estimated hydraulic conductivities ranging from 20.6 to 152.2 feet per day (PRC Environmental Management Incorporated, 1993).

Table 3-6 summarizes shallow alluvium and bedrock hydraulic conductivity data available in HR-2 and HR-3.

No direct data has been obtained to estimate aquifer storativity and porosity for the confined bedrock porous-media or fractured-rock aquifers on KFC. In confined bedrock aquifers, storativity generally ranges from 0.005 to 0.00005 (Freeze and Cherry, 1979). Expected porosity ranges for different rock types include: sandstone/siltstone, 0.05 to 0.30; mudstone/shale, 0.00 to 0.10; fractured limestone, 0.05 to 0.50; and fractured crystalline rock, 0.00 to 0.10 (Freeze and Cherry, 1979).

Table 3-6. Shallow Alluvium and Bedrock Hydraulic Conductivity Data in Hydrogeologic Regions 2 and 3

Data Type	Hydraulic Conductivity (Feet per Day)
Pumping test ^a	1.70 to 2.22 (fractured granite, quartzite, schist, and metamorphosed sedimentary rock)
Pneumatic slug test ^b	6.24 to 147.1 (shallow alluvium)
1993 pumping tests ^b	20.6 to 152.2 (shallow alluvium)
1994 pumping test at SFR-3T ^c	0.003 (Lower Tertiary sandstone/siltstone)
1995 pumping test at TRN-1 ^d	0.16 (Permian Abo sandstone/siltstone)
Sources:	
^a Geohydrology Associates Incorporated, 1987.	
^b PRC Environmental Management Incorporated, 1990, 1993.	
^c Sandia National Laboratories, 1995a.	
^d Sandia National Laboratories/New Mexico, 1996d.	

Aquifers in igneous, metamorphic, and limestone rocks likely are dominated by fracture flow. When fracture density and connectivity is sufficiently high, the fractured media act hydraulically similar to porous media. However, irregular spacing of fractures and variability of fracture-filling can result in discrete, high-permeability flow paths. In addition, fractures differing in orientation introduce anisotropy to the local flow system. Some limited, general characterization of fracture flow systems is possible from outcrop studies to identify predominant fracture directions and fracture density. SNL/NM conducted a feasibility study on outcrop fracture characterization and observations from this study indicated that a significant percentage of bedrock fractures are open, which suggests that bedrock areas may be effective recharge regions (Sandia National Laboratories, 1995a). In addition, fracture orientations vary significantly.

3.3 Hydrology

The hydrologic setting interrelates with the local geologic framework and includes the meteorological environment (precipitation and evapotranspiration), surface water runoff and infiltration, percolation through the unsaturated (vadose) zone, and saturated groundwater flow. The objective of this section is to summarize current understanding regarding the occurrence, movement, and interaction of surface and subsurface water on and under the Kirtland Federal Complex (KFC).

3.3.1 Meteorology and Groundwater Interactions

Local climatic conditions are a major determinant for the overall groundwater system for the Kirtland Federal Complex (KFC) area. The climate is typical of a high desert plateau with low precipitation, wide temperature extremes, and typically low-humidity days. A detailed discussion of the climate at SNL/NM is provided in Chapter 4.0, "AIR QUALITY AND METEOROLOGY." This section describes those aspects of the local climate (i.e., precipitation, temperature, and relative humidity) that are instrumental in determining the nature of the groundwater system. Local weather conditions are one factor that determines the amount of water available for groundwater recharge and the distribution of potential recharge.

The average precipitation at Albuquerque International Sunport (at the northwestern corner of Kirtland Air Force Base [KAFB], elevation 5,311 feet) is 8.12 inches per year and increases with elevation across KAFB to a maximum near 20 inches per year at an approximate 8,000-foot elevation in the Manzano Mountains (National Oceanic and Atmospheric Administration, 1990). Site-specific rainfall data for SNL/NM indicates annual accumulations for 1995 of 5.62 inches at Tech Area II, 6.01 inches at Tech Area V, and 7.76 inches at the Coyote Test Field (Sandia National Laboratories, 1996d). Thus, the general spatial trend of measured rainfall amounts is an increase eastward across KAFB until the higher elevations of the foothills and Manzanita Mountains are reached. Calendar year 1995 (CY1995) was a dry year for the region with the

official accumulation at the airport measured at 5.68 inches (National Oceanic and Atmospheric Administration, 1996). Most precipitation occurs during July, August, and September (Sandia National Laboratories, 1996d). Summertime rainfall usually originates from small cells, with substantial variation in intensity over short distances.

Maximum daily highs measured at Tech Area V in 1995 for June, July, and August are 94.4 degrees Fahrenheit (°F), 101.14°F, and 96.71°F, respectively (Sandia National Laboratories, 1996b). Minimum relative humidity values for the same months are 34.1%, 28.04%, and 28.8%. Temperature and relative humidity combine to produce evaporation rates of up to 0.34 inches per day (Goetz and Shelton, 1990). Estimated evapotranspiration losses are at 95% of the precipitation for the Albuquerque area (Logan, 1990).

Average annual snowfall for Albuquerque is 14.7 inches, the melted equivalent of approximately two inches of water (snow-water equivalent) (National Oceanic and Atmospheric Administration, 1990). Snow cover is common in the mountains from mid-November to early spring. Extrapolation of U.S. Department of Agriculture (USDA) Soil Conservation Service cooperative snow-course data from snow courses on surrounding mountains (all more than 60 miles distant) suggest that between three to four inches of snow-water equivalent should be present near peak snowpack accumulation (i.e., February 15 to March 1) at elevations of approximately 8,000 feet in an average year.

In conclusion, meteorological conditions at SNL/NM suggest little moisture is available for groundwater recharge west of the mountains as a result of direct precipitation on the site. Groundwater recharge, to the extent that it occurs at SNL/NM, is associated with infiltration of surface runoff in the arroyos draining the mountains and foothills, or infiltration of water entering SNL/NM via Tijeras Arroyo. Only the largest storm events produce sufficient runoff for flow in Arroyo del Coyote to reach the confluence with Tijeras Arroyo. For further details on surface runoff and channel flows, see "4.1 Channels and Arroyos."

3.3.2 Arroyo-Groundwater Interactions

Arroyo recharge may affect groundwater flow direction and velocity and may serve as a pathway for groundwater contamination. Onsite tests have shown that infiltration rates of pure water (sediment-free water) into coarse-textured arroyo channels average 15 to 30 feet per day (Sandia National Laboratories, 1996a); however, little data is available on actual recharge rates with natural flows of sediment-laden water over local arroyos.

The significance of arroyo-channel-surface characteristics and fine soil layers underlying coarse-textured arroyo bottom materials in relation to recharge potential was identified by the Environmental Restoration (ER) project site-wide characterization activities (Sandia National Laboratories, 1995a). As a result, an arroyo survey was completed to identify: (1) the width of channel surfaces exposed to infiltration, (2) infiltration rates and particle size of surficial arroyo-bottom materials, (3) the depth to fine layers beneath the channel surface, and (4) infiltration rates through buried fine materials (Sandia National Laboratories, 1996a).

Groundwater recharge from arroyo flow during a typical runoff event was estimated from these channel characteristics. Channel flow associated with runoff events typically was observed to last between two to four hours. Data from U.S. Geological Survey (USGS) gauging stations in Arroyo del Coyote indicated an average of three runoff events annually, and data from the stations in Tijeras Arroyo indicated nine events. Applying the USGS data and the data from the SNL/NM arroyo channel survey provides an estimate for recharge to groundwater. Recharge based on three runoff events is estimated at 400,000 cubic feet per year for Arroyo del Coyote, from the Lovelace Road bridge to the confluence with Tijeras Arroyo. For the reach of Tijeras Arroyo on Kirtland Air Force Base (KAFB), recharge based on nine runoff events is estimated at 2.2 million cubic feet per year. The number of runoff events at the gauging may be skewed high by above-normal precipitation during the period for which gauging data is available.

Recharge to the aquifer from Tijeras Arroyo upstream of its entry into the Kirtland Federal Complex (KFC) may be significantly larger than that occurring on KFC itself. Tijeras Arroyo flows continuously for months at a time upstream of KFC above the Four Hills Bridge (U.S. Geological Survey, 1990, 1991, 1992b). The average discharge measured was 0.19 cubic feet per second for 850 days of records, or approximately 5.9 million cubic feet per year. Only an approximate 2% of this flow evaporated, suggesting that most became aquifer recharge (Thomas, 1995) and most flow infiltrated before reaching the northern boundary of the KFC.

3.3.3 Vadose Zone Hydrology

The vadose (or unsaturated) zone is the region located between the land surface and the groundwater system (the saturated zone). The water table, defined as the surface on which the fluid pressure in the pores is equal to atmospheric pressure, is commonly defined to be the boundary between the vadose zone and saturated zone (Freeze and Cherry, 1979). The vadose zone provides the link between surficial processes such as precipitation, snow melt, runoff, infiltration, overland flow, and evapotranspiration and groundwater (Gee and Hillel, 1988, 255-266).

The vadose zone is a significant part of the hydrologic system in the Kirtland Federal Complex (KFC) area. In this semiarid climate, the vadose zone thickness is generally quite large, consequently, travel times of infiltrated moisture from the surface to the water table are quite long. The vadose zone east of the Tijeras/Hubbell Springs/Sandia fault complex ranges from approximately 50 feet thick in arroyos and valleys to several hundred feet thick near the faults. On the west side of the faults, the unsaturated zone is up to 500 feet thick. In the eastern valleys and arroyos, the vadose zone consists primarily of alluvial fill. In the eastern hills, however, fractured Precambrian, Pennsylvanian, and Permian bedrock materials are exposed at the ground surface.

Important flow and transport processes in the vadose zone are highly interconnected with, and dependent on, many other hydrogeologic aspects, such as climate, geomorphology, vegetation, geology, and the location of the saturated zone. In general, in the KFC area, water enters the vadose hydrologic system as infiltrating rainfall and channel losses from flow in arroyos, and leaves the system as evapotranspiration to the atmosphere and recharge into the underlying aquifer. The following discussion briefly describes infiltration studies conducted by the Environmental Restoration (ER) Project within the KFC.

The climate at SNL/NM implies low recharge rates to the groundwater system from areal infiltration resulting from the low precipitation and high evapotranspiration conditions. Whether any areal infiltration (and consequent downward transport of contaminants to the water table) occurs through the geologic media between major arroyos is presently unknown. Recharge studies conducted on open rangeland at the Sevilleta National Wildlife Refuge south of Albuquerque indicate modern, deep, drainage rates ranging from millimeters to a couple of centimeters per year (Stephens and Knowlton, 1986, 881-889; McCord and Stephens, 1987, 225-238; Phillips et al., 1988, 1877-1891). Recent environmental isotope studies in the nearby Santa Fe basin suggest "negligible" recharge (U.S. Geological Survey, 1992a).

Chloride mass balance studies undertaken by the ER Project Site-Wide Hydrogeologic Characterization (SWHC) Task provide estimates for various vadose settings (Sandia National Laboratories, 1996a). Nine distinct settings were defined based on vegetation type, slope, soil permeability, and soil available water capacity. Recharge rates were obtained for five settings (see Table 3-7). Recharge estimates for the other four settings are not available because, either there are no ER sites in the settings, the characteristics of the settings violate the assumptions of the chloride mass balance procedure, or topography precluded the use of alternative techniques.

Table 3-7. Chloride Mass Balance Estimated Recharge Rates

Vadose Zone Setting	Estimated Recharge Rate* (Centimeters per Year)
Grasslands, low to medium slope, high permeability, medium available water capacity (awc)	0.029 to 0.068
Grasslands, low to medium slope, medium permeability, low to high awc	0.04 to 0.26
Grasslands, low to medium slope, high permeability, low awc	0.04 to 0.26
Open to closed canopy woodlands, medium slope, high permeability, low awc	0.015 to 0.07
Open to closed canopy woodlands, low to medium slope, medium permeability, low to high awc	0.018 to .03
*Source: Sandia National Laboratories, 1996d.	

The results of these studies indicate that the recharge rates for these settings are quite small. The recharge estimates range from 0.01 to 0.26 centimeters per year.

3.3.4 Groundwater Hydrology

This subsection summarizes the Kirtland Federal Complex (KFC) installation-wide groundwater hydrology. This description is a synthesis of information from hydrogeologic reports, SNL/NM Environmental Restoration (ER) Project investigations, and other environmental characterization programs being carried out on the KFC. These independent programs include the Kirtland Air Force Base (KAFB) Installation Restoration Program (IRP), the Lovelace Inhalation Research Institute (LIRI) facility investigation, and the SNL/NM Groundwater Protection Program.

Regional Groundwater-Level Trends - Groundwater withdrawal by water supply wells for the City of Albuquerque and KAFB has resulted in significant changes to the groundwater flow regime in the Santa Fe Group aquifer system over the past 30 years, as discharge exceeds recharge for this region of the Albuquerque Basin (Thorn et al., 1993). Groundwater flow at the KFC has been altered from a principally westward direction to northwestward and northward flow directions along the western and northern portions of KAFB (see Figure 3-3).

Water level declines have occurred within the Albuquerque Basin since the 1960s, when significant increases in groundwater withdrawal began. Basin-wide declines from steady-state conditions have been estimated to range from 20 to 160 feet (Thorn et al., 1993). The greatest declines are to the east of the eastern limit of fluvial deposits of the ancestral Rio Grande.

Since the mid-1980s through 1996, water levels have been collected from monitoring wells on the KFC (Sandia National Laboratories, 1995h). Hydrographs from this data indicate that

groundwater levels are declining at rates of between 0.2 to 3.0 feet per year within the upper unit of the Santa Fe Group aquifer system (Hydrogeologic Region 1 [HR-1]). Figure 3-4 shows average groundwater-level declines in feet per year for the KFC area. On KAFB, the rate of water level declines generally increases westward from the Sandia/Tijeras fault zone and northward near water-supply production wells. Groundwater level surveillance by SNL/NM since approximately 1990 indicates that wells completed west of the eastern extent of fluvial deposits have water level declines of 1.0 to 3.0 feet per year, whereas wells on the east in alluvial deposits display declines of 1.0 foot or less per year (Sandia National Laboratories, 1995h).

Hydrographs for wells within Hydrogeologic Regions 2 and 3 (HR-2 and HR-3) show that water levels in these regions currently are not affected by water supply production within the Santa Fe Group aquifer system. Although water levels show significant seasonal variability, the long-term trends show that water levels have remained relatively constant or are increasing only slightly. Wells in the shallow alluvium near Lake Christian show an increase in water levels of 0.4 to 0.6 foot per year since 1991, perhaps from higher-than-average precipitation over the past 10 years. Wells completed in bedrock and shallow alluvium in Lurance Canyon show minimal increases in the long-term water-level trends. These wells may have a faster response time to meteorological changes and may already have equilibrated with the higher precipitation rate.

Wells screened in the shallow groundwater system underlying Tijeras Arroyo near Tech Area II do not show the same pattern of water level decline as wells screened in the deeper, regional aquifer zones. This indicates that the shallow system is not directly connected to the regional aquifer system. As such, the shallow system is referred to as perched groundwater. Insufficient historical data is available to evaluate water level trends adequately in most of the wells screened in the perched aquifer system, with the exception of the Tijeras Arroyo Golf Course wells and KAFB-0310. Water levels in these wells are increasing at a rate of approximately two feet per year, although this increase should not be generalized to the entire perched system.

Groundwater Flow Direction - The direction of groundwater flow through porous and fractured media is controlled by the hydraulic gradient. At a more limited, local scale, the distribution of hydraulic conductivities affects flow direction. Hydraulic gradient is associated with a specific aquifer, and is determined from measurements of the static water level in wells completed within that specific aquifer unit. The direction of groundwater flow is generally perpendicular to the potentiometric contours of the measured static-water level.

Figure 3-3. Potentiometric Surface for the Regional Groundwater System at SNL/NM and Kirtland Air Force Base (KAFB) (October/November 1995)

Lateral Groundwater Flow - Figure 3-3 shows the potentiometric surface for October to November 1995 of the upper portion of the regional aquifer underlying SNL/NM and Kirtland Air Force Base (KAFB). The potentiometric contours on these maps are intended to indicate flow directions and gradients representative of the uppermost aquifer units. Therefore, to the extent possible, water level data was selected from wells with relatively short screen lengths that spanned the water table. Water level measurements were collected and analyzed through the SNL/NM Groundwater Protection Program (Sandia National Laboratories, 1996e).

East of the Sandia/Tijeras fault zone, the first encounter of saturated conditions can occur either in the upper unit of the Santa Fe Group, in fractured nonporous bedrock, in porous bedrock (fractured and unfractured), or in shallow alluvial deposits overlying bedrock. Groundwater elevation contours have been drawn using water-level data from wells that are screened in different geologic units. To construct water-level elevation contours in this area, the assumption must be made that the geologic units are hydraulically connected and that flow occurs laterally across geologic units and faults. The apparent groundwater-flow direction and gradients shown on Figure 3-3 seem to indicate that this is the case.

West of the Sandia/Tijeras fault zone, the uppermost regional aquifer is within the upper unit of the Santa Fe Group, consequently Figure 3-3 does not show groundwater potentiometric contours of the perched unit in the vicinity of Tech Area II and the Tijeras Arroyo Golf Course. Figure 3-5 shows a potentiometric surface map of the perched system, based on data from wells screened in this system.

As Figure 3-3 indicates, groundwater flows from bedrock and shallow alluvial aquifers in HR-2 and HR-3, across fault zones, and into the Santa Fe Group aquifer system. East of the Tijeras fault zone, groundwater flow directions and gradients are controlled by topography, aquifer type, and faults. In general, groundwater flows from the northeast to the southwest, oriented with the trend of the mountain front and Lurance Canyon. As groundwater moves west into a more subdued topographic area, where the water-bearing unit consists of thin alluvial materials, the flow direction appears to shift to the west and then crosses the Tijeras fault zone. Lateral hydraulic gradients from well sites Lake Christian to Solar Tower West (STW) and from well sites Target Road South (TRS) to Thunder Range East (TRE) are approximately 0.02 foot per foot. From wells Explosives Ordnance Disposal (EOD) to LMF-1, the hydraulic gradient steepens to 0.12. In general, lateral hydraulic gradients east of the fault zone appear to be approximately equal to, or even greater than, the topographic gradients. At Lovelace Inhalation Research Institute (LIRI), groundwater occurs in shallow alluvial sediments that fill a north-trending buried channel carved into the Abo/Yeso formations (PRC Environmental Management Incorporated, 1993; GRAM Incorporated, in conjunction with WLA, 1995). Groundwater in this area has a low hydraulic gradient (0.002) to the north until it probably mixes with groundwater flowing from the east.

The distinction between a potentiometric map and a water table map is important for this region. Confined and unconfined aquifer data are represented as potentiometric contours and do not necessarily represent water table elevations.

No potentiometric contours are shown for Manzano Area because of the lack of data for this area. Data is also sparse for the area directly west of the Sandia fault. Groundwater flow through the granitic terrain of the Manzano Area is probably from the northeast, with flow components to the south into the Arroyo del Coyote drainage. Assuming the granite has a very low permeability, direct precipitation in this area is probably shed mostly from the bedrock through surface runoff, and percolates into the surrounding piedmont sediments.

Figure 3-3 shows that groundwater elevations are approximately 300 feet lower west of the Sandia/Tijeras fault complex than groundwater elevations east of it. In general, groundwater in the Santa Fe Group aquifer west of the fault complex flows westward until reaching a north-to-south-trending, elongated trough in the water table, which alters the flow direction to the north. This trough has been created over several decades by the pumping of the water supply wells located along the northern boundary of KAFB, primarily from the ancestral Rio Grande deposits of the upper unit of the Santa Fe Group aquifer. In the northern KFC area, monitoring wells show a dynamic response to pumping from nearby production wells, creating localized variations in the groundwater flow directions and hydraulic gradients throughout the year. These water supply wells pump much larger volumes in the summer months than in the winter months (Sandia National Laboratories, 1995h). South of Tijeras Arroyo, response to water supply pumping is not evident in monitoring wells, although long-term water-level declines remain significant.

Lateral hydraulic gradients within the uppermost aquifer unit of the Santa Fe Group range from 0.0007 for northward flow within the groundwater trough on the KAFB western boundary to 0.01 near active production wells in the northern portion of KFC. The lateral hydraulic gradient for most of the uppermost Santa Fe Group aquifer system having a primarily westward flow direction is 0.005 (measured near Tech Area III). Locally, the hydraulic gradients may vary significantly because of the heterogeneous and anisotropic nature of the Santa Fe Group deposits. Also, vertical hydraulic gradients are significant in portions of the aquifer system (see "Vertical Groundwater Flow" under "3.3.4 Groundwater Hydrology").

Figure 3-5. Potentiometric Surface for the Perched Aquifer System Near Tijeras Arroyo (September 1995)

Figure 3-5 shows the potentiometric surface of the shallow groundwater system that underlies the reach of Tijeras Arroyo above its confluence with Arroyo del Coyote assuming a single, common perching layer. In this area, the relatively shallow groundwater occurs within the alluvial fan facies in the Santa Fe Group that does not appear to be hydraulically well connected with the regional aquifer system (shown in Figure 3-3). The relatively shallow groundwater may represent perched water or a system of perched water zones (Sandia National Laboratories, 1995a). The lateral and vertical extent of this shallow groundwater system is currently not well known. Based on limited data points within the perched system, the apparent direction of flow is to the south and southeast. The approximate lateral hydraulic gradient is 0.01 (TA2-NW1-325 to TJA-2). There may be several sources of recharge to the perched system, including direct recharge from Tijeras Arroyo and/or artificial recharge.

Flow Across the Faults - Water levels of the uppermost aquifer unit on the west side of the Sandia/Tijeras/Hubbell Springs fault complex are approximately 300 feet lower than water levels east of the fault complex. The wedge-shaped area southeast of Tech Area III, between the Tijeras and Hubbell Springs faults, is a structural block named the Thunder Range Block. As the flow system crosses the Hubbell Springs fault zone, there is an abrupt change in the water level elevation in the uppermost aquifer unit of approximately 75 feet over a horizontal distance of approximately 1,900 feet. This apparent horizontal gradient of approximately 0.04 contrasts with the lower gradients on the east and west of approximately 0.02 and 0.005 respectively. Across the Thunder Range Block, the horizontal gradient ranges from 0.002 foot per foot in the east to approximately 0.01 approaching the Tijeras fault. As the flow system crosses the Tijeras fault along the southern boundary of KAFB, between the SFR-1 and Heliport well locations, there is another precipitous change in the water level elevation, this time of approximately 380 feet over the horizontal distance of approximately 6,000 feet. This apparent horizontal gradient of approximately 0.06 contrasts with the much lower gradient of approximately 0.005 west of the fault. The hydraulic-head equipotential lines on either side of the faults generally trend parallel to the faults, indicating an east-to-west gradient across the faults (see Figure 3-3).

In the southern part of the KFC area, the flow system crosses the Hubbell Springs fault zone from the Hubbell Bench area on the east, flows across the Thunder Range Block, and then crosses the Tijeras fault on the west and flows to the west-northwest within the Santa Fe Group aquifer. Water levels in the Thunder Range Block (SFR-1D and SFR-2S) are approximately 300 feet lower than the TRN-1 water level in the south-central portion of the Hubbell Bench area, and 300 to 400 feet higher than the water level in the Chemical Waste Landfill (CWL) monitoring well BW-2, west of the Tijeras fault. The wells in the Thunder Range Block and at the CWL are completed in the Santa Fe Group aquifer, whereas the TRN-1 well is completed in a confined bedrock aquifer in the Permian Abo Formation. The chemistry in all four monitoring wells is remarkably similar. In particular, bromide (Br⁻), chloride (Cl⁻), and sulfate, chemical

species that are typically most conservative (move with groundwater and are nonreactive), have very similar concentrations in water samples from these wells. These similarities in conservative chemical species support the conceptual model of groundwater flowing east to west across the faults.

Vertical Groundwater Flow - Vertical groundwater flow within and between aquifers is possible when there is a difference in hydraulic heads between two points at the same horizontal coordinates but with vertical separation. Whether it occurs depends on the conductivity of the material separating the points of differing head; that is, if the conductivity is sufficiently low, no flow will occur.

In the HR-1 alluvial fan facies of the Santa Fe Group aquifer underlying Tech Area III and Tech Area V, observed hydraulic head differences indicate downward vertical flow between the uppermost fine-grained (and low hydraulic conductivity) unit and the underlying sandy intervals. In general, this downward gradient ranges between 0.02 and 0.07. However, at the Mixed Waste Landfill (MWL), this gradient is much higher, ranging from 0.11 to 0.88 (Sandia National Laboratories, 1996d).

In the HR-1 fluvial facies of the Santa Fe Group aquifer, there is a small downward gradient ranging from 0.001 to 0.008. Several locations near Tijeras Arroyo have monitoring wells in both the uppermost perched groundwater system and the underlying regional aquifer. The vertical hydraulic gradients at these locations are approximately 0.9 in a downward direction.

In HR-2, vertical gradient data is available in the Thunder Range Block both within the Santa Fe Group, and between the Santa Fe Group and the underlying Tertiary bedrock (Sandia National Laboratories, 1995b). In the Santa Fe Group, the vertical gradient is downward and ranges from a low of 0.006 at monitoring wells SFR-3S/SFR-3D to a high of 0.25 at monitoring wells SFR-1S/SFR-1D. The high vertical gradient at the SFR-1 location is between the unconfined upper aquifer (SFR-1S) and an underlying confined aquifer (SFR-1D) (Sandia National Laboratories, 1995b). At the SFR-3 location, where hydraulic head data is available for both the bedrock (SFR-3T) and the Santa Fe Group (SFR-3P), the gradient is upward from the bedrock into the Santa Fe Group at 0.15.

There is insufficient data to develop specific information regarding vertical flow gradients in HR-3. Because this region is geologically complex, and groundwater occurs under unconfined conditions in relatively thin, surficial alluvial material as well as in confined and unconfined conditions in fractured limestones, low-porosity metamorphic rock, and porous sandstone and siltstone bedrock, vertical gradients are expected to vary considerably. The obvious demonstration of vertical gradients is the existence of Coyote Springs, where groundwater rises above the ground surface in a sustained year-round flow. Similarly, the existence of numerous

springs and seeps in the foothills and mountains suggests confining groundwater conditions, at least in a portion of the area.

3.4 Groundwater Quality

This section presents information on groundwater quality at SNL/NM. Groundwater quality is discussed in the context of naturally occurring or background concentrations of principal constituents and their related geochemistry, and in the context of contamination where it has been detected at SNL/NM and the associated sources.

3.4.1 Background Groundwater Quality

See “3.2 Hydrogeologic Setting” for a discussion on the impact of faults at SNL/NM on groundwater system characteristics and the subsequent division of SNL/NM into three hydrogeologic regions (HR-1, 2, and 3). As early as 1991, the water chemistry data suggested a quantifiable difference in the concentration of the major ions in water samples collected from wells east and west of the Tijeras and Hubbell Springs Faults (Goodrich and Stein, 1991, 178). Subsequent studies, based on significantly expanded and refined data, have supported the earlier finding (Rust Geotech, 1995; Moats and Wynn, 1995). Data derived from water analyses by the SNL/NM Environmental Restoration (ER) Project and the Kirtland Air Force Base (KAFB) Installation Restoration Program (IRP) were used in a detailed study of the background values and distribution of 19 metals in groundwater. Statistical results of the study showed that the water chemistry west of the fault zone differs significantly from the water chemistry of wells near the fault zone (Sandia National Laboratories, 1996f; IT Corporation, 1996). The difference can be attributed to the groundwater flow paths and the chemical compositions of the sediments and rocks encountered along the paths. A report prepared by Rust Geotech for the ER Project Site-Wide Hydrogeologic Characterization (SWHC) Task discusses the geochemical significance of these interactions in determining the chemical characteristics of groundwater at SNL/NM (Rust Geotech, 1995). Thus, elevated chloride (Cl^-) concentrations of groundwater near the fault zone may be associated with deeper groundwater movement up through the faults. Similarly, elevated sulfate values of water from a monitor well completed in bedrock near the South Fence Road (SFR) at the Hubbell Springs fault result from “SFR” groundwater contact with gypsum stringers associated with the Yeso Formation. The Yeso has been identified in surface outcrops south of the Kirtland Federal Complex (KFC).

Waters from Coyote Springs and the Explosives Ordnance Disposal (EOD) well appear to be from a deeper source than other waters in the basin. Differences in calcium and bicarbonate can be explained by exsolution of carbon dioxide gas and precipitation of calcite (CaCO_3) at Coyote Springs. Higher concentrations of bromide (Br^-) and chloride (Cl^-) at Coyote Springs can be accounted for by evaporation at that site. The chemical pathways proposed in the Rust

Geotech report offer plausible explanations for the variability of the chemistry at SNL/NM. These proposals are not unique, and other explanations may also be valid (Rust Geotech, 1995).- Groundwater samples collected from wells west of the fault zone, toward the basin center, show less variability in chemical composition and, in general, have lower concentrations of the major ions. This suggests dilution with water from other recharge sources. In addition, the thick sediments of the inner basin contain considerable amounts of clays that may remove some ions through an exchange mechanism (Logan, 1990).

Tables 3-8 and 3-9 show selected physical parameters and concentrations of major ion species for groundwater at SNL/NM.

Table 3-8. Physical Characteristics of Groundwater at SNL/NM, March 1996

Site	pH ^a	Temperature (°C) ^b	SC (μmho/cm) ^c	Turbidity (NTU) ^d	E _H (mV) ^e
Hydrogeologic Region 3 (HR-3), east of the fault zone					
Lurance Canyon Burn Site Well	7.24	17.2	907	1.04	97
Coyote Springs	6.16	9.6	1714	6.43	4.47
EOD Well	6.18	16.9	3,210	1.98	-13
Greystone Well	7.27	11.6	590	43.3	244
School House Well	6.71	18.0	1,368	14.1	10
TRN-1	6.69	18.4	1,661	0.66	112
Sol se Mete Spring	7.51	8.2	675	0.39	371
Hydrogeologic Region 2 (HR-2), fault zone					
SFR-3P	6.84	17.6	1,235	8.97	60
SFR-3T	7.84	20.6	3,930	1.13	102
SFR-4T	7.77	17.6	470	0.88	83
TRE-1	6.64	16.4	1,519	0.24	116
Hubbell Spring	7.95	13.0	468	1.45	407
Hydrogeologic Region 1 (HR-1), west of the fault zone					
KAFB-901	7.28	18.3	592	1.79	78
MRN-2	7.41	19.6	530	1.49	82
MVMWK	7.86	15.7	242	129	336
NWTA-3	7.49	20.0	540	0.93	90
PL-2	7.50	17.1	449	2.76	90
PL-3	7.31	17.2	560	0.77	92
Source: Sandia National Laboratories, 1997b. ^a Measured in standard pH units. ^b C = degree(s) Celsius. ^c SC = specific conductance in micromho(s) per centimeter (μmho/cm). ^d Turbidity values are not stability measurements; NTU = nephelometric turbidity units. ^e E _H = oxidation-reduction potential, E _H values are not stability measurements; mV = millivolts.					

Table 3-9. Major Ion Concentrations in Groundwater at SNL/NM, March 1996

Site	Calcium (mg/L) ^a	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Bicarbonate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Nitrate (mg/L)
Hydrogeologic Region (HR-3), east of the fault zone									
Lurance Canyon Burn Site Well	100	37	30	3.4	280	150	51	1.0	30.5
Coyote Springs	280	60	360	29	1220	120	470	2.4	1.55
EOD Well	460	110	400	41	2562	110	380	2.2	ND ^b
Greystone Well	73	21	63	4.5	353	28	75	0.66	9.3
School House Well	130	26	93	6.4	500	62	130	1.7	18.6
TRN-1	100	54	160	9.7	768	73	130	0.94	1.5
Sol se Mete Spring	97	16	11	1.7	280	36	12	0.35	5.8
Hydrogeologic Region (HR-2), fault zone									
SFR-3P	110	27	82	4.6	427	80	120	1.8	4.8
SFR-3T	450	39	460	4.5	22	2,300	44	ND ^b	ND ^b
SFR-4T	54	3.2	770	2.3	122	2,000	180	4.9	2.5
TRE-1	160	36	95	6.5	586	100	140	1.6	9.3
Hubbell Spring	75	30	51	1.2	207	210	31	0.96	3.8
Hydrogeologic Region (HR-1), west of the fault zone									
KAFB-0901	72	11	25	1.6	232	78	14	0.28	12.8
MRN-1	53	14	31	4.1	207	67	14	0.48	13.7
MRN-2	52	17	35	3.9	195	63	14	0.74	20.4
MVMWK	32	3.7	19	2.1	122	27	6.9	0.41	2.9
NWTA-3	58	15	21	4.3	195	58	15	0.36	28.8
PL-2	45	7.7	25	3.0	171	54	11	0.54	2.6
PL-3	62	12	23	4.7	195	68	15	0.35	22.6

Source: Sandia National Laboratories, 1997b.

^a mg/L = Milligrams per liter.^b ND = Not detected.

3.4.2 Groundwater Contamination at SNL/NM

Groundwater contamination is defined as the introduction of microorganisms, chemicals, toxic substances, or wastes in a concentration that makes the water unfit for its next intended use (U.S. Environmental Protection Agency, 1994). The groundwater at SNL/NM is the source of drinking water for SNL/NM, Kirtland Air Force Base (KAFB), and adjacent portions of the City of Albuquerque and Pueblo of Isleta. Irrigation, domestic, and industrial uses also impose specific limitations on groundwater quality. The State of New Mexico Water Quality Control Commission (NMWQCC) has established groundwater standards for human health, domestic water supply, and irrigation in 20 NMAC 6.2, *Water Quality, Groundwater and Surface Water Protection*. In addition, drinking water standards are imposed by the New Mexico Environmental Improvement Board (20 NMAC 7.1, *Wastewater and Water Supply Facilities, Drinking Water*). The latter standards are based on the National Primary Drinking Water Regulations established by the U.S. Environmental Protection Agency (EPA). The NMWQCC standards are more comprehensive in setting maximum allowable concentrations (MAC) for a greater number of substances; the drinking water standards are more stringent in setting lower maximum contaminant levels (MCL) for those substances listed under both regulations. For purposes of defining groundwater contamination at SNL/NM, the drinking water standards (MCL) will be used; for those substances for which primary drinking water standards are not established, the MAC established by the NMWQCC will apply. Although concentrations of specific substances may exceed the standards for specific uses, the source of the elevated concentrations may be the natural condition of the waters, and is not necessarily from the introduction of substances as a result of human activity.

In 1996, groundwater samples collected at various locations by SNL/NM monitoring and surveillance activities were above the established standards for drinking water (Sandia National Laboratories, 1996d). The substances exceeding specified standards may be grouped as inorganic, organic, and radionuclides.

Inorganic constituents that exceeded standards at specific locations were the metals beryllium, nickel, and chromium, and the anions fluoride and nitrate. Beryllium was detected in a water sample from Coyote Springs at a concentration of 0.0051 milligram per liter; the MCL value is 0.004 milligram per liter. Nickel concentrations exceeding the drinking water MCL of 0.1 milligram per liter were detected in samples from monitor wells along the southern boundary of KAFB (SFR-3P, 0.36 milligram per liter), and at the Chemical Waste Landfill (CWL-BW3, 0.68 milligram per liter), and at the Mixed Waste Landfill (MWL-MW1, 0.145 milligram per liter). Chromium concentrations exceeding the MCL of 0.1 milligram per liter were detected in two wells at the CWL. The highest concentration of 0.160 milligram per liter was detected in CWL-BW3. The coincidence of elevated nickel and chromium in wells with stainless-steel

components suggests these levels are the result of corrosion rather than contamination from surface activities (Sandia National Laboratories, 1997b).

The fluoride concentration from monitor well SFR-4T along the south boundary was measured at 4.9 milligram per liter; the MCL is 4.0 milligram per liter. Fluoride is a common substance in groundwater; it is believed that elevated values are attributable to natural processes (Sandia National Laboratories, 1997b).

In 1996, nitrate concentrations exceeding the established MCL of 10 milligrams per liter (as nitrogen) were found in several groundwater samples from widely dispersed locations at SNL/NM. Concentrations up to 12 milligrams per liter were reported for monitor wells LWDS-MW1, AVN-2, and AVN-1 near Tech Area V. In Tech Area II, nitrate concentrations of 29 milligrams per liter were obtained from water samples drawn from monitor well TA2-SW1-320. The Lurance Canyon Burn Site well had a nitrate concentration of 27 milligrams per liter. Nitrate contamination of groundwater is commonly associated with septic tank effluent and excessive fertilizer application. Septic tanks are used in remote areas that lack access to sanitary sewer systems; however, the specific sources of the nitrates in groundwater have not been identified. Additional water samples collected at the Burn Site were analyzed for specific isotopes of nitrates that may be associated with septic waste, fertilizers, or explosives. The isotopic distributions of these samples appear not to be those of the common sources of nitrate: fertilizers, septic tanks, or explosives (Sandia National Laboratories, 1997b).

Organic solvents are a common groundwater contaminant. Of the solvents, trichloroethylene (TCE) is prevalent. At SNL/NM, TCE contamination has been detected at several locations. At the CWL, analyses indicated the presence of TCE in six of the 13 wells sampled. In some cases, the TCE concentrations exceeded the MCL value of 0.005 milligram per liter. The highest levels were in well CWL-MW6L, where the concentrations were 0.01 milligram per liter. The concentrations of TCE in the CWL monitoring wells have changed little during the current sampling year, suggesting that the plume has attained a steady-state condition.

In the vicinity of Tech Area V, TCE was consistently detected in monitor wells LWDS-MW1 and TA5-MW1. TCE concentrations in well LWDS-MW1 ranged from 14 milligrams per liter in March 1996 to 18 milligrams per liter in September. Cis-1,2-dichloroethene (1,2-DCE), a breakdown product of TCE, was detected at 3.4 milligrams per liter (J) in a sample from LWDS-MW1. (The [J] indicates that the value is below the quantitation limit for the analytical method.) The TCE concentration in monitor well TA5-MW1 was reported at 2.7 milligrams per liter in June and September 1996.

TCE was also detected near Tech Area II. The TCE concentration in well WYO-1 was 0.0056 milligram per liter. TCE in well TA2-W-19 decreased from a level of 0.0054 milligram per liter in January 1995 to less than the quantitation limit for the sample collected in August 1996. TA2-W-19 is a well completed in the perched water zone, whereas WYO-1 is completed in the regional aquifer. TCE was detected in other wells at trace amounts below the quantitation limit. Three wells completed in the perched water zone and one well in the regional aquifer have contained 1,1-dichloroethane (1,1-DCA) and 1,2-DCE. Organic solvent 1,1-DCA is also a breakdown product of TCE. The regional well sample from WYO-1 contained up to 3.5 milligrams per liter 1,2-DCE in 1995. The highest concentration values for the perched wells were in well WYO-2 with 3.1 milligrams per liter (J) of 1,2-DCE and 1.8 milligrams per liter of 1,1-DCA (Sandia National Laboratories, 1997b).

The presence of certain naturally occurring radioactive isotopes of uranium and thorium and their decay products in groundwater is not uncommon in granitic terranes. In some instances, the values exceed MCLs, which preclude the source's use as drinking water. Radium-226 activities in the sample from the Explosives Ordnance Disposal (EOD) well slightly exceeded the MCL of 4.0 picocuries per liter. Also at EOD, the sum of radium-226 (4.15 ± 0.59 picocuries per liter) and radium-228 (2.86 ± 0.44 picocuries per liter) exceeded the MCL of 5 picocuries per liter. Uranium isotope activities were consistent with naturally occurring isotopic ratios in all the samples, although the activities in the samples from the EOD, TRN-1, and the TRE-1 wells exceeded the DOE guideline of 20 picocuries per liter. The EOD results were consistent with prior analyses and are considered to be a background concentration value. The TRE-1 sample activity of 25.7 ± 4.8 picocuries per liter was slightly above the DOE guideline of 20 picocuries per liter. Because this was the first time the well had been sampled, there was no prior data for comparison, although the ratios of the isotopes suggested natural origins. The uranium-234 activity was 45.4 ± 9.6 picocuries per liter at TRN-1. All these wells are east of the fault zone (Sandia National Laboratories, 1997b).

4.0 SNL/NM SURFACE HYDROLOGY

4.1 Channels and Arroyos

The surface water system within the Kirtland Federal Complex (KFC) consists primarily of ephemeral (briefly flowing) drainages. The major surface drainages include Tijeras Arroyo, Arroyo del Coyote, and an unnamed drainage south of Arroyo del Coyote (Sandia National Laboratories, 1993b). Except for two very short reaches of channel with intermittent flow, these drainages are all ephemeral within Kirtland Air Force Base (KAFB). Figure 3-6 shows drainage locations.

4.1.1 Tijeras Arroyo

Tijeras Arroyo is the primary drainage feature on Kirtland Air Force Base (KAFB). Above the point where Tijeras Arroyo enters KAFB, it drains approximately 80 square miles (207 square kilometers) and at the point it exits KAFB, the drainage area has increased to approximately 122 square miles (315 square kilometers). The elevation in the watershed area ranges from 9,600 feet (2,925 meters) to approximately 5,180 feet (1,580 meters) at the point where the arroyo exits KAFB. The total topographic relief in the watershed is 4,420 feet (1,346 meters).

4.1.2 Arroyo del Coyote

Arroyo del Coyote joins Tijeras Arroyo approximately 2 miles (3.2 kilometers) upstream of where Tijeras Arroyo leaves Kirtland Air Force Base (KAFB), and they drain approximately 39 square miles (101 square kilometers). Arroyo del Coyote can be divided into five watersheds: Lurance Canyon, Madera Canyon, Sol se Mete Canyon, upper Arroyo del Coyote, and lower Arroyo del Coyote.

4.1.3 Lurance Canyon

Lurance Canyon drains an area of approximately 2.97 square miles (7.7 square kilometers). The elevation in the watershed ranges from 7,641 feet (2,388 meters) to approximately 6,160 feet (1,925 meters) at its confluence with Sol se Mete Canyon. The total topographic relief in the watershed is 1,481 feet (463 meters). The total length of the main drainage is 13,400 feet (4,188 meters). The primary SNL/NM activity in Lurance Canyon is the Burn Site.

4.1.4 Madera Canyon

Madera Canyon drains an area of approximately 8.6 square miles (22.3 square kilometers). The elevation in the watershed ranges from 7,988 feet (2,496 meters) at the Manzano Lookout Tower to approximately 6,080 feet (1,900 meters) at its confluence with middle Lurance Canyon. The total topographic relief in the watershed is 1,908 feet (596 meters). The total length of the main drainage is 41,600 feet (13,000 meters). SNL/NM conducted gun and rocket tests in Madera Canyon in the past. There is no major SNL/NM activity in Madera Canyon at present, although minor activities are conducted intermittently.

4.1.5 Sol se Mete Canyon

Sol se Mete Canyon drains an area of approximately 3.6 square miles (9.3 square kilometers). The elevation in the watershed ranges from 7,988 feet (2,496 meters) at the Manzano Lookout Tower to approximately 6,160 feet (1,925 meters) at its confluence with upper Lurance Canyon. The total topographic relief in the watershed is 1,828 feet (571 meters). The total length of the main drainage is approximately 19,800 feet (6,188 meters). The primary SNL/NM activity in Sol se Mete Canyon is the Sol se Mete Aerial Cable Facility.

4.1.6 Upper Arroyo del Coyote

Upper Arroyo del Coyote drains an area of approximately 9.8 square miles (25.4 square kilometers). The elevation ranges from 7,360 feet (2,300 meters) to approximately 5,920 feet (1,850 meters) at its delineated discharge point. Total topographic relief in the watershed is 1,440 feet (450 meters). The total length of the main drainage is 21,800 feet (6,645 meters). The primary SNL/NM activities in upper Arroyo del Coyote are the testing of containment vessels and storage of mixed waste in the Manzano Area.

4.1.7 Lower Arroyo del Coyote

Lower Arroyo del Coyote drains an area of approximately 21 square miles (54 square kilometers). The elevation ranges from 7,000 feet (2,130 meters) to 5,250 feet (1,600 meters) at its delineated discharge point in Tijeras Arroyo. Total topographic relief in the watershed is 1,750 feet (534 meters). The total length of the main drainage is 19,000 feet (5,790 meters).

4.1.8 Drainages South of Arroyo del Coyote

Several well-defined, unnamed arroyos and drainages to the south of Arroyo del Coyote disappear as the topographic relief decreases to the west. Storm water in this area infiltrates the soil; therefore, there is no hydrologic surface connection from these areas to Tijeras Arroyo or the Rio Grande. The majority of SNL/NM remote testing activities occur in this area. Tech Areas III and V, the Solar Tower, the Hyper Velocity Gun Facility, and numerous explosive and hazardous testing sites are located in this area.

4.1.9 Flow Data

Flow information is limited because of the lack of data. The only stream gauge that has been monitored for a sufficient amount of time to give any indication of predictable flows from storm events is a U.S. Geological Survey (USGS) gauge (#8330580) located in Tijeras Arroyo,

approximately one-half mile outside the Kirtland Air Force Base (KAFB) boundary. The USGS monitored this stream gauge from 1988 through 1995. The Site-Wide Hydrogeologic Characterization (SWHC) Project, which included research in Arroyo del Coyote and Tijeras Arroyo, installed and monitored seven stream gauges in 1994 and 1995. Two gauges were installed in Tijeras Arroyo (USGS Gauge #8330569 and Station 4), three in Arroyo del Coyote (USGS Gauge #8330565, USGS Gauge #8330567, and Station 3), and two in Madera Canyon (Station 1 and Station 2). Figure 3-7 shows gauging station locations. Tables 3-10 and 3-11 summarize the collected data.

Table 3-10. Streamflow Data Collected from Four Local U.S. Geological Survey (USGS) Gauges during Water Year 1994

Date	Upper Arroyo del Coyote USGS Gauge #8330565 Discharge*	Lower Arroyo del Coyote USGS Gauge #8330567 Discharge*	Upper Tijeras Arroyo USGS Gauge #8330569 Discharge*	Lower Tijeras Arroyo USGS Gauge #8330580 Discharge*
Watershed area	35 square miles	39 square miles	121 square miles	122 square miles
05/11/94	1,700	95,000	660,000	2,100,000
05/26/94	21,000	72,000	22,000	350,000
06/18/94	No discharge	No discharge	110,000	560,000
06/21/94	No discharge	No discharge	350,000	790,000
07/23/94	No discharge	No discharge	1,000	260,000
07/28/94	No discharge	No discharge	8,000	200,000
08/01/94	45,000	95,000	500,000	1,200,000
08/14/94	No discharge	1,700	No discharge	8,600
08/15/94	230,000	1,100,000	2,900,000	7,100,000
08/20/94	95,000	Data missing	67,000	380,000
08/21/94	900	Data missing	No discharge	No discharge
08/26/94	120,000	Data missing	8,600	No discharge
09/18/94	No discharge	No discharge	No discharge	200,000
Total	520,000	1,400,000	4,600,000	13,000,000
Acre feet	12	32	105	300

*Values are in cubic feet unless noted otherwise.

In addition to this data, SNL/NM's Storm Water Program has monitored the primary discharge from Tech Areas I and II at the 9th Street outfall since 1995. Table 3-12 summarizes the flow data.

Table 3-11. Streamflow Data Collected from Four Site-Wide Hydrogeologic Characterization Gauges during Water Year 1995

Date	Station 1 (Madera Canyon) Discharge*	Station 2 (Madera Canyon) Discharge*	Station 3 (Arroyo del Coyote) Discharge*	Station 4 (Tijeras Arroyo) Discharge*
Watershed area	6.6 square miles	8.1 square miles	21 square miles	About 80 square miles
10/14/94	66,000	50	No discharge	750,000
10/15/94	2,800	Trace	No discharge	1,460,000
10/16/94	7,100	Trace	No discharge	No discharge
10/17/94	5,100	Trace	No discharge	No discharge
10/26/94	11	Trace	No discharge	810,000
11/11/94	1,000	Trace	No discharge	No discharge
11/12/94	36,000	Trace	No discharge	1,150,000
02/25/94	No discharge	No discharge	No discharge	110,000
03/26/95	No discharge	No discharge	No discharge	240,000
04/09/95	No discharge	No discharge	No discharge	300,000
04/26/95	No discharge	No discharge	77,000	1,000,000
07/16/95	No discharge	No discharge	No discharge	420,000
07/18/95	ND	3,400	6100	670,000
08/22/95	10	Trace	27,000	2,660,000
08/23/95	12,000	Trace	20,000	1,860,000
08/27/95	62,000	Trace	39,000	1,200,000
08/30/95	No discharge	No discharge	5,500	No discharge
09/07/95	No discharge	No discharge	No discharge	270,000
09/08/95	Trace	No discharge	No discharge	190,000
09/28/95	1,200	No discharge	870	160,000
09/29/95	25,000	No discharge	5,500	No discharge
Total	218,221	3,450	180,970	13,250,000
Acre feet	5.01	0.08	4.15	304.18
*Values are in cubic feet unless noted otherwise.

Table 3-12. Streamflow Data Collected from Three Storm Water Monitoring Stations in 1995 and 1996

Date	Station 2 Discharge*	Station 4 Discharge*	Station 5 Discharge*
Watershed area	2 square miles	0.01 square miles	0.74 square miles
04/10/95	110	No discharge	No discharge
04/19/95	132	No discharge	No discharge
04/21/95	25	No discharge	No discharge
06/29/95	46	No discharge	No discharge
07/04/95	114	No discharge	No discharge
07/18/95	5,292	105	828
08/11/95	1,172	No discharge	No discharge
08/14/95	26	No discharge	No discharge
08/16/95	1,052	678	381
08/23/95	2,276	1,581	171
08/27/95	977	15	1,108
09/07/95	24,076	8,843	8,494
09/08/95	1,495	11	1,296
09/28/95	7,568	640	3,450
07/14/96	454	No discharge	No discharge
06/26/96	7,215	186	1,906
06/27/96	1,170	27	2,004
06/28/96	22,455	5,114	7,245
06/30/96	604	2,825	1,058
07/09/96	1,517	24	399
07/10/96	39,954	4,006	9,294
08/20/96	2,431	No discharge	87
08/22/96	1,957	No discharge	1,417
08/23/96	14,889	660	2,320
08/25/96	3,614	973	4,569
08/26/96	9,778	1,228	5,176
08/29/96	4,127	156	615
09/14/96	2,860	896	1,174
09/17/96	Unavailable	77	477
09/18/96	Unavailable	327	260
10/04/96	Unavailable	6,294	9,748
11/23/96	Unavailable	121	513
11/24/96	Unavailable	6	51
Total	162,792	10,738	48,313
Acre feet	3.74	0.25	1.11

*Values are in cubic feet unless noted otherwise.

The SWHC Project performed a historical flood evaluation on a large tree trunk deposited by storm runoff in Arroyo del Coyote, about one-half mile upstream of Lovelace Road. The flow that deposited this tree trunk was estimated to be 6,300 cubic feet per second. In 1993, IT Corporation produced a hydrology report for Lurance Canyon, and estimated the maximum flow in the upper reaches of Arroyo del Coyote to be 5,000 cubic feet per second using the USGS method to estimate the surface water discharge for a 50-year storm (IT Corporation, 1993).

Storm water from Tech Area I is collected in a storm sewer system consisting of curb and gutter open channels, and underground pipes (see Figure 3-8). The northwest portion of the Tech Area I-system discharges into the KAFB storm sewer system. The remainder of Tech Area I, the western portion of Tech Area II, and the western 3/4 of Tech Area IV discharge directly to Tijeras Arroyo through Storm Water Monitoring Station 5, southwest of Tech Area IV at Pennsylvania Avenue. Storm Water Monitoring Station 2 monitors run-on flow to SNL/NM from a KAFB housing area. Storm Water Monitoring Station 4 monitors flow from SNL/NM's reapplication yard. The eastern portions of Tech Area II and Tech Area IV discharge directly into Tijeras Arroyo.

4.2 Floodplains and Wetlands

This section contains a discussion of the floodplains and wetlands on the Kirtland Federal Complex (KFC). Because of the semiarid climate, these areas are small when compared with the total area of the KFC.

4.2.1 Floodplains

Floods and runoff occur most commonly during the summer thunderstorm season (July through September) when approximately 50% of the average annual rainfall occurs. Snow in the Manzano Mountains can produce local runoff in the mountains, which rarely reaches the lower portions of the arroyos or the Rio Grande. Although none have occurred in Albuquerque recently, large frontal storms in the fall or winter have resulted in localized flooding in other nearby areas.

Extreme precipitation values for points in Albuquerque include 0.5 inch in five minutes, 1.34 inches in 25 minutes, and 4.6 inches in six hours (Fischer, Rote, and Borland, 1984; Metzker, Gold, and Thomas, 1993). Too little data is available to assign a recurrence interval to these intensities. Generalized precipitation intensity maps are available elsewhere (Miller, Frederick, and Tracey, 1973).

Several floodplain delineation efforts for the KFC were summarized previously (Sandia National Laboratories, 1993b) and the 100- and 500-year floodplains are depicted in Figure 3-9. The accuracy of these calculated floodplains is limited because of the lack of historical data and the nature of storms at the KFC. The small size of convective thunderstorms makes modeling rainfall, runoff and floodplains difficult.

Figure 3-9. 100- and 500-Year Floodplains

It is probable that rainfall from one storm may affect only half the watershed. If storms of identical areal distributions of rainfall amount and timing strike the same watershed in two locations, runoff from the two events may differ because initial soil-water conditions can vary, or because the water from one event is colder (more viscous) than from the other (Sandia National Laboratories, 1996d).

The estimated 100-year flow rate for Tijeras Arroyo above the Arroyo del Coyote confluence is 17,300 cubic feet per second; for Arroyo del Coyote at its confluence with Tijeras Arroyo, the estimated 100-year flow rate is 8,400 cubic feet per second (U.S. Army Corps of Engineers, 1979). For the discharge at storm water sampling Station #5, which primarily comes from Tech Areas I and II, the estimated 100-year flow rate is approximately 800 cubic feet per second (Bohannon-Huston Incorporated, 1990).

4.2.2 Wetlands

There are no springs or active wetlands located on DOE or SNL/NM assigned properties.

4.3 Water Quality and Contamination Issues

The Kirtland Federal Complex (KFC) is located on an alluvial plain on the eastern slopes of the Rio Grande Valley. The climate is typical of a high desert plateau with low precipitation, wide temperature extremes, and typically clear, sunny days.

As described above, the surface water system within the KFC consists primarily of ephemeral drainages. There are three ways surface runoff can be a significant factor in contaminant transport.

1. It can erode surface materials and uncover and suspend previously buried contaminants.
2. Contaminants suspended in surface runoff may be transported hundreds of feet within minutes, whereas transport in subsurface flows may require years to cover the same distance. Interaction with sediments results in little retardation of contaminants when the sediments are also moving with the water flow.
3. Contaminated surface runoff may infiltrate the channel bottom and recharge the underlying aquifer far from the original contamination source.

The net result of such hybrid surface and subsurface transport could be contaminated groundwater existing far from a known contamination source, and far in advance of groundwater plumes emanating from the source.

The sparse vegetation associated with high desert climates, combined with the large topographic relief in the KFC area, is conducive to high erosion rates that could lead to subsequent surface transport and redistribution of contaminants.

SNL/NM has conducted limited sampling of surface runoff from areas under its control. Analysis results are contained in the *National Pollution Discharge Elimination System (NPDES) Storm Water Permit Application 1992* (Sandia National Laboratories, 1992b), site environmental reports (Sandia National Laboratories, 1993c, 1994c, 1995i, 1996g); annual storm water reports, and the Site-Wide Hydrogeologic Characterization (SWHC) Project reports (Sandia National Laboratories, 1993b, 1994b, 1995a, 1996d).

SNL/NM personnel are aware of no major sources of contamination in areas where severe surface erosion is likely, and sampling activities show no clear evidence of contamination in local surface runoff waters. However, storm water sampling results indicate some contamination from SNL/NM activities may have occurred. Storm water samples collected below SNL/NM operational sites in upper Arroyo del Coyote showed higher levels of aluminum, magnesium, and copper compared to samples taken upstream of the operational sites (Sandia National Laboratories, 1995a).

If such contamination is present in surface runoff, many contaminants will be retarded (i.e., move slower than water) when moving through soils. The retardation of contaminants by generally very thick vadose zones would suggest that much time may be required before some contaminants reach groundwater.

Another major source of potential pollution in older facilities, according to the U.S. Environmental Protection Agency (EPA), is illicit connections to the storm water drain system. SNL/NM has completed a multiyear project to locate and eliminate all illicit connections to the storm water drain system. Details of this project may be found in the *Storm Drain System Cross Connection Project* report (Sandia National Laboratories, 1995j).

Figure 3-8 shows the locations of Storm Water Stations 2, 4, and 5. Tables 3-13 and 3-14 display 1995 and 1996 monitoring results from these stations. The locations of Storm Water Stations 4 and 5 were selected to monitor discharges from SNL/NM's NPDES-permitted activities. Station 2 monitors storm water run-on from a KAFB housing area.

Table 3-13. 1995 Storm Water Sampling Results

Parameter	Units	SW#2 09/08/95	SW#4 07/20/95	SW#4 08/24/95	SW#5 ^a	NM Limits (MAC) ^b	MCL ^c
General Properties							
Oil and grease	mg/L ^d	ND ^e	8.7	ND			
Cyanide	mg/L	ND	U ^f	0.001		0.2	0.2
Phenolics	mg/L	ND	NA ^g	0.014			
Fluoride	mg/L	0.3	NA	ND			
Residual chlorine	mg/L	NA	NA	ND			
pH (Standard pH units)		NA	NA	8.6		6 to 9	6.5 to 8.5
Temperature	°C ^h	NA	NA	ND			
Total suspended solids	mg/L	NA	NA	293			
Total dissolved solids	mg/L	110	78	168		1,000	500
Biological							
Total coliform (colonies/100 L)		NA	NA	NA			
Fecal coliform (colonies/100 L)		NA	NA	NA			
Biological oxygen demand	mg/L	NA	NA	5.9			
Chemical oxygen demand	mg/L	NA	NA	16.8			
Nitrogen and Phosphorus							
Nitrate plus nitrite	mg/L	NA	0.83	1.5			
Total Kjeldahl nitrogen	mg/L	NA	NA	1.1			
Orthophosphate	mg/L	NA	NA	ND			
Total phosphorus	mg/L	0.54	0.17	0.31			
Metals							
Arsenic	mg/L	ND	U	0.003		0.01	.05
Barium	mg/L	0.24	1.1	0.16		1.0	2
Cadmium	mg/L	ND	U	ND		0.01	0.005
Chromium	mg/L	0.02	U	0.011		0.05	0.1
Copper	mg/L	ND	U	0.02			1.3
Lead	mg/L	ND	U	ND		0.05	0.015
Manganese	mg/L	0.24	0.57	0.18		0.2	0.05
Mercury	mg/L	ND	U	ND		0.002	0.002
Nickel	mg/L	ND	U	0.011		0.2	0.1
Selenium	mg/L	ND	U	ND		0.05	0.05
Silver	mg/L	ND	U	ND		0.05	0.05
Zinc	mg/L	0.1	0.57	0.12		10	5

Table 3-13. 1995 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 09/08/95	SW#4 07/20/95	SW#4 08/24/95	SW#5 ^a	NM Limits (MAC) ^b	MCL ^c
Nitrobenzene	µg/L	ND	U	ND		TOX	-
Isophorone	µg/L	ND	U	ND			-
2-Nitrophenol	µg/L	ND	U	ND		-	-
2,4-Dimethylphenol	µg/L	ND	U	ND		-	-

Table 3-13. 1995 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 09/08/95	SW#4 07/20/95	SW#4 08/24/95	SW#5 ^a	NM Limits (MAC) ^b	MCL ^c
Bromodichloromethane	µg/L	ND	U	ND		-	-
Bromoform	µg/L	ND	U	ND		-	-
Bromomethane	µg/L	ND	U	ND		-	-
Carbon tetrachloride	µg/L	ND	U	ND		0.01	0.005
Chlorobenzene	µg/L	ND	U	ND		TOX	0.1
Chloroethane	µg/L	ND	U	ND		0.001	0.002
2-Chloroethyl vinyl ether	µg/L	ND	U	ND			
Chloroform	µg/L	ND	U	ND			
Chloromethane	µg/L	ND	U	ND		TOX	-
Dibromochloromethane	µg/L	ND	U	ND		0.01	0.005
1,2-Dichlorobenzene	µg/L	ND	U	ND		TOX	0.06
1,3-Dichlorobenzene	µg/L	ND	U	ND		TOX	-
1,4-Dichlorobenzene	µg/L	ND	U	ND		TOX	0.075
1,1-Dichloroethene	µg/L	ND	U	ND		0.025	-
1,2-Dichloropropane	µg/L	ND	U	ND		-	0.005
trans-1,2-Dichloroethene	µg/L	ND	U	ND		0.01	0.005
cis-1,3-Dichloropropene	µg/L	ND	U	ND			
Ethylbenzene	µg/L	ND	U	ND		0.075	1.0
Methylene chloride (dichloromethane)	µg/L	ND	1.4	ND		0.1	0.005
Tetrachloroethene	µg/L	ND	U	ND			
1,1,1-Trichloroethane	µg/L	ND	U	ND			
1,1,2-Trichloroethane	µg/L	ND	U	ND		0.01	-
Trichloroethene TCE	µg/L	ND	U	ND		0.06	0.2
Trichlorofluoromethane	µg/L	ND	U	ND			
1,1,2,2-Tetrachloroethane	µg/L	ND	U	ND		0.01	-
Toluene (methylbenzene)	µg/L	ND	U	ND		0.75	1.0
Vinyl chloride (chloroethene)	µg/L	ND	U	ND		0.001	0.002
Semivolatile Organics							
N-Nitrosodimethylamine	µg/L	ND	U	ND		TOX	-
Phenol	µg/L	ND	U	ND		TOX	-
bis(2-Chloroethyl) ether	µg/L	ND	U	ND			
2-Chlorophenol	µg/L	ND	U	ND			
bis(2-Chloroisopropyl) ether	µg/L	ND	U	ND			
N-Nitroso-di-n-propylamine	µg/L	ND	U	ND			
Hexachloroethane	µg/L	ND	U	ND		TOX	-

Table 3-13. 1995 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 09/08/95	SW#4 07/20/95	SW#4 08/24/95	SW#5 ^a	NM Limits (MAC) ^b	MCL ^c
Nitrobenzene	µg/L	ND	U	ND		TOX	-
Isophorone	µg/L	ND	U	ND			
2-Nitrophenol	µg/L	ND	U	ND		-	-
2,4-Dimethylphenol	µg/L	ND	U	ND		-	-
bis(2-Chloroethoxy) methane	µg/L	ND	U	ND			
2,4-Dichlorophenol	µg/L	ND	U	ND		TOX	-
1,2,4-Trichlorobenzene	µg/L	ND	U	ND		-	0.07
Naphthalene	µg/L	ND	U	ND		0.03	-
Hexachlorobutadiene	µg/L	ND	U	ND			
Hexachlorocyclopenta- diene	µg/L	ND	U	ND			
2,4,6-Trichlorophenol	µg/L	ND	U	ND		TOX	-
2-Chloronaphthalene	µg/L	ND	U	ND			
2,6-Dinitrotoluene	µg/L	ND	U	ND		TOX	-
Acenaphthylene	µg/L	ND	U	ND			
Acenaphthene	µg/L	ND	U	ND			
2,4-Dinitrophenol	µg/L	ND	U	ND			
4-Nitrophenol	µg/L	ND	U	ND			
2,4-Dinitrotoluene	µg/L	ND	U	ND		TOX	-
Diethyl phthalate	µg/L	ND	U	ND			
4-Chlorophenyl phenyl ether	µg/L	ND	U	ND		TOX	-
Fluorine	µg/L	ND	U	ND		TOX	-
4,6-Dinitro-2- methylphenol	µg/L	ND	U	ND			
N-Nitrosodiphenylamine	µg/L	ND	U	ND		TOX	-
1,2-Diphenylhydrazine	µg/L	ND	U	ND			
4-Bromophenyl phenyl ether	µg/L	ND	U	ND			
Hexachlorobenzene	µg/L	ND	U	ND		TOX	0.001
Pentachlorophenol	µg/L	ND	U	ND		TOX	0.001
Phenanthrene	µg/L	ND	U	ND			
Anthracene	µg/L	ND	U	ND		-	0.0001
Di-n-butyl phthalate	µg/L	ND	U	1.8			
Fluoranthene	µg/L	ND	U	ND		TOX	-
Benzidine	µg/L	ND	U	ND		TOX	-
Pyrene	µg/L	ND	U	ND			
Butyl benzyl phthalate	µg/L	ND	U	ND			
bis(2-Ethylhexyl) phthalate	µg/L	ND	0.013	6.1			
3,3'-Dichlorobenzidine	µg/L	ND	U	ND		TOX	-

Table 3-13. 1995 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 09/08/95	SW#4 07/20/95	SW#4 08/24/95	SW#5 ^a	NM Limits (MAC) ^b	MCL ^c
Benzo(a)anthracene	µg/L	ND	U	ND			
Chrysene	µg/L	ND	U	ND			
Di-n-octyl phthalate	µg/L	ND	U	ND			
Benzo b fluoranthene	µg/L	ND	U	ND			
Benzo k fluoranthene	µg/L	ND	U	ND			
Benzo(a)pyrene	µg/L	ND	U	ND			
Indeno(1,2,3-cd)pyrene	µg/L	ND	U	ND			
Dibenz(a,h)anthracene	µg/L	ND	U	ND			
Benzo(g,h,i)perylene	µg/L	ND	U	ND			
Organochlorine Pesticides and Polychlorinated Biphenyls - EPA Method 608^d							
Aldrin	µg/L	ND	U	ND		TOX	-
Aroclor 1016	µg/L	ND	U	ND			
Aroclor 1221	µg/L	ND	U	ND			
Aroclor 1232	µg/L	ND	U	ND			
Aroclor 1242	µg/L	ND	U	ND			
Aroclor 1248	µg/L	ND	U	ND			
Aroclor 1254	µg/L	ND	U	ND			
Aroclor 1260	µg/L	ND	U	ND			
alpha-BHC	µg/L	ND	U	ND		TOX	-
beta-BHC	µg/L	ND	U	ND		TOX	-
delta-BHC	µg/L	ND	U	ND		-	-
gamma-BHC (Lindane)	µg/L	ND	U	ND		TOX	0.0002
Chlordane	µg/L	ND	U	ND		TOX	0.0002
4,4'-DDD	µg/L	ND	U	ND		-	-
4,4'-DDE	µg/L	ND	U	ND		-	-
4,4'-DDT	µg/L	ND	U	ND		TOX	-
Dieldrin	µg/L	ND	U	ND			
Endosulfan I	µg/L	ND	U	ND			
Endosulfan II	µg/L	ND	U	ND		TOX	-
Endosulfan sulfate	µg/L	ND	U	ND		TOX	-
Endrin	µg/L	ND	U	ND			
Endrin aldehyde	µg/L	ND	U	ND			
Heptachlor	µg/L	ND	U	ND		TOX	0.0004
Heptachlor epoxide	µg/L	ND	U	ND		TOX	0.0002
Toxaphene	µg/L	ND	U	ND		TOX	0.003
Explosives by High-Performance Liquid Chromatography - Low Level^e							
Method 8330 ^f	µg/L	ND	U	ND			
HMX	µg/L	ND	U	ND		-	-
RDX	µg/L	ND	U	ND			
1,3,5-Trinitrobenzene	µg/L	ND	U	ND			
1,3-Dinitrobenzene	µg/L	ND	U	ND			
Tetryl	µg/L	ND	U	ND			
Nitrobenzene	µg/L	ND	U	ND			

Table 3-13. 1995 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 09/08/95	SW#4 07/20/95	SW#4 08/24/95	SW#5 ^a	NM Limits (MAC) ^b	MCL ^c
2,4,6-Trinitrotoluene	µg/L	ND	U	ND			
4-Amino-2,6-dinitrotoluene	µg/L	ND	U	ND			
2-Amino-4,6-dinitrotoluene	µg/L	ND	U	ND			
2,6-Dinitrotoluene	µg/L	ND	U	ND			
2,4-Dinitrotoluene	µg/L	ND	U	ND		TOX	-

Table 3-14. 1996 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 07/10/96	SW#2 08/20/96	SW#4 06/28/96	SW#4 07/10/96	SW#5 08/23/96	NM Limits (MAC) ^a	MCL ^b
Methylene chloride (dichloromethane)	µg/L	ND	2.6	ND	ND	1.7	0.1	0.005
Tetrachloroethene	µg/L	ND	ND	ND	ND	ND		
1,1,1-Trichloroethane	µg/L	ND	ND	ND	ND	ND		
1,1,2-Trichloroethane	µg/L	ND	ND	ND	ND	ND	0.01	-
Trichloroethene TCE	µg/L	ND	ND	ND	ND	ND	0.06	0.2
Trichlorofluoromethane	µg/L	ND	ND	ND	ND	ND		
1,1,2,2-Tetrachloroethane	µg/L	ND	ND	ND	ND	ND	0.01	-
Toluene (methylbenzene)	µg/L	ND	ND	ND	ND	ND	0.75	1.0
Vinyl chloride (chloroethene)	µg/L	ND	ND	ND	ND	ND	0.001	0.002
Semivolatile Organics								
N-Nitrosodimethylamine	µg/L	NT	NT	ND	ND	NT	TOX	-
Phenol	µg/L	NT	NT	ND	ND	NT	TOX	-
bis(2-Chloroethyl) ether	µg/L	NT	NT	ND	ND	NT		
2-Chlorophenol	µg/L	NT	NT	ND	ND	NT		
bis(2-Chloroisopropyl) ether	µg/L	NT	NT	ND	ND	NT		
N-Nitroso-di-n-propylamine	µg/L	NT	NT	ND	ND	NT		
Hexachloroethane	µg/L	NT	NT	ND	ND	NT	TOX	-
Nitrobenzene	µg/L	NT	NT	ND	ND	NT	TOX	-
Isophorone	µg/L	NT	NT	ND	ND	NT		
2-Nitrophenol	µg/L	NT	NT	ND	ND	NT	-	-
2,4-Dimethylphenol	µg/L	NT	NT	ND	ND	NT	-	-
bis(2-Chloroethoxy) methane	µg/L	NT	NT	ND	ND	NT		
2,4-Dichlorophenol	µg/L	NT	NT	ND	ND	NT	TOX	-
1,2,4-Trichlorobenzene	µg/L	NT	NT	ND	ND	NT	-	0.07
Naphthalene	µg/L	NT	NT	ND	ND	NT	0.03	-
Hexachlorobutadiene	µg/L	NT	NT	ND	ND	NT		
Hexachlorocyclopentadiene	µg/L	NT	NT	ND	ND	NT		
2,4,6-Trichlorophenol	µg/L	NT	NT	ND	ND	NT	TOX	-
2-Chloronaphthalene	µg/L	NT	NT	ND	ND	NT		

Table 3-14. 1996 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 07/10/96	SW#2 08/20/96	SW#4 06/28/96	SW#4 07/10/96	SW#5 08/23/96	NM Limits (MAC) ^a	MCL ^b
Nitrogen and Phosphorus								
Nitrate plus nitrite	mg/L	NT	NT	1.2	1.8	NT		
Total Kjeldahl nitrogen	mg/L	NT	NT	1	1.5	NT		
Orthophosphate	mg/L	NT	NT	ND	ND	NT		
Total phosphorus	mg/L	NT	NT	0.16	0.26	NT		
Metals								
Arsenic	mg/L	NT	NT	J	0.0028J	NT	0.01	.05
Barium	mg/L	NT	NT	0.14	0.15	NT	1.0	2
Cadmium	mg/L	NT	NT	0.0066	ND	NT	0.01	0.005
Chromium	mg/L	NT	NT	ND	0.0062J	NT	0.05	0.1
Copper	mg/L	NT	NT	0.018J	0.021	NT		1.3
Lead	mg/L	NT	NT	ND	ND	NT	0.05	0.015
Manganese	mg/L	NT	NT	0.15	0.17	NT	0.2	0.05
Mercury	mg/L	NT	NT	ND	ND	NT	0.002	0.002
Nickel	mg/L	NT	NT	ND	0.0099J	NT	0.2	0.1
Selenium	mg/L	NT	NT	ND	ND	NT	0.05	0.05
Silver	mg/L	NT	NT	ND	ND	NT	0.05	0.05
Zinc	mg/L	NT	NT	0.11	0.084	NT	10	5
Radionuclide Analyses								
Gross alpha	pCi/L ¹	NT	NT	2.19	NT	NT		15
Gross beta	pCi/L	NT	NT	5.74	NT	NT		4
Volatile Organics								
Acetone	µg/L ¹	ND	ND	ND	ND	ND		
Acrolein	µg/L	ND	ND	ND	ND	ND	TOX ^k	-
Acrylonitrile	µg/L	ND	ND	ND	ND	ND	TOX	-
Benzene	µg/L	ND	ND	ND	ND	ND	0.01	0.005
Bromodichloromethane	µg/L	ND	ND	ND	ND	ND	-	-
Bromoform	µg/L	ND	ND	ND	ND	ND	-	-
Bromomethane	µg/L	ND	ND	ND	ND	ND	-	-
Carbon tetrachloride	µg/L	ND	ND	ND	ND	ND	0.01	0.005
Chlorobenzene	µg/L	ND	ND	ND	ND	ND	TOX	0.1
Chloroethane	µg/L	ND	ND	ND	ND	ND	0.001	0.002
2-Chloroethyl vinyl ether	µg/L	ND	ND	ND	ND	ND		
Chloroform	µg/L	ND	ND	ND	ND	ND		
Chloromethane	µg/L	ND	ND	ND	ND	ND	TOX	-
Dibromochloromethane	µg/L	ND	ND	ND	ND	ND	0.01	0.005
1,2-Dichlorobenzene	µg/L	ND	ND	ND	ND	ND	TOX	0.06
1,3-Dichlorobenzene	µg/L	ND	ND	ND	ND	ND	TOX	-
1,4-Dichlorobenzene	µg/L	ND	ND	ND	ND	ND	TOX	0.075
1,1-Dichloroethene	µg/L	ND	ND	ND	ND	ND	0.025	-
1,2-Dichloropropane	µg/L	ND	ND	ND	ND	ND	-	0.005
trans-1,2-Dichloroethene	µg/L	ND	ND	ND	ND	ND	0.01	0.005
cis-1,3-Dichloropropene	µg/L	ND	ND	ND	ND	ND		
Ethylbenzene	µg/L	ND	ND	ND	ND	ND	0.075	1.0

Table 3-14. 1996 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 07/10/96	SW#2 08/20/96	SW#4 06/28/96	SW#4 07/10/96	SW#5 08/23/96	NM Limits (MAC) ^a	MCL ^b
Methylene chloride (dichloromethane)	µg/L	ND	2.6	ND	ND	1.7	0.1	0.005
Tetrachloroethene	µg/L	ND	ND	ND	ND	ND		
1,1,1-Trichloroethane	µg/L	ND	ND	ND	ND	ND		
1,1,2-Trichloroethane	µg/L	ND	ND	ND	ND	ND	0.01	-
Trichloroethene TCE	µg/L	ND	ND	ND	ND	ND	0.06	0.2
Trichlorofluoromethane	µg/L	ND	ND	ND	ND	ND		
1,1,2,2- Tetrachloroethane	µg/L	ND	ND	ND	ND	ND	0.01	-
Toluene (methylbenzene)	µg/L	ND	ND	ND	ND	ND	0.75	1.0
Vinyl chloride (chloroethene)	µg/L	ND	ND	ND	ND	ND	0.001	0.002
Semivolatile Organics								
N-Nitrosodimethylamine	µg/L	NT	NT	ND	ND	NT	TOX	-
Phenol	µg/L	NT	NT	ND	ND	NT	TOX	-
bis(2-Chloroethyl) ether	µg/L	NT	NT	ND	ND	NT		
2-Chlorophenol	µg/L	NT	NT	ND	ND	NT		
bis(2-Chloroisopropyl) ether	µg/L	NT	NT	ND	ND	NT		
N-Nitroso-di-n- propylamine	µg/L	NT	NT	ND	ND	NT		
Hexachloroethane	µg/L	NT	NT	ND	ND	NT	TOX	-
Nitrobenzene	µg/L	NT	NT	ND	ND	NT	TOX	-
Isophorone	µg/L	NT	NT	ND	ND	NT		
2-Nitrophenol	µg/L	NT	NT	ND	ND	NT	-	-
2,4-Dimethylphenol	µg/L	NT	NT	ND	ND	NT	-	-
bis(2-Chloroethoxy) methane	µg/L	NT	NT	ND	ND	NT		
2,4-Dichlorophenol	µg/L	NT	NT	ND	ND	NT	TOX	-
1,2,4-Trichlorobenzene	µg/L	NT	NT	ND	ND	NT	-	0.07
Naphthalene	µg/L	NT	NT	ND	ND	NT	0.03	-
Hexachlorobutadiene	µg/L	NT	NT	ND	ND	NT		
Hexachlorocyclopentadiene	µg/L	NT	NT	ND	ND	NT		
2,4,6-Trichlorophenol	µg/L	NT	NT	ND	ND	NT	TOX	-
2-Chloronaphthalene	µg/L	NT	NT	ND	ND	NT		
2,6-Dinitrotoluene	µg/L	NT	NT	ND	ND	NT	TOX	-
Acenaphthylene	µg/L	NT	NT	ND	ND	NT		
Acenaphthene	µg/L	NT	NT	ND	ND	NT		
2,4-Dinitrophenol	µg/L	NT	NT	ND	ND	NT		
4-Nitrophenol	µg/L	NT	NT	ND	ND	NT		
2,4-Dinitrotoluene	µg/L	NT	NT	ND	ND	NT	TOX	-
Diethyl phthalate	µg/L	NT	NT	ND	ND	NT		
4-Chlorophenyl phenyl ether	µg/L	NT	NT	ND	ND	NT	TOX	-

Table 3-14. 1996 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 07/10/96	SW#2 08/20/96	SW#4 06/28/96	SW#4 07/10/96	SW#5 08/23/96	NM Limits (MAC) ^a	MCL ^b
Fluorine	µg/L	NT	NT	ND	ND	NT	TOX	-
4,6-Dinitro-2-methylphenol	µg/L	NT	NT	ND	ND	NT		
N-Nitrosodiphenylamine	µg/L	NT	NT	ND	ND	NT	TOX	-
1,2-Diphenylhydrazine	µg/L	NT	NT	ND	ND	NT		
4-Bromophenyl phenyl ether	µg/L	NT	NT	ND	ND	NT		
Hexachlorobenzene	µg/L	NT	NT	ND	ND	NT	TOX	0.001
Pentachlorophenol	µg/L	NT	NT	1.5	ND	NT	TOX	0.001
Phenanthrene	µg/L	NT	NT	ND	ND	NT		
Anthracene	µg/L	NT	NT	ND	1.8	NT	-	0.0001
Di-n-butyl phthalate	µg/L	NT	NT	ND	ND	NT		
Fluoranthene	µg/L	NT	NT	ND	ND	NT	TOX	-
Benzdine	µg/L	NT	NT	ND	ND	NT	TOX	-
Pyrene	µg/L	NT	NT	ND	ND	NT		
Butyl benzyl phthalate	µg/L	NT	NT	ND	ND	NT		
bis(2-Ethylhexyl) phthalate	µg/L	NT	NT	4	7.4	NT		
3,3'-Dichlorobenzidine	µg/L	NT	NT	ND	ND	NT	TOX	-
Benzo(a)anthracene	µg/L	NT	NT	ND	ND	NT		
Chrysene	µg/L	NT	NT	ND	ND	NT		
Di-n-octyl phthalate	µg/L	NT	NT	ND	ND	NT		
Benzo b fluoranthene	µg/L	NT	NT	ND	ND	NT		
Benzo k fluoranthene	µg/L	NT	NT	ND	ND	NT		
Benzo(a)pyrene	µg/L	NT	NT	ND	ND	NT		
Indeno(1,2,3-cd)pyrene	µg/L	NT	NT	ND	ND	NT		
Dibenz(a,h)anthracene	µg/L	NT	NT	ND	ND	NT		
Benzo(g,h,i)perylene	µg/L	NT	NT	ND	ND	NT		
Organochlorine Pesticides and Polychlorinated Biphenyls - EPA Method 608¹								
Aldrin	µg/L	NT	NT	ND	ND	NT	TOX	-
Aroclor 1016	µg/L	NT	NT	ND	ND	NT		
Aroclor 1221	µg/L	NT	NT	ND	ND	NT		
Aroclor 1232	µg/L	NT	NT	ND	ND	NT		
Aroclor 1242	µg/L	NT	NT	ND	ND	NT		
Aroclor 1248	µg/L	NT	NT	ND	ND	NT		
Aroclor 1254	µg/L	NT	NT	ND	ND	NT		
Aroclor 1260	µg/L	NT	NT	ND	ND	NT		
alpha-BHC	µg/L	NT	NT	ND	ND	NT	TOX	-
beta-BHC	µg/L	NT	NT	ND	ND	NT	TOX	-
delta-BHC	µg/L	NT	NT	ND	ND	NT	-	-
Gamma-BHC (Lindane)	µg/L	NT	NT	ND	ND	NT	TOX	0.0002
Chlordane	µg/L	NT	NT	ND	ND	NT	TOX	0.0002
4,4'-DDD	µg/L	NT	NT	ND	ND	NT	-	-

Table 3-14. 1996 Storm Water Sampling Results (Continued)

Parameter	Units	SW#2 07/10/96	SW#2 08/20/96	SW#4 06/28/96	SW#4 07/10/96	SW#5 08/23/96	NM Limits (MAC) ^a	MCL ^b
4,4'-DDE	µg/L	NT	NT	ND	ND	NT	-	-
4,4'-DDT	µg/L	NT	NT	ND	0.024	NT	TOX	-
Dieldrin	µg/L	NT	NT	ND	ND	NT		
Endosulfan I	µg/L	NT	NT	ND	ND	NT		
Endosulfan II	µg/L	NT	NT	ND	ND	NT	TOX	-
Endosulfan sulfate	µg/L	NT	NT	ND	ND	NT	TOX	-
Endrin	µg/L	NT	NT	ND	ND	NT		
Endrin aldehyde	µg/L	NT	NT	ND	ND	NT		
Heptachlor	µg/L	NT	NT	ND	ND	NT	TOX	0.0004
Heptachlor epoxide	µg/L	NT	NT	ND	ND	NT	TOX	0.0002
Toxaphene	µg/L	NT	NT	ND	ND	NT	TOX	0.003
Explosives by High-Performance Liquid Chromatography - Low Level								
Method 8330 ⁱ	µg/L	NT	NT	ND	ND	NT		
HMX	µg/L	NT	NT	ND	ND	NT	-	-
RDX	µg/L	NT	NT	ND	ND	NT		
1,3,5-Trinitrobenzene	µg/L	NT	NT	0.11J	ND	NT		
1,3-Dinitrobenzene	µg/L	NT	NT	ND	ND	NT		
Tetryl	µg/L	NT	NT	ND	ND	NT		
Nitrobenzene	µg/L	NT	NT	ND	ND	NT		
2,4,6-Trinitrotoluene	µg/L	NT	NT	ND	ND	NT		
4-Amino-2,6-dinitrotoluene	µg/L	NT	NT	ND	ND	NT		
2-Amino-4,6-dinitrotoluene	µg/L	NT	NT	ND	ND	NT		
2,6-Dinitrotoluene	µg/L	NT	NT	ND	ND	NT		
2,4-Dinitrotoluene	µg/L	NT	NT	ND	ND	NT	TOX	-
2-Nitrotoluene	µg/L	NT	NT	ND	ND	NT		
4-Nitrotoluene	µg/L	NT	NT	ND	ND	NT		
3-Nitrotoluene	µg/L	NT	NT	ND	ND	NT		

^a MAC = Maximum allowable concentration, established by New Mexico Water Quality Control Commission, 20 NMAC 6.2.

^b MCL = Maximum contaminant levels, established by the U.S. Environmental Protection Agency Primary Drinking Water Regulations in 40 CFR 141.11(b), subsequent amendments, or the New Mexico Environmental Improvement Board in 20 NMAC 7.1.

^c mg/L = milligram(s) per liter.

^d J = Analyte present at less than the laboratory quantification limit; estimated concentration.

^e NT = Not tested.

^f ND = Not detected.

^g NA = Not analyzed.

^h °C = Degree(s) Celsius.

ⁱ pCi/L = Picocurie(s) per liter.

^j µg/L = Microgram(s) per liter.

^k TOX = A numerical standard has not been established, but the contaminant is listed in a narrative standard of "toxic pollutant" defined in New Mexico Water Quality Control Commission regulations.

^l U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response, 1996.

5.0 SNL/NM DISCHARGES

5.1 Overview

Prior to any discharge to the surface, approval must be obtained from the Environmental and Emergency Management Department. All requests to discharge are reviewed for volume, frequency, location, pH, chemical composition, and process associated with the discharge. The Environmental and Emergency Management Department prepares a Notice of Intent (NOI) to Discharge for submittal to the New Mexico Environment Department (NMED) as required. Permission is given to requesting organizations for specified discharges if all water quality requirements are met. Table 3-15 lists all fiscal year 1996 (FY1996) surface discharge requests.

5.2 Natural Discharges

Storm water runoff is drained from the SNL/NM tech areas by a combination of overland flow, natural channels, open drainage ditches, culverts, and storm sewers. Generally, drainage patterns are most clearly defined in Tech Area I, Tech Area IV, and Tech Area V and least clearly defined in Tech Area II, Tech Area III, and the Coyote Test Field (CTF). The site drainage maps (see Figures 3-6 and 3-8) outline the storm water drainage areas and indicate the outfall locations for each of the drainage areas. Ten outfalls have been identified as the primary storm water discharge points for SNL/NM.

5.2.1 SNL/NM Storm Water Drainage System

In Tech Area I, storm water is conveyed through a system of storm sewers and open channels that direct water south to Tijeras Arroyo or west to Kirtland Air Force Base (KAFB) (see Figure 3-8). Storm water collected in the northwest corner of Tech Area I flows west to KAFB in storm sewers beneath "E" Street and south of "K" Street. The remainder of Tech Area I is drained by storm water lines running south along 9th, 11th, and 14th Streets. These sewers flow into open ditches south of Tech Area I. Flow from open ditches south of Tech Area I is combined south of Ordnance Road into a single ditch that empties into Tijeras Arroyo. Outfalls 001, 002, 003, and 005 represent the discharge points for storm water drainage from Tech Area I.

Table 3-15. Fiscal Year 1996 (FY1996) Surface Discharges Requests

Date	ID	SNL/NM Organization	Location	Volume	Frequency	Contaminants or Source	Meets NMAC ^a	Comments
10/11/95	SW96-01	7913	South of City of Albuquerque water reservoir, adjacent to Eubank Boulevard	2,500 gallons and 20 cubic yards of soil	Duration of project	None	Yes	
10/11/95	SW96-02	7582	East of CWL ^b	2,500 gallons of water	One time	Decontamination/purge water	Yes	
10/11/95	SW96-03	5941	Building 9967	5 gallons	Daily	Soap	Yes	
10/25/95	SW96-04	7582	Adjacent to Tech Area II <90-day accumulation area	220 gallons	One time	None	Yes	
11/13/95	SW96-05	7582	Not applicable	Not applicable	Not applicable	Contaminants exceed groundwater standards	No	Recommend discharge to sanitary sewer. Not approved for surface discharge.
11/13/95	SW96-06	7582	Not applicable	Not applicable	Not applicable	Contaminants exceed groundwater standards	No	Recommend discharge to sanitary sewer. Not approved for surface discharge.
12/12/95	SW96-07	1522	Building 894	Condensate from three dehumidifiers	As required	None	Yes	
02/06/96	SW96-08	1554	Building 9956	Fewer than five gallons per minute	As required	None	Yes	
02/06/96	SW96-09	1554	French drain west of Building 9956	Fewer than five gallons per minute	As required	None	Yes	
03/05/96	SW96-10	7574	NW-TA3	35 gallons	As required	None	Yes	
03/11/96	SW96-11	7582	Adjacent to CWL <90-day storage area	600 gallons	One time	None	Yes	

Table 3-15. Fiscal Year 1996 (FY1996) Surface Discharges Requests (Continued)

Date	ID	SNL/NM Organization	Location	Volume	Frequency	Contaminants or Source	Meets NMAC ^a	Comments
03/11/96	SW96-12	7511	Tech Area IV	30 gallons	Weekly	Trace amounts of fuel	No	Informal review by NMED ^c suggests this discharge would not meet regulations.
03/15/96	SW96-13	7582	KAFB-10	3,000+ gallons	One time	Water from well development and decontamination	Yes	
03/20/96	SW96-14	7711	Various	1.5 gallons	As required	Disinfectant	No	Recommend discharge to sanitary sewer. Not approved for surface discharge.
04/02/96	SW96-15	1139	Building 9940	35 gallons	As required	Cooling water	Yes	
04/05/96	SW96-16	9342	Tech Area IV Lagoon II	500 gallons	One time	None	Yes	
04/09/96	SW96-17	7575	Tech Area III	2,000 gallons	If required	Small amounts of API ^d class G cement	Yes	
04/16/96	SW96-18	7511	Adjacent to MWL ^e	435 gallons	One time	None	Yes	
04/25/96	SW96-19	7582	Adjacent to CWL <90-day storage area	550 gallons	One time	Decontamination water	Yes	
04/25/96	SW96-20	7712	Dirt roads	5,000 gallons	One time	Less than 10 ppm ^f chlorine	Yes	
05/02/96	SW96-21	7582	Adjacent to CWL <90-day storage area	500 gallons	One time	None	Yes	
05/02/96	SW96-22	7582	Adjacent to CWL <90-day storage area	600 gallons	One time	None	Yes	
05/02/96	SW96-23	6117	Building 849	100 gallons	Four times per year	Rock flour	Yes	

Table 3-15. Fiscal Year 1996 (FY1996) Surface Discharges Requests (Continued)

Date	ID	SNL/NM Organization	Location	Volume	Frequency	Contaminants or Source	Meets NMAC ^a	Comments
05/03/96	SW96-24	5514	Building 9920	160 gallons of AFC-380	As required	AFC-380	Yes	
05/30/96	SW96-25	7582	TAV-MW02	Fewer than 10,000 gallons	One time	None	Yes	Purge water - historical data does not indicate any toxic pollutants present.
06/03/96	SW96-26	6428	Building 6530	200 gallons	Every two months	None	Yes	
06/10/96	SW96-27	7582	Adjacent to Tech Area II <90-day storage area	30 gallons	One time	None	Yes	
06/20/96	SW96-28	9333	Building 9330	1,925 gallons	Every two months	None	Yes	
06/27/96	SW96-29	6400	Building 9949	50 gallons	One time	Concrete dust	Yes	
06/11/96	SW96-30	7582	Building 6540	120 gallons	One time	Nitrate	No	Recommend discharge to sanitary sewer. Not approved for surface discharge.
06/11/96	SW96-31	7582	Mixed Waste Landfill	340 gallons	One time	Purge and decontamination water	Yes	
07/17/96	SW96-32	9333-1	Building 9330	150 gallons	Two tests	Explosive test	Yes	
07/29/96	SW96-33	7582	Tech Area III	3 gallons	One time	None	Yes	Ten containers rejected for surface discharge. Recommend sanitary sewer disposal.

^a NMAC = New Mexico Administrative Code, 20 NMAC 6.2.
^b CWL = Chemical Waste Landfill.
^c NMED = New Mexico Environment Department.
^d API = American Petroleum Institute.
^e MWL = Mixed Waste Landfill.
^f ppm = parts per million.

Storm water drainage from Tech Area II is primarily to the west by overland or unchannelized flows to the 9th Street storm channel immediately to the west of Tech Area II. Runoff from larger buildings in Tech Area II is drained by small (four to six inch) storm sewer lines. Drainage from Buildings 903, 904, 907, and 913 is routed to Tijeras Arroyo and to an open area in the western portion of Tech Area II. Outfall 005 represents the discharge point for storm water drainage from Tech Area II. Outfall 004 represents the discharge point for storm water drainage from the main salvage yard.

In Tech Area III, runoff follows natural contours and drains to the west. Some runoff coalesces in small arroyos that eventually flow into playas on undeveloped state land to the west before infiltrating the coarse surface soils. Outfalls 009 and 010 represent the discharge points for storm water drainage from Tech Area III.

Storm water drainage from Tech Area IV is a combination of overland flow and controlled drainage by storm sewers. Runoff from parking lots on the west side of Tech Area IV as well as Buildings 962 and 980 is collected by storm sewers that discharge to the open ditch alongside 9th Street and adjacent to the western edge of Tech Area IV. This ditch empties into Tijeras Arroyo 1,500 feet to the south. Drainage from the southern and eastern portions of Tech Area IV is conducted by storm sewers, open ditches, and swales to just outside the south fence line and over the rim of Tijeras Arroyo. Drainage from three containment areas, built for dielectric oil storage tanks (tanks 981-1 and 983-1 through 983-4), is directed to a lined evaporation lagoon located just south of the Tech Area IV fence line. Drainage for a similar containment area southwest of Building 970 (tanks 970-1 and 970-2) is discharged to a similar, but unlined, lagoon south of the containment area. Storm water runoff for the remainder of Tech Area IV follows the existing slope to the east into Tijeras Arroyo. Outfall 006 represents the discharge point for storm water drainage from Tech Area IV.

Most runoff from Tech Area V flows west as overland flow and in natural and manmade surface drainage features onto Tech Area III. The remainder flows into two storm sewers in the northern portion of Tech Area V. Both storm sewers discharge to open channels within, and just north of, Tech Area III. Drainage from Tech Area III is to the west onto undeveloped portions of KAFB and then into playas on undeveloped state land. Outfalls 009 and 010 represent the discharge points for storm water drainage from TA-III and Tech Area V.

The Coyote Test Field (CTF) extends from the eastern boundary of Tech Area III into the foothills of the Manzanita Mountains. Two drainages, Lurance and Madera Canyons, flow into the CTF from the east, joining to form Arroyo del Coyote. The arroyo continues west-southwest for approximately 4 miles, before turning northwest at Manzano Area to flow 4 miles to Tijeras Arroyo. Surface drainage from most of the CTF northeast of Tech Area III and Tech Area IV flows into these canyons or arroyos, and eventually to Tijeras Arroyo. Surface drainage from

the southern portion of the CTF flows west down several smaller arroyos onto Tech Area III and undeveloped state lands. Outfall 007 represents the discharge point for storm water drainage from the CTF. Outfall 008 represents the discharge point for storm water drainage from the Solar Test Facility.

5.2.2 Meteorology

The Albuquerque area is dominated by a sunny, semiarid, high-altitude climate. Average summer temperatures range from a daily high of 82 degrees Fahrenheit (°F) to 91°F (28 degrees Celsius [°C] to 33°C) to a low of 57°F to 66°F (14°C to 19°C). Average winter temperatures range from a daily high of 46°F to 52°F (8°C to 11°C) to a low of 23°F to 27°F (-5°C to -3°C). Precipitation in the form of snow is not uncommon in the winter months. The relative humidity varies from average lows of 10 to 20% to average highs of 60 to 70%. Typically, the highest humidity occurs before and after precipitation.

Rainfall for the Albuquerque area averages eight inches per year. The lowest average monthly precipitation, 0.5 inch, occurs in the winter. Summer thunderstorms account for half of the annual rainfall. Discharge data from outfalls 004 and 005 is available from 1995 to present (see Table 3-12). Table 3-11 shows data from Monitoring Station 002, through which storm water travels from KAFB onto SNL/NM property. Discharge data from four U.S. Geological Survey (USGS) gauging stations and four stations placed by the Site-Wide Hydrogeologic Characterization (SWHC) Project is shown in Tables 3-10 and 3-11.

The runoff coefficient at the Kirtland Federal Complex (KFC) is estimated to range from 0.1 to 0.35. It has been estimated that runoff from precipitation events is less than 1% in the remote areas (Sandia National Laboratories, 1995a). The runoff from Tech Area I, Tech Area II, and Tech Area IV is greater because there are more impervious surfaces in these highly developed areas.

Prevailing winds at SNL/NM are from the east but may come from any direction during stormy weather. Winds average eight miles per hour, but exceed 29 miles per hour an average of 48 days a year.

5.3 Process-Related Surface Discharges and Monitoring at the Tech Area IV Lagoons

5.3.1 Overview

Prior to release, all SNL/NM discharges are evaluated for compliance with applicable regulations, as specified in MN471001, *ES&H Manual*, Chapter 10, Section T, "Surface and Storm Water Discharges" (Sandia National Laboratories, 1999). Discharges approved by the New Mexico Environment Department (NMED) Groundwater Protection and Remediation Bureau include once-through cooling water solution; solutions of soap, vinegar, and ammonia; and water with total dissolved solids (TDS) less than 1,000 parts per million from cooling towers. Except for storm water, the only surface discharges routinely monitored are those from the Tech Area IV lagoons.

5.3.2 Lagoon Discharge Plan for Tech Area IV

On March 8, 1988, discharge plan DP-530 was approved for SNL/NM, Pulsed Power Development Facilities, Lagoons 1 and 2 (Sandia National Laboratories, 1996h). The discharge plan was submitted pursuant to Section 3-106 of the New Mexico Water Quality Control Commission (NMWQCC) Regulations and was approved pursuant to Section 3-109. This discharge plan, modified on December 19, 1989, was reissued on February 21, 1995, to include semiannual monitoring and reporting for the following actions:

- Water-level readings
- Sampling and analysis
 - Major cations, anions, and total dissolved solids (TDS)
 - Purgeable organics using EPA Method 8240 (U.S. Environmental Protection Agency, 1996)
 - Extractable organics using EPA Method 8270 (U.S. Environmental Protection Agency, 1996)

5.3.3 Runoff Collection System for the Lagoons

Both Lagoon 1 and Lagoon 2 have similar operations that can produce surface discharges. For the Pulsed Power Development Complex, Lagoon 1 services Building 981/983, and Lagoon 2 services Building 970.

The primary purpose of both lagoons is to receive surface runoff from precipitation that collects in the sump of the oil tank farm spill-containment area. A manually operated sump pump transfers the collected runoff to the lagoons. If visible oil is in the sump, a manually operated oil-skimmer system removes it to a storage tank at each facility. The sumps in the oil tank farms also receive nonroutine water and oil spills from the Building 981/983 and 970 floor trenches that are designed to prevent any flooding.

5.3.4 Summary of Analytical Results

Table 3-16 summarizes analytical results for the December 1996 reporting period. All measured water quality concentrations were less than the applicable New Mexico Water Quality Control Commission (NMWQCC) standard (Sandia National Laboratories, 1996h).

Table 3-16. Semiannual Water Quality Parameters, December 1996, Lagoons 1 and 2

Parameter	Sample No. 030449 Lagoon 1 ^a	Sample No. 030450 Lagoon 2 ^a	NMWQCC ^{a,b} Standard
Total dissolved solids	229	260	1,000
Sodium	25.1	45.2	NE ^c
Calcium	34.3	23.6	NE
Magnesium	6.0	9.7	NE
Potassium	5.3	6.6	NE
Chloride	20.0	40.3	250
Sulfate	32.0	8.83	600
Total alkalinity	96	124	NE
Volatile organics	ND ^d	ND	NE ^e
Extractable organics	ND	ND	NE ^e

^a Values are in milligrams per liter unless noted otherwise.
^b NMWQCC = New Mexico Water Quality Control Commission.
^c NE = Not established (not a constituent of concern listed in the NMWQCC regulations).
^d ND = Analytes were not detected above the laboratory quantitation limit.
^e The NMWQCC standards list organic compounds by chemical species, not by analytical group (i.e., volatile or extractable organics).

Water levels in the Tech Area IV lagoons are recorded semiannually using a pole, marked in feet that is positioned in each lagoon center. Table 3-17 presents the historical results of water level measurements for both lagoons.

Table 3-17. Tech Area IV Water Levels Measured to Date

Date	Lagoon 1		Lagoon 2	
	Water Level	Percent Full (%)	Water Level	Percent Full (%)
07/15/88	5 feet, 11 inches	55	4 feet, 4 inches	30
07/22/88	5 feet, 9 inches	54	4 feet, 0 inches	25
08/16/88	6 feet, 9 inches	64	4 feet, 0 inches	33
09/15/88	5 feet, 7 inches	52	4 feet, 0 inches	25
10/18/88	5 feet, 4 inches	49	3 feet, 4 inches	18
11/21/88	5 feet, 7 inches	52	1 foot, 0 inches	5
12/29/88	5 feet, 6 inches	51	0 feet, 0 inches	0
01/20/89	6 feet, 6 inches	61	0 feet, 0 inches	0
02/15/89	6 feet, 5 inches	60	0 feet, 6 inches	3
03/14/89	5 feet, 8 inches	54	2 feet, 0 inches	10
04/20/89	5 feet, 2 inches	48	1 foot, 6 inches	8
05/18/89	4 feet, 8 inches	41	NM*	NM*
06/27/89	4 feet, 0 inches	36	3 feet, 6 inches	20
07/19/89	3 feet, 7 inches	32	2 feet, 8 inches	13
08/11/89	4 feet, 2 inches	38	1 foot, 2 inches	6
09/21/89	4 feet, 2 inches	38	1 foot, 6 inches	8
10/13/89	4 feet, 9.5 inches	44	1 foot, 5 inches	7
11/15/89	4 feet, 8 inches	41	0 feet, 0 inches	0
12/18/89	4 feet, 9 inches	44	0 feet, 0 inches	0
01/24/90	4 feet, 9 inches	44	0 feet, 0 inches	0
04/04/90	5 feet, 2 inches	48	1 foot, 0 inches	5
07/24/90	5 feet, 4 inches	49	3 feet, 0 inches	15
10/08/90	3 feet, 7 inches	32	3 feet, 6 inches	20
01/08/91	4 feet, 2.5 inches	38	2 feet, 6 inches	12
04/16/91	4 feet, 3.75 inches	39	2 feet, 8 inches	13
10/21/91	2 feet, 10 inches	24	2 feet, 0 inches	10
07/10/91	3 feet, 3 inches	28	0 feet, 0 inches	0
01/10/92	4 feet, 9 inches	44	2 feet, 6 inches	12
05/04/92	4 feet, 0 inches	36	4 feet, 6 inches	33
07/30/92	4 feet, 7 inches	43	0 feet, 11 inches	4
10/30/92	5 feet, 4 inches	49	0 feet, 0 inches	0
03/03/93	8 feet, 4 inches	80	0 feet, 0 inches	0
06/25/93	6 feet, 1 inch	56	1 foot, 9 inches	8
08/11/93	5 feet, 6 inches	51	5 feet, 3 inches	44
12/09/93	5 feet, 11 inches	55	5 feet, 11 inches	54
03/31/94	5 feet, 1 inch	47	6 feet, 8 inches	71
06/02/94	4 feet, 8 inches	41	6 feet, 0 inches	55
09/29/94	4 feet, 10 inches	45	5 feet, 0 inches	40
12/01/94	4 feet, 9 inches	44	5 feet, 0 inches	40
03/21/95	4 feet, 7 inches	43	4 feet, 10 inches	37
06/27/95	3 feet, 2 inches	28	3 feet, 3 inches	17
12/19/95	1 foot, 6 inches	14	1 foot, 9 inches	9
06/19/96	2 feet, 0 inches	17	0 feet, 0 inches	0

*NM = The water level in Lagoon 2 was inadvertently not measured during the May 18, 1989 sampling.

5.4 Sanitary Sewer Discharges and Monitoring

5.4.1 Overview

SNL/NM produces both sanitary and industrial effluents that are discharged to the City of Albuquerque's sanitary sewer system. Sanitary effluents include wastewater from rest rooms, cafeterias, and other domestic activities. Industrial discharges originate from laboratory processes, general manufacturing, and experimental activities. SNL/NM monitors all its liquid effluent discharges and strives to minimize toxic pollutants through cognizant pollution prevention and waste minimization tactics. These tactics are implemented through the following:

- Good management and engineering practices
- Chemical substitution
- Equipment modification
- Reduction of hazardous material use at the source
- Strict discharge guidelines for the public sewer system

If pollutants above regulatory levels are detected in the waste stream, SNL/NM personnel investigate the discharge source and implement corrective actions, as needed.

As part of the wastewater management program, SNL/NM also maintains active septic systems that are periodically pumped and discharged by certified pumping contractors. Contents are sampled before pumping to ensure that the sewage meets all regulatory criteria.

Pollutants present in SNL/NM wastewaters include contaminants in rinse waters or process baths, which may include toxic organics found in industrial cleaners, coatings, and solvents. Toxic organics and metals also arise as byproducts from microelectronic manufacturing, metal finishing, electroplating, and photographic processes. Another significant pollutant source is cooling tower (swamp cooler) water, which can be high in dissolved salts. SNL/NM policy allows no direct disposal of toxic chemicals or radioactive materials into the sewer system.

5.4.2 Monitoring Stations

Currently, SNL/NM maintains six wastewater monitoring stations. Four stations measure general outfalls (industrial and sanitary effluents) and are the final discharge points into the publicly owned treatment works (POTW). Two stations, upstream of the general outfalls, are defined under categorical pretreatment operations. Station WW007 (City of Albuquerque Permit Number 2069G) monitors only wastewater emanating from the acid waste neutralization system at the Building 858 Microelectronics Development Laboratory (MDL). Station WW009 (City of Albuquerque Permit Number 2069H) monitors only wastewater generated from the Advanced Manufacturing Process Laboratory (AMPL) (Building 878). Combined SNL/NM discharges were under 800,000 gallons per day during 1996.

Discharges into the POTW are regulated by the City of Albuquerque Public Works Department, Liquid Waste Division, under the authority of the city's *Sewer Use and Wastewater Control Ordinance* ('74 Code, § 8-9-1 and 8-944.H; Ordinance 21-1985; Am. Ordinance 42-1996). Discharges from SNL/NM flow to the city water reclamation plant located just north of the point where Tijeras Arroyo meets the Rio Grande. All wastewater is treated by the city in accordance with National Pollutant Discharge Elimination System (NPDES) permit requirements before being discharged into the river. Table 3-18 lists the SNL/NM monitoring station characteristics. Figure 3-10 shows a map of the stations and associated sewer lines.

Table 3-18. SNL/NM Wastewater Monitoring Station Characteristics

Station Manhole	Waste Stream Process	Flume Size	Average Flow (Gallons per Day)
WW001	General	3-inch Parshall	67,239
WW006	General	6-inch Parshall	317,808
WW007	MDL ^a	45° v-notch Weir	144,722 ^b
WW009	AMPL ^c	2-inch Parshall	2,082 ^b
WW008	General	6-inch Parshall	334,247
WW011	General	6-inch Parshall	48,931
^a MDL = Microelectronics Development Laboratory.			
^b All discharges from the MDL and AMPL flow through a General Station (WW008) before discharge to the publicly owned treatment works (POTW).			
^c AMPL = Advanced Manufacturing Process Laboratory. AMPL became a zero discharge location effective July 1, 1997.

Figure 3-10. SNL/NM's Wastewater Monitoring Station Locations

5.4.3 Permitting and Reporting

To comply with U.S. Environmental Protection Agency (EPA) regulations, the City of Albuquerque has implemented a pretreatment program for industrial wastewater. This program specifies the required quality of discharges that the city will accept at the water reclamation plant and the required reporting frequency. To meet these specifications, SNL/NM requires all internal organizations producing continuous process discharges other than normal sanitary effluent to obtain prior approval from the Environmental and Emergency Management Department. The department reviews descriptive documentation associated with the discharge and makes a recommendation as to the acceptability of the discharge. Internal permits are reviewed annually or whenever the wastewater processes change. One-time releases are evaluated on a case-by-case basis. Semiannual reports are submitted to the City of Albuquerque as required by July 31 for the first reporting period (January to June) and by January 31 for the second reporting period (July to December) (Sandia National Laboratories, 1996i; 1997c). For further details, see "5.4.6 Wastewater Discharge Policy."

In addition to the sampling performed by SNL/NM, the City of Albuquerque performs quarterly inspections and sampling. City staff tour the facility to inspect for discharge requirements compliance. The New Mexico Environment Department (NMED) also samples periodically. In 1996, SNL/NM received pretreatment awards from the City of Albuquerque for adherence to requirements.

SNL/NM's *Wastewater Sampling and Analysis Plan* documents the regulatory discharge limits, sampling procedures, sampling frequency, analytical methods, and quality control (QC)/quality assurance (QA) criteria (Sandia National Laboratories, 1996a). Analytical results are also documented in *Wastewater Monitoring Program (Monthly Reports)* (Sandia National Laboratories, 1996j) produced for internal records. Table 3-19 lists primary regulatory drivers for the Wastewater Program.

Table 3-19. Primary Regulatory Drivers for the Wastewater Program

Regulation	Citation
Clean Water Act	33 U.S.C. 1251
City of Albuquerque Sewer Use and Wastewater Control Ordinance	Chapter XIII, Article IX Section 8-944.H
New Mexico Water Quality Control Commission (NMWQCC) Regulations	Water Quality Control Commission (WQCC) 82-1, Amendment No. 10
United States Nuclear Regulatory Commission (USNRC) regulations for radiological levels in wastewater	10 CFR 20
Radiation Protection of the Public and the Environment	DOE 5400.5

5.4.4 Tech Area V Radiological Screening

SNL/NM policy prohibits the disposal of radiological material above regulatory levels into the sanitary sewer system. Tech Area V houses several research reactors that could potentially produce process wastewater contaminated by radiation. To ensure that all wastewater from SNL/NM meets regulatory standards, liquid effluent is separated into two streams: reactor and nonreactor wastewater. All nonreactor sanitary waste is discharged directly to the sanitary sewer. Reactor process wastewater, defined as effluent originating from any drain located in a building that uses, processes, or stores radioactive material, is diverted to the Liquid Effluent Control System (LECS). The LECS, comprised of three 5,000-gallon tanks, is equipped with ion exchange and filtration systems. All wastewater undergoes radiological screening before being discharged to the sanitary sewer. Alarms will alert personnel to the presence of radioactive material and high water levels. Samples are usually taken monthly, dependent upon the amount of water that has collected, and sent to a laboratory approved by the U.S. Environmental Protection Agency (EPA) for analysis of gross alpha and gross beta activity, tritium, and gamma spectroscopy. Since this system began operating in 1994, no radioactive contaminants above regulatory levels have been detected, and the ion exchange and filtration

systems have not been needed. All discharges from Tech Area V flow through monitoring station WW011 (City of Albuquerque, permit number 2069K).

5.4.5 Sewer Wastewater Sampling

SNL/NM submits wastewater permit applications to the City of Albuquerque that detail all SNL/NM's potential pollutant sources and the raw materials used in its industrial processes. To ensure compliance with discharge limits stated on each city permit, SNL/NM conducts periodic sampling at each general outfall monitoring station and quarterly splits with the City of Albuquerque at selected stations. All samples are taken as 24-hour flow proportional composites and are analyzed at laboratories approved by the U.S. Environmental Protection Agency (EPA) using EPA-approved procedures. The city requires continuous monitoring of pH and flow at all permitted stations.

SNL/NM also performs gross alpha, gross beta, tritium, and gamma spectroscopy on all wastewater samples to verify compliance with the city's requirements for radioactive materials management. Radiological sampling results are contained in the *Wastewater Monitoring Program (Monthly Reports)* (Sandia National Laboratories, 1996j).

5.4.6 Wastewater Discharge Policy

SNL/NM organizations discharging process water with any pollutants that can interfere with or disrupt the operation or performance of the publicly owned treatment works (POTW) are required to notify the Environmental and Emergency Management Department for approval prior to discharge. Process dischargers are referred to MN471001, *ES&H Manual*, Chapter 10, Section H, "Discharges to the Sanitary Sewer System" (Sandia National Laboratories, 1999) for common examples of the pollutants and of the applicable discharge requirements, including the following:

- SNL/NM organizations must not discharge wastewater that contains pollutants such as heavy metals or other toxic substances in excess of regulatory limits.
- SNL/NM organizations must not discharge cooling water, storm water, reject water, any kind of unpolluted water, or any combination of these kinds of water in quantities greater than 2,000 gallons per day without prior written approval from the Environmental and Emergency Management Department.
- SNL/NM organizations must evaluate discharge processes for treatment options using the best available technology that is economically achievable.

Current SNL/NM policy is to review all continuous or batch process discharges to the sanitary sewer system and provide written approval. Each request for a one-time or batch discharge approval is evaluated to determine acceptability under current regulatory requirements. Accidental releases are also evaluated on a case-by-case basis to determine the need for occurrence reporting. The approval is obtained by the discharging organization by submitting documentation describing the amount, frequency, location, composition, and process associated with the discharge to the Environmental and Emergency Management Department. Organizations with discharges acceptable for release to the environment are issued a written, site-specific approval to discharge to the sanitary sewer system, which may be renewed. Table 3-20 presents several examples of discharge approvals issued in fiscal year 1996 (FY1996).

Table 3-20. Examples of Sanitary Sewer Discharges FY1996

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
10/02/95	96-01	14621	Tech Area V	2069K	Water from Sandia Experimental Reactor (SER) tank	30 days, beginning 10/02/95
10/10/95	96-02	7572	Building 870	2069I	Water and Nalco 2827	30 days, beginning 10/10/95
10/10/95	96-03	6115	BDM Building	Not applicable	Soltrol 130, Soltrol 220, trichloroethylene, and tetrachloroethylene	One year, beginning 10/10/95
10/10/95	96-04	6115	BDM Building	Not applicable	Gelling agents, buffering agents, and surfactants	One year, beginning 10/10/95
10/12/95	96-05	7672	Tech Area V	2069K	Purge water	30 days, beginning 10/12/95
10/16/95	96-06	14466	Building 870	2069I	Solder plating solution, acids, and metals	One year, beginning 10/16/95
10/26/95	96-07	6216	Building 823/1073	2069A	Ion chromatograph	One year, beginning 10/26/95
11/06/95	96-07A	6216	Building 823/1065	2069A	Moved ion chromatograph from Building 823/1073 to 823/1065	One year, beginning 10/26/95
11/02/95	96-08	7582	Tech Area III	2069K	Purge water	30 days, beginning 11/02/95
11/06/95	96-09	1822	Building 897/B205g	2069I	Acid/alcohol solutions	One year, beginning 11/06/95
11/06/95	96-10	1822	Building 897/B05a	2069I	Phosphorous pentoxide and phosphoric acid	One year, beginning 11/06/95

Table 3-20. Examples of Sanitary Sewer Discharges FY1996 (Continued)

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
11/06/95	96-11	2471-2	Building 878	2069I	Cleaning solutions	One year, beginning 11/06/95
11/06/95	96-12	6212	Building 823/2039/2296	2069A	Acidic spectrometer residue and metals	One year, beginning 11/06/95
11/09/95	96-13	7574	Building 6540	2069K	Water from automatic industrial x-ray film processor	30 days, beginning 11/09/95.
11/15/95	96-14	7582	Building 6540	2069K	Decontamination water	30 days, beginning 11/15/95
11/15/95	96-15	7585	Building 6540	2069K	Decontamination water	30 days, beginning 11/15/95
11/15/95	95-16	7582	Building 6540	2069K	Decontamination water	30 days, beginning 11/15/95
12/11/95	96-17	7582	Building 6540	2069K	Decontamination and purge water	30 days, beginning 12/11/95
12/21/95	96-02A	7511	Building 870	2069I	Water and Nalco 2827	30 days, beginning 01/02/96
12/21/95	96-19	7582	Building 6636	2969K	Contents of septic tank	30 days, beginning 01/02/96
12/22/95	Close out	6423	Building 9940	2069K	Ethylene glycol or propylene glycol	Close out
12/22/95	96-18	7582	Building 6540	2069K	Purge water, deep well KAFB-10	30 days, beginning 01/02/96
12/22/95	96-20	7913	Building 846	2069F	Decontamination water	30 days, beginning 01/02/96
12/22/95	96-21	6422	Building 6922	2069K	Boiler demineralizer/ Neutrox 53	One year, beginning 01/02/96
12/22/95	96-22	1832	Building 805/212,221	2069F	Rinse water	One year, beginning 01/02/96.
12/22/95	96-23	7582	Building 6540	2069K	Purge water	30 days, beginning 01/02/96
12/22/95	96-24	7582	Building 6540	2069K	Purge water	30 days, beginning 01/02/96

Table 3-20. Examples of Sanitary Sewer Discharges FY1996 (Continued)

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
12/22/95	96-25	7814-1	Building 832	2069F	Heating water	30 days, beginning 12/18/95
01/16/96	96-26	7712	Advanced Materials Laboratory (AML) (University Park)	Not applicable	Superchlorinated water, 20 parts per million	May be discharged to ground surface as dust control water
01/24/96	96-27	7577	Building 6540	2069K	Septic tank contents from Buildings 6643, 6720, 6922, 6631, 6730, and 6741	30 days, beginning 01/24/96
01/24/96	96-28	6219	Building 883	2069I	Acids, bases, and solvents	One year, beginning 01/24/96
01/29/96	96-29	7577	Building 6540	2069K	Decontamination water	30 days, beginning 01/29/96
02/02/96	96-30	1472	Building 878	2069I	Brulin 815D	One year, beginning 02/02/96
02/02/96	96-31	7614	Building 876A	2069F	Steam pit and car wash bay cleanout	30 days, beginning 02/02/96
02/02/96	96-32	1400-1	Building 840	2069F	Water mixed with machine coolant	30 days, beginning 02/02/96
02/02/96	96-33	7574	MO235, MO100/8895, MO242-245, Buildings 6583, 6584W	2069K	Septic tank contents	30 days, beginning 02/05/96
02/07/96	96-34	6748	Buildings 823/2079 and B45	2069I	Salt water solutions	One year, beginning 02/07/96
02/20/96	96-35	9112	Building 865, Room 15	2069F	Polyacrylamide solutions mixed with syrup or glycerine	One year, beginning 02/20/96
02/27/96	96-36	9342-1	Building 970	2069I	Cleaning solutions and transformer oil	One year, beginning 02/27/96.
02/27/96	96-37	9611	Building 904 Room 4	2069A	Witcolate SE-5, Emcol CC37-18, Emcol LO, and Witcolate 1276	One year, beginning 03/01/96
02/27/96	96-38	1492	Building 864	2069F	Hydrofluoric acid	One year, beginning 02/27/96

Table 3-20. Examples of Sanitary Sewer Discharges FY1996 (Continued)

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
02/27/96	96-39	7913	Building 846	2069F	Asbestos-containing lead-based paint	30 days, beginning 02/27/96
02/27/96	96-40	1333	Building 858	2069I	Limonene, 100 milliliters per day	One year, beginning 03/07/95
02/29/96	96-41	6621	Thermal Enhanced Vapor Extraction System (TEVES) (Tech Area III)	2069K	Volatile organic compounds (VOCs)	30 days, beginning 03/01/96
03/06/96	96-42	6449	Building 867N	2069F	Steam condensate/Nalco	One year, beginning 03/06/96
03/06/96	96-43	1823	Building 805	2069F	Chloramine-T	One year, beginning 03/06/96
03/06/96	96-44	1512	Building 865E	2069F	Brine water solution, uranine dye, food color, and titanium dioxide	One year, beginning 03/27/95.
03/06/96	96-45	7577	Building 889	2069K	Septic tank discharge	30 days, beginning 03/06/96
03/06/96	96-46	9512	Building 966	2069A	1,500 gallons of water from oil tank containment area	30 days, beginning 03/06/96
03/07/96	96-47	7582	Building 6540	2069K	Decontamination and purge water	30 days, beginning 03/06/96
04/08/96	96-48	7511	Building 980	2069A	Water, bicarbonate of soda, and trace fuel	One year, beginning 04/08/96
04/11/96	96-49	7582	Building 6540	2069K	Decontamination and purge water	30 days, beginning 04/11/96
04/11/96	96-50	7582	Building 6540	2069K	Decontamination and purge water	30 days, beginning 04/11/96
04/15/96	96-51	7582	Building 6540	2069K	Decontamination water from the Chemical Waste Landfill (CWL)	30 days, beginning 04/11/96
05/02/96	96-52	6115	BDM Building	BDM	10% potassium iodide	One year, beginning 05/02/96
05/02/96	96-53	6117	Building 849	2069F	Cooling water used for rock sawing and coring	One year, beginning 05/02/96

Table 3-20. Examples of Sanitary Sewer Discharges FY1996 (Continued)

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
05/02/96	96-54	6111	Building 851	2069F	Food quality materials	
05/02/96	96-55	1815	Building 897	2069I	Alconox® and detergent	One year, beginning 05/15/95
05/02/96	96-56	9573	Building 960	2069A	Water with antifreeze	30 days, beginning 05/02/96
05/02/96	96-57	1553	Building 905/1105	2069A	Acid vapors (HCl and H ₂ SO ₄)	One year, beginning 05/02/96
05/02/96	96-58	7582	Building 6540	2069K	Purge and decontamination water	30 days, beginning 05/02/96
05/07/96	96-59	14002	Building 870	2069I	Acids, metals, buffers, and cleaners	One year, beginning 05/07/96
05/08/96	96-60	7582	Building 6540	2069K	Purge and decontamination water	30 days, beginning 05/08/96
05/09/96	96-61	7582	Building 6540	2069K	Purge and decontamination water	30 days, beginning 05/09/96
05/09/96	96-62	7582	Building 6540	2069K	Purge and decontamination water	30 days, beginning 05/09/96
05/13/96	96-63	1275	Building 858/1371C	2069I	Acids, hydrogen peroxide, and potassium hydroxide	One year, beginning 05/13/96
05/16/96	96-64	7577	Building 6596	2069K	Condensate water	30 days, beginning 05/16/96
06/03/96	96-65	7582	Building 6540	2069K	Sandia North Well development water	30 days, beginning 06/03/96
06/03/96	96-66	1811	Building 897/1207	2069I	Polymers	One year, beginning 06/03/96
06/06/96	96-67	1552	Building 905/1214	2069I	Methanesulfonic acid	One year, beginning 06/06/96
06/06/96	96-68	7582	Building 9925	2069K	Purge water from Tech Area V	30 days, beginning 06/06/96
06/06/96	96-69	1845	Advanced Materials Laboratory, Room 195	City of Albuquerque	Metal oxides-doped glass	One year, beginning 06/06/96

Table 3-20. Examples of Sanitary Sewer Discharges FY1996 (Continued)

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
06/10/96	96-70	7511	Building 870	2069I	Chiller water	30 days, beginning 06/10/96
06/27/96	96-71	6118	Building 823	2069A	Acids, buffers, and metals	One year, beginning 06/27/96
07/03/96	96-72	7575	Building 6540	2069K	Waste from ecological study	One year, beginning 07/03/96
07/16/96	96-73	6621	Building 823	2069A	Water condensate	One year, beginning 07/16/96
07/16/96	96-74	6621	Building 823	2069A	Buffers, acids, and metals	One year, beginning 07/16/96
07/22/96	96-75	1846	Advanced Materials Laboratory (Room 237)	City of Albuquerque	Rinse waters and cleaning solutions from plating activities	One year, beginning 07/16/96
07/22/96	96-76	1833	Advanced Materials Laboratory	City of Albuquerque	Buffers for neutralization	One year, beginning 07/16/96
07/23/96	96-77	7582	Building 9925	2069K	Waste and decontamination water	30 days, beginning 07/24/96
07/24/96	96-78	1492	Building 878	2069I	Varistor material	One year, beginning 07/24/96
07/29/96	96-79	7582	Building 9925	2069K	Purge water	30 days, beginning 07/24/96
08/01/96	96-80	1553	Building 905/1100 Laboratory	2069I	Water testing and disposal process	One year, beginning 08/01/96
08/07/96	96-81	7577	Building 6580	2069K	Condensate	30 days, beginning 8/7/96.
08/08/96	96-82	7615	All buildings	2069A	Custodial products: Grand Slam and 3M Stripper	One year, beginning 08/08/96.
08/14/96	96-85	6832	Building 3/2079	2069A	Disposal of trace amounts of industrial dyes into sink	One year, beginning 08/14/96
08/27/96	96-87	9311	Building 962/B-306	2069A	Chilled water containing Nalco 8330-M Inhibitor	30 days, beginning 08/27/96

Table 3-20. Examples of Sanitary Sewer Discharges FY1996 (Continued)

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
10/24/96	Did not renew permit	6212	Building 823/2039/2296	2069A		One year, beginning 11/06/95
11/11/96	97-12	9536	Lagoon #1	2069A	Discharge approx. 27,500 gallons from Lagoon #1 in Tech Area IV	30 days, beginning 11/11/96
08/08/96	96-83	7913	Building 805/B17	2069F	Decontamination water containing asbestos	30 days, beginning 08/08/96
08/08/96	96-82	7615	All buildings	2069F	Custodial products: Grand Slam and 3M Stripper	One year, beginning 08/08/96
10/22/96	96-07	1522	Building 894	2069F	Cleaning solution and rinse water	One year, beginning 10/22/96
12/17/96	97-18	1832	Building 805/212/221	2069F	Rinse water	One year, beginning 12/17/96
07/03/96	96-72	7575	Tech Area II	2069I	Lysol and water	One year, beginning 07/03/96
07/24/96	96-78	2476	Building 878	2069I	Varistor material	One year, beginning 07/10/95
08/01/96	96-80	1553	Building 905/1100	2069I	Holding tank	One year, beginning 08/01/96
08/08/96	96-82	7615	All buildings	2069I	Custodial products: Grand Slam and 3M Stripper	One year beginning 08/08/96.
08/27/96	96-86	1492	Building 878	2069I	Wastewater, cleaning parts at glass shop	One year, beginning 08/27/96
10/15/96	97-02	1552	Building 905/1214	2069I	Methanesulfonic acid	One year, beginning 10/15/96
10/15/96	97-04	6682	Tech Area II	2069I	Personnel hygiene water	30 days, beginning 10/15/96
10/29/96	97-08	1822	Building 897/b205A	2069I	Phosphorous pentoxide and phosphoric acid	One year, beginning 10/29/96
10/29/96	97-09	1822	Building 897/205G	2069I	Phosphorous pentoxide and phosphoric acid	One year, beginning 10/29/96
11/06/96	97-11	1471	Building 878	2069I	Fluorinated organic solvents for degreasing	One year, beginning 11/6/96

Table 3-20. Examples of Sanitary Sewer Discharges FY1996 (Continued)

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
11/22/96	97-15	5511	Building 904/4	2069I	Cold Smoke Generator waste rinse water	One year, beginning 11/22/96
07/16/96	96-74	6621	Building 6542/6920	2069K	Buffers, acids, and metals	One year, beginning 07/16/96
07/23/96	96-77	7582	Building 9925	2069K	Purge water	30 days, beginning 07/24/96
07/29/96	96-79	7582	Building 6540	2069K	50 gallons to sanitary sewer, 150 gallons to evaporation	30 days, beginning 07/29/96
08/07/96	96-81	7577	Building 6580/203	2069K	Methanol, brine	30 days, beginning 08/07/96
08/08/96	96-84	7511	Building 9925	2069K	Decontamination and purge water	30 days, beginning 08/08/96
08/08/96	96-82	7615	All buildings	2069K	Custodial products: Grand Slam and 3M Stripper	One year, beginning 08/08/96
08/29/96	96-88	1304	Building 9956	2069K	Wastewater from cleaning power gun	One year, beginning 08/29/96
10/15/96	97-03	6682	Building 9925	2069K	Purge water	30 days, beginning 10/15/96
10/22/96	96-06	6682	Building 9925	2069K	Purge and decontamination water	30 days, beginning 10/22/96
11/22/96	97-13	6682	Building 9925	2069K	Purge and decontamination water	30 days, beginning 11/22/96
11/22/96	97-14	6423	Building 6922	2069K	Boiler condensate from Building 6922	One year, beginning 11/22/96
12/04/96	97-16	6682	Building 9925	2069K	Purge and decontamination water	30 days, beginning 12/04/96
12/17/96	97-17	1841	Building 6505A	2069K	Cooling water from Building 6505A cooling tower	30 days, beginning 12/17/96
12/18/96	97-19	6428	Building 6585	2069K	Cooling water from Plasma Materials Test Facility	30 days, beginning 12/18/96

Table 3-20. Examples of Sanitary Sewer Discharges FY1996 (Continued)

Date	ID	SNL/NM Organization	Location	City Of Albuquerque Permit #	Contaminant or Source	Restrictions
07/22/96	96-75	1846	Advanced Materials Laboratory (Room 237)	City of Albuquerque	Rinse waters and cleaning solutions from plating activities	One year, beginning 07/16/96
07/22/96	96-76	1833	Advanced Materials Laboratory	City of Albuquerque	Buffer solutions	One year, beginning 07/16/96
09/18/96	96-69A	1833	Advanced Materials Laboratory (Room 195)	City of Albuquerque	Additional metal oxides	One year, beginning 09/18/96
10/14/96	97-01	6115	BDM Building	City of Albuquerque	Soltrol 130, tetrachloroethylene, and perchloroethylene	One year, beginning 10/10/95
10/22/96	97-05	6115	BDM Building	City of Albuquerque	Gelling agents, buffers, and surfactants	One year, beginning 10/22/96
10/29/96	97-10	1846	Advanced Materials Laboratory	City of Albuquerque	Water-soluble oil	One year, beginning 10/29/96

5.4.7 Trend Data for Sanitary Sewer Discharges at SNL/NM

Many operations at SNL/NM require large quantities of high-purity water (e.g., the Microelectronics Development Laboratory [MDL], the Steam Plant, and the 23 cooling towers located throughout SNL/NM). An estimated 130 million gallons of water circulate through these processes per year. Losses from blowdown and rejected ultra-pure water are discharged to the sanitary sewer at approximately 25 million gallons per year. The incoming water is obtained from Kirtland Air Force Base (KAFB) and the City of Albuquerque and processed through water treatment facilities that utilize procedures such as carbon adsorption, reverse osmosis (RO), vacuum degassing, and ion exchange. SNL/NM has reduced its water consumption and wastewater discharges by applying water conservation and waste reduction efforts, resulting in wastewater discharge reductions of 58 million gallons from 1994 through 1996. These water conservation and use reductions are expected to further reduce SNL/NM total water consumption and help achieve the SNL/NM goal of a 30% reduction by the year 2004. Summaries of the total wastewater discharges recorded for the following calendar years are:

- CY1994 - 338 million gallons per year
- CY1995 - 291 million gallons per year
- CY1996 - 280 million gallons per year

5.4.8 Summary of Monitoring Results

The 1996 wastewater results with respect to meeting permit requirements are documented in the semi-annual wastewater monitoring reports for 1996 (Sandia National Laboratories, 1996h, 1997c).

A summary of compliance with each permit is presented here:

- Permit 2069A-3, General Station WW001 - No violations occurred.
 - Permit 2069F-3, General Station WW006 - On December 28, 1996, a pH excursion above 11 lasted three hours. The maximum permitted pH level is 12.7. The City of Albuquerque imposed no fines.
 - Permit 2069G-3, Microelectronics Development Laboratory (MDL) Station WW007 - No violations occurred.
 - Permit 2069H-3, Advanced Manufacturing Process Laboratory (AMPL) Station WW009 - On November 8, 1996, a pH excursion above 11 lasted 1.5 hours. The maximum permitted pH level is 11.8. Regulations state that pH cannot fall outside the range of 5 to 11 for over one hour. The City of Albuquerque imposed no fines.
 - Permit 2069I-2, General Station WW008 - No violations occurred.
 - Permit 2069K-2, General Station WW011 - No violations occurred.
-

6.0 POTABLE WATER USE AT SNL/NM

6.1 Overview

SNL/NM is committed to helping conserve Albuquerque area water resources. In 1996, the Operations and Engineering Center funded several water conservation projects. These projects included a site-comprehensive water audit and plan, installation of water meters, and a water conservation web site. A water conservation officer was designated to manage the site-wide efforts to reduce SNL/NM's water consumption by 30% by the year 2004. The City of Albuquerque and Kirtland Air Force Base (KAFB), SNL/NM's water supplier, are addressing the increasing water demand and a decreasing supply. Their water conservation activities include programs that emphasize public education, rebates for retrofitting water fixtures, encouraging

the use of low-water landscaping, and increased rates for water supply use and wastewater treatment. The 1996 total water use recorded by KAFB was 3,150,685 gallons per day. SNL/NM water consumption was estimated to be 1,206,225 gallons per day.

SNL/NM water withdrawals are expected to decrease with implementation of projects designed to:

- Recycle process wastewater.
- Increase the cycles of concentration for cooling towers.
- Reduce lost condensate from the Steam Plant.
- Use low-flow fixtures.
- Continue with the practice of xeriscaping in the majority of areas.

6.2 Water Use Estimates

The Environmental and Emergency Management Department has combined sanitary sewer data from calendar year 1996 (CY1996) and engineering estimates to develop a comprehensive understanding of water use within the SNL/NM complex and the effect of that use on water resources. The sanitary sewer data is the only available information source because most SNL/NM buildings are not metered to measure water consumption. As part of SNL/NM's water conservation program, a site-comprehensive water audit was proposed to calculate water use.

Table 3-21 presents wastewater flow data from 1996 SNL/NM activities. The flow data is documented in the *Wastewater Monitoring Program (Monthly Reports)* (Sandia National Laboratories, 1996j).

Table 3-21. SNL/NM Daily Wastewater Discharge Volumes

Station Manhole	Waste Stream Process	Average Flow (Gallons per Day)
WW001	General	67,239
WW006	General	317,808
WW008	General	334,247
WW011	General	48,931
Total flow		768,225

6.3 Adjustments to Metered Wastewater Flows

Table 3-22 summarizes adjustments to metered wastewater flows that are required to estimate SNL/NM's overall water use. The data was compiled from van der Leeden (1990), Montgomery (1985), and the Water Conservation Initiative Project's world-wide web site for the Steam Plant (Sanchez-Brown, 1997).

Table 3-22. Adjustments to Wastewater Flows

Adjustment Process	Average Flow (Gallons per Day)
Evaporation	300,000
Steam Plant	40,000
Irrigation	90,000
Miscellaneous	8,000
Total flow	438,000

The total water used in the cooling towers is estimated at 500,000 gallons per day; approximately 300,000 gallons are evaporated, and about 200,000 gallons are attributed to blowdown and drift. The volumes of water lost to blowdown and drift are included in the sanitary sewer wastewater discharge values shown in Table 3-22.

Steam Plant estimated condensate losses are 40,000 gallons per day. It is believed that a large part of these losses go directly to the sanitary sewer, but the actual quantity is unknown.

Landscape irrigation use is 90,000 gallons per day based on consumptive-use factors for sod and trees at SNL/NM. Miscellaneous losses total approximately 8,000 gallons per day and total adjustments equal 438,000 gallons per day.

Total water use for SNL/NM (sum of wastewater discharge volumes and adjustments to wastewater flows) is approximately 1,206,000 gallons per day.

6.4 Water Conservation

SNL/NM has established an active program for reducing water use. Projects such as those at the Steam Plant and the Microelectronics Development Laboratory (MDL) have the potential to increase efficiency, decrease expenses, and reduce water use.

6.4.1 Current Projects

The following summaries, documenting the activities that began in 1996, are examples of SNL/NM's management plan to reduce water use by 30% by the year 2004.

Steam Plant (Building 605) - The Steam Plant, located in Building 605 at SNL/NM, supplies on average 1.5×10^6 pounds per day of saturated steam for space heating and laboratory processes for SNL/NM, the eastern portion of Kirtland Air Force Base (KAFB), the Department of Energy's Albuquerque Operations Office, and the Coronado Club. The Steam Plant has been in continuous operation since 1947. This section summarizes the ongoing water conservation and waste reduction efforts at the SNL/NM Steam Plant.

Projects implemented to date include the following:

- Through inspecting the condensate return line and interfacing with steam users, SNL/NM staff identified and repaired leaks, increasing the average returned steam from 52% to 68%.
- Replacement of an aging dealkalizer with a more efficient model resulted in an 80% reduction in chemical use (amine and salt) and an increase in the amount of water treated between regeneration cycles. By adding caustic to the sodium during resin regeneration cycles, silica was removed from the makeup water, lowering the concentration from 24 parts per million to 7 parts per million. Silica, which forms deposits in the boiler, must be removed through boiler blowdown.
- By recycling treated water used to cool fan bearings and feedwater pumps, water use and wastewater generation was reduced by 4 million gallons per year.

The combined benefits of an increased condensate return, the installation of a new dealkalizer, the addition of a caustic to the regeneration cycle, and the elimination of a once-through cooling loop reduced annual water use by 23 million gallons and annual fuel use by 19.3×10^6 standard cubic feet, eliminated 11.5 million gallons per year in wastewater discharged to the sewer, and significantly reduced chemical use. Overall yearly cost savings exceed \$100,000 (Sanchez-Brown, 1997).

Microelectronics Development Laboratory (MDL) Reverse Osmosis Efficiency

Improvements - The MDL provides more than 30,000 square feet of clean room space and a fully operational state-of-the-art equipment set for processing wafers up to 150 millimeters in diameter. The MDL conducts microtechnologies research and development (R&D), including advance packaging and interconnection development, microsensor research, compound semiconductor studies, advanced nonvolatile memory R&D, micromachining, equipment

improvement, and advanced materials and process development for the semiconductor industry.

Many MDL operations require high-purity water. Incoming water from Kirtland Air Force Base (KAFB) is processed through a water treatment facility that includes the following unit processes: carbon adsorption, reverse osmosis (RO), vacuum degassing, and ion exchange. The production of ultra-pure water before water conservation required 128 million gallons of water per year.

MDL goals in 1996 included reduced water consumption and wastewater discharges. The MDL facilities team sought to minimize the effect of the MDL's water consumption upon the aquifer and to support the SNL/NM water conservation plan to reduce water use by 30% by the year 2004.

The water treatment system of the MDL was modified to meet this goal. Specifically, the following changes were implemented: new stainless-steel control valves were installed for precise control of water flow; a new manifold was added to the RO pump, converting it to a more efficient two-stage pump; high-surface-area RO membranes were added; and the existing polyvinyl chloride (PVC) piping was replaced with industrial, water production piping.

These modifications cost \$107,113 and resulted in an annual reduction of 38 million gallons in water use. Annual water and sewer discharge savings were \$100,000. The improved RO system also reduced the operation hours, saving an additional \$22,000.

In recognition of this work, MDL received the SNL/NM 1997 Employee Recognition Award in the Teams - Business/Operational Excellence Category (Sanchez-Brown, 1997).

Microelectronics Development Laboratory (MDL) Water Recycling Project - At about the time that SNL/NM signed the water conservation memorandum of understanding (MOU) with the City of Albuquerque and Kirtland Air Force Base (KAFB) in 1994, *The National Technology Roadmap for Semiconductors/Semiconductor Industry Association (SIA)* was published (Semiconductor Industry Association, 1994). Among its manufacturing performance targets is a 50% reduction in water use per unit area of silicon produced. In reducing its draw on the Albuquerque aquifer, SNL/NM reinforces its commitment to the semiconductor roadmap and to conserving the region's water resources by recycling water in the MDL.

The MDL Water Recycling Project is funded by SEMATECH, the U.S. semiconductor industry consortium. The project's objective is to document a case history of introducing water recycling into a semiconductor laboratory such as MDL. Water recycling, which could reduce water consumption by 70% to 80%, has met industry resistance from operational personnel because

of the serious risk of product line shutdowns from system contaminants being introduced into the recycle loop.

Project researchers develop near real-time sensors for detecting organic spikes or excursions in a water recycle loop. Upstream detection will prevent the introduction of contaminants, effectively eliminating the risks associated with recycling spent rinse water. Installation of the common drain system and the collection tanks at MDL is completed. Sensor development and testing continue.

6.4.2 Funded Future Water Conservation Projects

The following projects, designed in 1996, have been scheduled for construction in 1998.

Process Water Reclamation for Cooling Towers at the Microelectronics Development Laboratory (MDL) - Design for this project is complete and the system has been scheduled for construction in 1998. The plan for this project is to take some of the process wastewater at the MDL and pump it to an adjacent cooling tower, resulting in a savings of approximately 12 million gallons of water per year. The estimated annual cost savings is \$25,000. Several technical issues have been re-addressed, including a chemical analysis of the process wastewater and a corresponding change to the chemical treatment program for the cooling tower (Sanchez-Brown, 1997).

Pollution Prevention Project for Cooling Towers - This project has received funding through SNL/NM's pollution prevention program. Sandia has 23 cooling tower systems serving 42 chillers. The estimated makeup water for blowdown, evaporation, and drift results in the use of approximately 110 million gallons of water per year. The proposed project would change the chemical treatment program and provide instrumentation in the operation of the cooling tower system to reduce water consumption by maximizing the system performance. Approximately 20 million gallons of water per year would be saved.

An estimated 110 million gallons of water circulate through SNL/NM's cooling towers per year. Although cooling towers are a water-efficient method of providing cooling, they also are the largest user of water in facilities with large cooling loads. In most of these systems, dissolved solids are removed by releasing bleeding-off from the recirculating water. Bleed-off usually is the only use of water in a cooling tower than can be reduced as a conservation measure. The relationship between the concentration of dissolved solids in the cooling tower and in the makeup water is known as the concentration ratio. As the concentration ratio increases, the total water consumption decreases, assuming evaporation remains constant.

This project will provide instrumentation in the operation of the cooling tower system to maximize the concentration ratio, resulting in a reduced water consumption. In addition, other alternatives will be considered, including installation of a filtration system. Monitoring devices to record the amount of bleed-off water discharged from each tower, conductivity meters to regulate the discharge of bleed-off from the cooling tower, and pH controllers are essential to ensure efficient cooling performance and water conservation. An automated system will replace the use of the manual bleed-off control. Management of the system also includes proper chemical treatment to prevent mineral concentrations. Installation of British thermal unit (BTU) meters will allow calculation of water used on a specific basis (gallons per ton of cooling) (Sanchez-Brown, 1997).

Laser Cooling Loop at the Compound Semiconductor Research Laboratory (CSRL)

(Building 893) Project - This project design has been scheduled for completion in 1997, and construction has been scheduled for completion in 1998. This project will install a chilled water loop for the lasers in Building 893, thus avoiding once-through cooling. An estimated savings of 10 million gallons per year will be realized when the closed-loop system is built (Sanchez-Brown, 1997).

6.4.3 Proposed Project

In calendar year 1996 (CY1996), the Golf Course Irrigation Project was proposed as part of SNL/NM's commitment to reduce water consumption. A preliminary design has been approved.

Kirtland Air Force Base (KAFB) uses approximately 1.6 billion gallons of water per year, 11% (approximately 176 million gallons) of which is used to irrigate the golf course. SNL/NM's Microelectronics Development Laboratory (MDL) uses 90 million gallons of water per year in its ultra-pure water production process. In addition, the cooling tower at MDL discharges approximately 10 million gallons per year to the sewer system.

A project has been proposed for Facilities to design a holding and distribution system that would capture the blowdown wastewater from the cooling towers, process water from MDL, and reverse osmosis (RO) reject water for the purpose of irrigating the golf course. Approximately 100 million gallons of water per year would be saved (Sanchez-Brown, 1997), resulting in a cost savings of \$121,000 to \$170,000 per year.

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20 NMAC 5, *New Mexico Underground Storage Tank Regulations.*

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CHAPTER 4 - AIR QUALITY AND METEOROLOGY

Contents

EXECUTIVE SUMMARY	4-7
1.0 INTRODUCTION.....	4-9
1.1 Purpose.....	4-9
1.2 Scope	4-9
1.3 Methods for Compiling Data	4-9
1.4 Links to Facilities and Programs.....	4-10
2.0 REGULATORY SETTING	4-12
2.1 Local and Federal Regulations	4-12
2.2 Summary of Past Violations	4-17
3.0 CLIMATE AND METEOROLOGY	4-17
3.1 Geographic Impact Region.....	4-17
3.2 Climatology	4-22
3.2.1 Regional Meteorology.....	4-23
3.2.2 Site-Specific Meteorology and Climatology.....	4-35
3.3 Transport and Dispersion Characteristics.....	4-41
3.3.1 Overview of Physical Phenomena	4-41
3.3.2 Factors Influencing Circulation	4-42
3.3.3 Local Transport	4-50
3.4 Meteorological Data Processing for Modeling Input.....	4-57
3.4.1 Overview of Technical Approach	4-57
3.4.2 Processing Procedure	4-58
4.0 CURRENT AIR QUALITY	4-63
4.1 Criteria Pollutant Emissions.....	4-63
4.1.1 Overview	4-63
4.1.2 Steam Plant.....	4-64
4.1.3 Electrical Power Generator Plant.....	4-70
4.1.4 Fire Testing Facilities.....	4-70
4.1.5 Chemical Usage	4-71
4.1.6 Input Data for Emissions Modeling	4-72
4.1.7 Modeling Methodology.....	4-77
4.1.8 Ambient Sampling	4-83
4.2 Hazardous Air Pollutants (HAPs).....	4-87
4.2.1 Overview	4-87
4.2.2 Hazardous Chemical Emissions	4-88
4.2.3 Major Emitter Input	4-88

4.2.4 Ambient Sampling Results	4-89
4.3 Radiological Air Pollutants.....	4-91
- 4.3.1 Radiological Emissions.....	4-91
4.3.2 Input Data for Dispersion Modeling	4-97
4.3.3 Dispersion Modeling Results	4-99
4.3.4 Ambient Sampling	4-101
4.4 Ambient Sampling for the Geographic Region.....	4-103
4.4.1 Ambient Monitoring Stations.....	4-103
5.0 SUMMARY OF AIR QUALITY TRENDS	4-108
5.1 Criteria Pollutant.....	4-108
5.1.1 Emissions Trend.....	4-108
5.1.2 Ambient Sampling Trend	4-113
5.2 Hazardous Air Pollutants (HAPs).....	4-119
5.2.1 Emissions Trend.....	4-119
5.2.2 Ambient Sampling Trend	4-119
5.3 Radiological Pollutants	4-120
5.3.1 Emission Trend	4-122
5.3.2 Ambient Sampling Trend	4-122
5.4 Geographic Region Ambient Trend	4-124
6.0 REFERENCES.....	4-127
6.1 Regulations, Orders, and Laws	4-127
6.2 General References	4-128
ATTACHMENTS	
4-1 - Meteorological Data to Support Windroses in the Albuquerque Basin	4-131
4-2 - Climatological Data for SNL/NM	4-159
4-3 - Meteorological Data to Support SNL/NM Windroses.....	4-167
4-4 - Chemical User Data for Volatile Organic Compounds (VOC) and Hazardous Air Pollutant (HAP) Emissions	4-181
4-5 - Steam Plant Operations Data.....	4-195
4-6 - Air Quality Data for the Albuquerque Basin.....	4-207
4-7 - SNL/NM Clean Air Network (CAN) Program Data.....	4-211

LIST OF TABLES

4-1. Air Quality Regulations Potentially Applicable to SNL/NM.....	4-13
4-2. Summary of Air Quality Permits	4-15
4-3. Applicable Ambient Air Quality Standards	4-16
4-4. Summary of Meteorological Stations.....	4-26
4-5. Summary of Meteorological Data	4-29
4-6. Monthly Climatology for the National Weather Service Station.....	4-30
4-7. Stability Frequency Distribution at the National Weather Service Station.....	4-35

4-8. Three-Year Descriptive Climatology for SNL/NM A36 Tower	4-37
4-9. SNL/NM Meteorological Network Variations and Extremes	4-38
4-10. Stability Frequency Distribution at Tower A36	4-41
4-11. Climatological Mixing Heights for Albuquerque by Season	4-45
4-12. Seasonal Wind Frequency Distributions for the A15, CW1, and KU1 Towers	4-54
4-13. SNL/NM Wind Profile Exponents	4-62
4-14. Description of the Meteorological Data Sets	4-63
4-15. Emission Sources of Criteria Pollutants at SNL/NM	4-63
4-16. Source Parameters for the SNL/NM Steam Plant	4-73
4-17. SNL/NM Steam Plant Potential Emission Rates	4-73
4-18. Relationship Between Source Parameters and Operating Load for the Steam Plant ..	4-76
4-19. Source Parameters for SNL/NM Building 862 Generators	4-77
4-20. Potential Emission Rates for SNL/NM Building 862 Generators	4-77
4-21. SCREEN3 Model Conversion Factors	4-80
4-22. Screening Meteorology Wind Speed/Stability Array	4-81
4-23. Criteria Pollutant Monitoring Results for 1996 and Current Regulatory Standards	4-86
4-24. Quarterly and Annual Averages of PM ₁₀ at SNL/NM in 1996	4-87
4-25. Results of Volatile Organic Compound Analysis in 1996	4-89
4-26. Summary of Radionuclide Releases for 1996	4-93
4-27. Release Parameters for 1996 SNL/NM Radiological Sources	4-96
4-28. Summary of Concentration Collections	4-102
4-29. Summary of 1996 Air Quality Data Within the Albuquerque Basin	4-107
4-30. Criteria Pollutant Emissions From 1992 Through 1996	4-109
4-31. Emissions Trends for the Steam Plant	4-112
4-32. Chemical Volatile Organic Compound Emissions	4-112
4-33. Criteria Pollutant Results From 1994 to 1996 Compared to the Most Stringent Standard	4-113
4-34. Hazardous Air Pollutant Emissions at SNL/NM	4-119
4-35. Summary of Volatile Organic Compounds Sample Analyses at SNL/NM	4-121
4-36. Summary of Five-Year Data Trends for Air Quality Within Albuquerque Basin	4-125

LIST OF FIGURES

4-1. Generalized Regional Tectonic Map of the Albuquerque Basin	4-18
4-2. Generalized Regional Cross-Sections through the Albuquerque Basin	4-20
4-3. Generalized Geology in the Vicinity of SNL/NM	4-21
4-4. Meteorological Stations within the City of Albuquerque	4-24
4-5. Meteorological Stations within the Albuquerque Basin	4-25
4-6. Period Windroses for the City of Albuquerque	4-31
4-7. Period Windroses for the Albuquerque Basin	4-32
4-8. Daytime Windroses for the City of Albuquerque	4-33

4-9. Nighttime Windroses for the City of Albuquerque.....	4-34
4-10. Meteorological Monitoring Network at SNL/NM	4-36
4-11. Three-Year Wind Climatology at SNL/NM.....	4-39
4-12. Generalized Flow Within a Valley.....	4-42
4-13. Illustration of Building-Induced Downwash Flow.....	4-43
4-14. Effect of Turbulent Dispersion on a Plume	4-46
4-15. Illustration of Pollutant Stagnation.....	4-47
4-16. Cold Air Drainage Representation.....	4-48
4-17. Illustration of Outflow/Stagnation/Return Flow Cycle.....	4-49
4-18. Nocturnal Wind Patterns at SNL/NM.....	4-51
4-19. Daytime Wind Patterns at SNL/NM	4-55
4-20. Tech Area I Sources	4-65
4-21. Northeast Tech Area III Sources	4-66
4-22. Tech Area IV Sources	4-67
4-23. Tech Area V Sources	4-68
4-24. Lurance Canyon Burn Site Sources	4-69
4-25. Monthly Fuel Usage for the SNL/NM Steam Plant Boilers.....	4-74
4-26. Relationship Between Exit Velocity and Operating Load for the Steam Plant.....	4-75
4-27. Relationship Between Exit Temperature and Operating Load for the Steam Plant.....	4-75
4-28. Ambient Air Monitoring Stations at SNL/NM.....	4-85
4-29. Air Quality Stations Within the City of Albuquerque.....	4-104
4-30. Air Quality Stations Within the Albuquerque Basin.....	4-105
4-31. Trend of Nitrogen Oxides Emissions	4-109
4-32. Trend of Carbon Monoxide Emissions	4-110
4-33. Trend of Total Suspended Particles Emissions	4-110
4-34. Trend of Sulfur Dioxide Emissions	4-111
4-35. Criteria Pollutant Monitoring Station Diurnal Concentrations Averaged for Each Hour	4-115
4-36. Monthly Maximum Short-Term Carbon Monoxide Concentrations Plotted Over Time and Compared to Regulatory Standards	4-116
4-37. Monthly and Maximum 24-Hour Average Nitrogen Dioxide Concentrations Plotted Over Time and Compared to Regulatory Standards	4-117
4-38. Monthly and 1-Hour Maximum Ozone Concentrations Plotted Over Time and Compared to Regulatory Standards	4-117
4-39. Monthly Average PM ₁₀ and Minimum and Maximum 24-Hour Concentrations for SNL/NM	4-118
4-40. Air Quality Trends for CO Within the Albuquerque Basin	4-126
4-41. Air Quality Trends for O ₃ Within the Albuquerque Basin	4-126
4-42. Air Quality Trends for PM ₁₀ Within the Albuquerque Basin.....	4-126
4-43. Daytime Windroses for the Albuquerque Basin.....	4-131

4-44. Nighttime Windroses for the Albuquerque Basin.....	4-132
4-45. Summer Windroses for the City of Albuquerque	4-133
4-46. Winter Windroses for the City of Albuquerque	4-134
4-47. Summer Windroses for the Albuquerque Basin	4-135
4-48. Winter Windroses for the Albuquerque Basin	4-136

EXECUTIVE SUMMARY

Air quality for SNL/NM is governed by regulations promulgated locally by the Albuquerque/Bernalillo County (A/BC) Air Quality Control Board (AQCB) and federally by the U.S. Environmental Protection Agency (EPA). The A/BC AQCB promulgates regulations in the New Mexico Administrative Code (NMAC) for compliance with the *Clean Air Act (CAA)* and applicable state and local air quality requirements.

SNL/NM manages air quality through the Environmental and Emergency Management Department. Compliance responsibilities are divided between the Air Quality Control Program, the Radiological National Emission Standards for Hazardous Air Pollutants (NESHAP) Program, and the Clean Air Network (CAN) Program.

Operations at SNL/NM emit both radiological and nonradiological emissions. Nonradiological emissions include criteria pollutants and hazardous air pollutants (HAPs). The criteria pollutants include nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), particulate matter less than 10 microns in diameter (PM_{10}), and volatile organic compounds (VOCs). The HAPs are those pollutants listed in Title III of the CAA. Operations emitting these pollutants include research and development facilities, environmental remediation, waste handling, steam-generated heat, and electrical power generators.

The largest source of criteria pollutant emissions at SNL/NM is the Steam Plant, which utilizes five steam-generating boilers. The boilers are dual-fired with natural gas (the primary fuel) and diesel fuel. Because of the NO_x emissions from the Steam Plant and CO emissions from the electrical power generators, SNL/NM is required to apply for a CAA Title V operating permit. The operating permit application (and permit, when issued) will summarize applicable requirements for governing air quality at SNL/NM.

Actual criteria and HAP emissions, including radionuclides, are relatively small for normal SNL/NM operations. During 1996, approximately 178 tons of criteria pollutants resulted from significant pollutant sources, and approximately 2.4 tons of HAPs resulted from the use of chemicals. The radiological sources at SNL/NM include the TANDEM Accelerator, Particle Fusion Accelerator, Annular Core Research Reactor (ACRR), Sandia Pulsed Reactors (SPRs) II and III, and radiological sources from several miscellaneous research and development laboratories. The dose associated with these operations for 1996 was 0.0073 millirem, which was well below the regulatory standard of 10 millirems per year.

The Environmental and Emergency Management Department uses meteorological data and ambient air monitoring data to assess the impact of emissions. The results of ambient air monitoring show that emissions from SNL/NM point sources have a relatively small impact when compared with vehicle emissions on Kirtland Air Force Base (KAFB). SNL/NM operations did not exceed air quality standards in 1996.

1.0 INTRODUCTION

1.1 Purpose

The purpose of this chapter is to provide the scope and methods for compiling data and provide background air quality information.

1.2 Scope

This chapter provides the data necessary to evaluate the current and future environmental impacts of air emissions from SNL/NM operations. This chapter presents:

- Data for three different pollutant types, which are criteria pollutants, hazardous air pollutants (HAPs), and radioactive pollutants.
- Meteorological data that defines the environmental conditions at SNL/NM and the surrounding air quality basin.
- Data representing historical emissions.

Accuracy of historical trending is dependent upon the data collected and the data quality for a given pollutant type.

1.3 Methods for Compiling Data

Several methods were used to compile data for this chapter. Data collection methods were dependent upon the pollutant or data type. Data types that were collected are:

- Criteria pollutant emissions
- Hazardous air pollutant (HAP) emissions
- Radionuclide emissions
- Onsite meteorological data

- Basin meteorological data
- Onsite ambient air quality data
- Basin ambient air quality data

The criteria pollutant data for 1996 is based on information supplied by SNL/NM line organizations. This data was compiled specifically for this document and is not cited elsewhere. The historical data for criteria pollutants is based on information supplied in previous annual site environmental reports (1992 through 1995) (Sandia National Laboratories, 1993, 1994, 1995, 1996). Both the historical and 1996 HAP emissions data were compiled from SNL/NM's Chemical Information System (CIS).

Radionuclide emissions, both historical and 1996 emissions data, are based on the annual radiological *National Emission Standards for Hazardous Air Pollutants (NESHAP)* report as required by 40 CFR 61, Subpart H.

Data for onsite ambient air quality includes criteria pollutant, HAP, radionuclide, and onsite meteorological data. The ambient data is based on data collected as a result of SNL/NM's Clean Air Network (CAN) Program. Offsite meteorological data used to define the air quality basin was compiled from data supplied by the National Weather Service (NWS), City of Albuquerque, State of New Mexico, and other sources as cited in "3.0 CLIMATE AND METEOROLOGY."

1.4 Links to Facilities and Programs

The data and information presented in this chapter were compiled via SNL/NM's Air Quality Compliance (AQC) Program, the Radiological National Emission Standards for Hazardous Air Pollutants (NESHAP) Program, and the Clean Air Network (CAN) Program. These programs assist SNL/NM line organizations in complying with the applicable local, state, and federal air quality regulations.

The AQC Program assists line organizations by:

- Assessing potential impacts from existing and planned sources of regulated air pollutants.
- Providing consultation when SNL/NM organizations develop new processes with the potential for emitting regulated pollutants.

- Ensuring compliance with air quality regulations through tracking, recordkeeping, and reporting.
- Providing criteria on air pollution devices that may be required.
- Providing assistance in air quality permitting.
- Conducting air dispersion modeling.

The Radiological NESHAP Program assists line organizations by:

- Assessing existing and planned sources of radionuclides.
- Compiling the annual radiological NESHAP report.
- Recording and tracking facility-specific radionuclide emissions.
- Providing assistance in air quality permitting.
- Performing special monitoring projects as requested.

The CAN Program assists line organizations in measuring and assessing ambient air quality and meteorological conditions. The data collected by the CAN Program is integral to responsibilities outlined in the Radiological NESHAP and AQC Programs.

The AQC, the CAN, and the Radiological NESHAP Programs are part of the Environmental and Emergency Management Department at SNL/NM. This department's mission is to assess, document, and report the impact of SNL/NM operations on the environment and assist SNL/NM line organizations with air and water quality issues.

Environmental and Emergency Management Department personnel work:

- Directly with facility managers, program managers, technical personnel, and environmental coordinating organizations.
- Closely with other departments within the Environment, Safety, and Health (ES&H) Center (part of the Laboratory Services Division) to ensure coordination of compliance issues. The

Environmental and Emergency Management Department also coordinates with the SNL/NM ES&H and Corporate Law Center.

The DOE/Kirtland Area Office (KAO) provides oversight and direction to the Environmental and Emergency Management Department and corresponding programs.

2.0 REGULATORY SETTING

2.1 Local and Federal Regulations

Air quality for SNL/NM is governed by regulations promulgated locally by the Albuquerque/Bernalillo County (A/BC) Air Quality Control Board (AQCB) and federally by the U.S. Environmental Protection Agency (EPA). The EPA has delegated authority for regulating sources under the *Clean Air Act (CAA)* to the State of New Mexico. In turn, the State of New Mexico has delegated authority for regulating sources under the CAA to the A/BC AQCB.

The A/BC AQCB promulgates regulations in 20 NMAC 11 for compliance with the CAA as well as applicable state and local air quality requirements. The Albuquerque Environmental Health Department (AEHD) Air Quality Division (AQD) administers the regulations promulgated by the A/BC AQCB. Regulations in 20 NMAC 11 govern operations emitting criteria pollutants and hazardous air pollutants (HAPs) including radionuclides. Radionuclide emissions are concurrently administered by the EPA under 40 CFR 61, Subpart H. The A/BC regulations incorporated *National Emission Standards for Hazardous Air Pollutants (NESHAP)* by reference, although the EPA has not delegated authority to the AEHD to administer the program. The A/BC regulations also govern radiological emissions through the Authority to Construct Program.

Drivers for air quality compliance also include DOE 5400.1. Table 4-1 summarizes air quality regulations potentially applicable to SNL/NM and the relationship between local and federal regulations with explanations of those that are specific and relevant. For more information, see Chapter 13, "Regulatory Requirements."

The *Clean Air Act Amendments (CAAA) of 1990* contained provisions requiring states to establish a program to require all major air emission sources to obtain an operating permit. These provisions for major sources are promulgated in 40 CFR 70, *State Operating Permit Programs*. The A/BC AQCB promulgates local regulations in 20 NMAC 11.42, *Operating Permits*.

Table 4-1. Air Quality Regulations Potentially Applicable to SNL/NM

Federal Regulation	Local Regulation	Subject	Description of Regulation and SNL/NM Relevancy
40 CFR 93 B* 40 CFR 51 W	20 NMAC 11.03 20 NMAC 11.04	Conformity (state and federal plans)	General
40 CFR 58 (Subpart C—Air Programs)	N/A	Ambient air quality surveillance	Air Quality Surveillance Program - Standards for state and local air monitoring stations (SLAMS)
40 CFR 50	20 NMAC 11.01 20 NMAC 2.03	National primary and secondary ambient air quality standards (NAAQS)	Establishes ambient air quality standards for criteria pollutants
	20 NMAC 11.02	Permit fees	Asbestos, inventories, permits, reviews
	20 NMAC 11.05	Visible air contaminants	<ul style="list-style-type: none"> • Smoke Emission Reduction Facility (SMERF) (now called Fire Laboratory for the Accreditation of Model and Experiments [FLAME]) (exempt) • Small Wind Shielded (SWISH) Facility (exempt)
	20 NMAC 11.06	Emergency action plan	If formulated by Albuquerque Environmental Health Department (AEHD)
	20 NMAC 11.07	Variance procedure	If variance is sought
	20 NMAC 11.20	Airborne particulate matter (PM)	Surface disturbing over 3/4 acre (e.g., general construction or demolition)
	20 NMAC 11.21	Open burning	<ul style="list-style-type: none"> • Open burns conducted (applies to fire testing facilities) • Explosive detonations
	20 NMAC 11.40	Source registration	Facilities with emissions >1 ton per year of hazardous air pollutants (HAPs) (applies to the FLAME and the Neutron Generator Facility [NGF])
	20 NMAC 11.41	Authority-to-construct	Stated operating conditions for facilities with emissions >25 tons per year or 10 pounds per hour or >5 tons per year of lead (Pb) or National Emission Standards for Hazardous Air Pollutants (NESHAP)-listed pollutant

Table 4-1. Air Quality Regulations Potentially Applicable to SNL/NM (Continued)

Federal Regulation	Local Regulation	Subject	Description of Regulation and SNL/NM Relevancy
40 CFR 51.100	20 NMAC 11.43	Stack height requirements	Good engineering practice
	20 NMAC 11.44	Emissions trading	Applicable if credit taken
	20 NMAC 11.60	Permitting in nonattainment areas	Applicable if >100 tons per year carbon monoxide (CO)
	20 NMAC 11.61	Prevention of significant deterioration	Applicable if >250 tons per year
40 CFR 60 40 CFR 63	20 NMAC 11.65	Volatile organic compounds (VOCs)	<ul style="list-style-type: none"> • Fuel use (N/A) • Remediation of solvent contaminated soil • Groundwater treatment
40 CFR 60	20 NMAC 11.66	Process equipment	Hammermill
	20 NMAC 11.63	New source performance standards (NSPS)	Prescribes operating conditions for new or modified listed sources
	20 NMAC 11.67	Equipment, emissions, and limitations (regulates nitrogen oxides [NO _x], PM, and sulfur dioxide [SO ₂] from gas-burning and oil-burning equipment)	N/A (the five natural gas-burning boilers at the Steam Plant produce less than the rated heat capacity threshold of 250 million British thermal units [BTUs] per hour)
40 CFR 85-86	20 NMAC 11.100 20 NMAC 11.101 20 NMAC 11.103	Mobile sources	SNL/NM's fleet of over 800 vehicles, inspection, and emissions testing
40 CFR 80	20 NMAC 11.02	Fuels and fuel additives	For motor vehicles
40 CFR 61 40 CFR 63	20 NMAC 11.64	NESHAP <ul style="list-style-type: none"> • Subpart H - Radionuclides • Subpart M - Asbestos • Subpart T - Degreasers 	General
40 CFR 70-71	20 NMAC 11.42	Operating permit (application under review)	For existing major sources (>100 tons per year)
40 CFR 82	20 NMAC 11.23	Ozone protection	Limiting the use of Class I and Class II ozone-depleting substances (ODSs): <ul style="list-style-type: none"> • Auto air conditioners • Refrigerators • Chillers
	20 NMAC 11.90	Administration, enforcement, inspection	Breakdown, abnormal operating condition, or scheduled maintenance
	20 NMAC 11.100	Motor vehicle inspection - decentralized	Emission testing
*Designates 40 CFR 93, Subpart B.			

SNL/NM is considered a major source based on the potential to emit nitrogen oxides (NO_x) and carbon monoxide (CO) greater than 100 tons per year. SNL/NM submitted an operating permit application as part of the DOE/Kirtland Area Office (KAO) application to AEHD on March 1, 1996. The operating permit application submitted to DOE was deemed complete on May 1, 1996. The permit was required to be issued and approved by the AEHD in March 1998. However, as of September 1998, AEHD has not issued an operating permit. The Title V operating permit will integrate all air quality requirements, including local, state, and federal regulations into one sitewide permit for air quality. Compliance with the permit terms and conditions will establish compliance with all applicable air quality requirements. This single permit will include all sources of air emissions for activities associated with DOE, including SNL/NM.

For new or modified sources of regulated air pollutants, the A/BC AQCB promulgated 20 NMAC 11.40, *Registrations*, and 20 NMAC 11.41, *Authority to Construct Permits*. Based on the pollutant type and the potential to emit these pollutants, a preconstruction permit or registration of an emission source may be required. The AEHD also requires submittal of an authority to construct permit application for radionuclide sources requiring EPA preconstruction approval. EPA preconstruction approval is required for the construction of or modification to a radionuclide source that results in an effective dose equivalent (EDE) to a public receptor greater than 0.1 millirems per year. Table 4-2 lists the current applicable permits or registrations for SNL/NM operations.

Table 4-2. Summary of Air Quality Permits

Facility Name	Permit Number	Permit Type
Hammermill, Building 6583	144	Authority to construct
Fire Laboratory for the Accreditation of Model and Experiments (FLAME)	196	Registration
Neutron Generator Facility (NGF), Building 870	374	Registration
Isotope Production Facility, Building 6580	374	Registration
Building 862 Electrical Power Generators	402 (150 - old permit)	Authority to construct
Radioactive and Mixed Waste Management Facility (RMWMF), Building 6920	415	Registration
Radioactive Waste Landfill, Tech Area II	480	Registration
Classified Waste Landfill, Tech Area II	560	Registration (pending)
Building 878 Electrical Power Generator	646	Authority to construct
Open burn pools	647	Authority to construct (pending)
Neutron Generator (NG) Recertification Project, Building 890	N/A	Registration (pending)
Radioactive Waste Landfill, Tech Area II	N/A	Radiological NESHAP approval

SNL/NM is located in the Albuquerque Middle Rio Grande Intrastate Air Quality Control Region. Under the national ambient air quality standards (NAAQS), Bernalillo County is currently in maintenance status for the carbon monoxide (CO) NAAQS. Depending on emission levels, modification to existing sources or construction of new sources emitting CO may require a general or transportation conformity analysis and additional levels of controls to comply with the NAAQS. In addition, modification to existing sources or construction of new sources emitting the other criteria pollutants for which a preconstruction permit must be obtained are required to comply with the NAAQS. SNL/NM, as dictated by the AEHD, is also required to comply with the State of New Mexico ambient air quality standards (NMAAQs). Table 4-3 lists the more stringent of the air quality ambient standards (AAQS).

Table 4-3. Applicable Ambient Air Quality Standards (AAQS)

Pollutant	Averaging Time	AAQS (ppm)*	Regulation
CO	8 hours	8.7	Federal
	1 hour	13.1	State
NO ₂	Annual	0.05	State
	24 hours	0.10	State
PM ₁₀ /PM _{2.5}	Annual	50/15 (µg/m ³)	Federal
	24 hours	150/65 (µg/m ³)	Federal
SO ₂	Annual	0.02	State
	24 hours	0.10	State
	3 hours	0.50	Federal
O ₃	8 hours	0.08	Federal

*Compliance standards are in parts per million unless noted otherwise.
CO = carbon monoxide
NO₂ = nitrogen dioxide
PM₁₀/PM_{2.5} = particulate matter less than 10 or 2.5 microns in diameter
SO₂ = sulfur dioxide
O₃ = ozone
µg/m³ = micrograms per cubic meter

The A/BC AQCB regulation, 20 NMAC 11, also requires that an application be submitted for an open burn permit for sources meeting the applicability of the open burn requirements. SNL/NM operates an open burn facility located in Lurance Canyon on Kirtland Air Force Base (KAFB). The Lurance Canyon Burn Site is used for research and development activities requiring high temperatures and/or fully involved fires. Permits are issued and expire as individual experiments are conducted.

Regulation 20 NMAC 11.05 and the CAA require all federal agencies to perform a conformity analysis to ensure new or modified operations comply with NAAQS. An analysis is only required for those actions not governed by current air regulations. A study to determine the current SNL/NM conformity was conducted and established in March 1996 (McClellan and Royer, 1996).

2.2 Summary of Past Violations

The regulations requiring the submittal of an operating permit, 20 NMAC 11.42 and 40 CFR 70, also required SNL/NM to provide certification of compliance. This certification included the following:

- SNL/NM's compliance status for each applicable requirement
- Statement of methods used for determining compliance
- Statement of continued compliance
- Schedule of compliance reporting
- SNL/NM certified compliance to all applicable requirements in the March 1, 1996 DOE/Kirtland Area Operations (KAO) application submittal

In preparation for submittal of the operating permit application, SNL/NM examined compliance with all applicable requirements. The examination identified a potential compliance issue. Certain operations had not applied for a permit or registration under 20 NMAC 11.40 and 20 NMAC 11.41. To address this potential compliance issue, SNL/NM and AEHD have entered into a permitting and registration settlement agreement. The settlement agreement states that submittal of the operating permit application, including the sources in question, provides the necessary registration or permitting for these historical sources. When the operating permit is issued, SNL/NM will submit annual compliance reports that certify compliance to all applicable requirements.

3.0 CLIMATE AND METEOROLOGY

3.1 Geographic Impact Region

The geography greatly influences the meteorological conditions and air quality within this regional area. The Albuquerque Basin of central New Mexico is about 100 miles long (north to south) and 25 to 40 miles wide (east to west) (see Figure 4-1). The Rio Grande flows southward through the basin and the mountains rise to heights of 5,500 feet or 1,676 meters above the basin floor to the east of SNL/NM. The Albuquerque Basin is bound on the east by the Sandia, Manzanita, and Manzano Mountains, and on the west by the Colorado Plateau, delineated by the Rio Puerco. The southern and northern boundaries are represented by the narrowing of the basin near the town of Socorro and the Jemez Caldera, respectively.

Figure 4-1. Generalized Regional Tectonic Map of the Albuquerque Basin

SNL/NM is located along the eastern margin of the Albuquerque Basin (see Figure 4-1), west of the Manzano and Manzanita Mountains on the alluvial fan complex that flanks the mountain front. The Albuquerque Basin underwent subsidence and a northwest-southeast extension, beginning 30 to 40 million years ago, with minor activity continuing to the present time. The Albuquerque Basin is divided into two halves bordered by major faults as shown by cross-sections in Figure 4-2.

SNL/NM is located in structurally complex terrain intersected by a number of major regional faults (see Figure 4-3). The Sandia Fault is the primary frontal fault that forms the eastern border of the Albuquerque Basin. The Tijeras Fault cuts diagonally across SNL/NM along the east side of the Four Hills and Manzano Area.

The mountains, canyons, and Rio Grande Valley significantly influence wind patterns in the Albuquerque Basin and interact to form a complex condition. The 13-mile escarpment, which forms the west face of the Sandia Mountains, greatly influences flow, creating diurnal up-slope and down-slope wind patterns. Mountain vegetation and elevations also create differences in ambient temperature and rainfall compared to the valley region. Tijeras Canyon, slightly northeast of SNL/NM, is the largest canyon pass in the area, dividing the Sandia and Manzanita Mountains. This canyon tends to create strong channeled or funneled winds, especially during late winter and early spring.

Dense, cold air creates temperature inversions during the winter months. These inversions, combined with low wind speed and basin geography, restrict the dispersion and dilution of air pollutants by trapping the pollution near the surface. Thus, the entire basin can be considered a single airshed when evaluating the emission, accumulation, and transportation of air pollutants.

Meteorological data was collected for the baseline year of 1996 and from the years 1992 through 1995 to develop trends within the basin. Data collected from meteorological stations within the basin was evaluated for completeness. Meteorological data was gathered from 12 stations meeting the completeness requirements. Of these 12 stations, six were located within the City of Albuquerque; two sites were located within Bernalillo County; and the remaining four sites defined the northern and southern boundaries of the basin. Meteorological data collected at these stations included temperature, wind speed, and wind direction. Annual precipitation amounts were collected at some of the stations. The statistics for the meteorological data are summarized in "3.3 Transport and Dispersion Characteristics."

Figure 4-2. Generalized Regional Cross-Sections through the Albuquerque Basin

Figure 4-3. Generalized Geology in the Vicinity of SNL/NM

3.2 Climatology

The ambient temperatures within the region are characteristic of high-altitude, dry continental climates; winter daytime temperatures average approximately 50 degrees Fahrenheit (°F) (10 degrees Celsius [°C]) with nighttime temperatures often reaching into the low teens. Summer daytime temperatures generally do not exceed 90°F (32°C), except in July, when average maximum temperatures reach 93°F (34°C). The Albuquerque Basin is characterized by low precipitation with averages of between 7.5 and 10 inches per year, occurring primarily as brief but heavy seasonal rain showers. About half of this precipitation falls in the late summer from July through September, the primary, monsoon-like season for precipitation in the southwest region of the United States.

The monsoon season develops as high pressure builds to the east of New Mexico and circulates moist air from the Gulf of California and the Pacific Ocean. When moist air meets the central mountain chain within New Mexico, storms develop during the hot afternoons as a result of the contrast between the dry and moist air masses. The storms frequently involve lightning and thunder. New Mexico has one of the greatest frequencies of lightning in the United States. The storms are also accompanied by localized heavy wind gusts. Tornadoes are uncommon in the Albuquerque Basin.

The dry, sparsely vegetated, high desert topography is particularly susceptible to erosive arroyo channeling and flash flood runoff conditions. Winter months are typically very dry, with less than two inches of precipitation and limited snowfall. The average annual relative humidity is about 43%.

The atmospheric variables of temperature, relative humidity, and precipitation, in general, do not vary dramatically across the region. However, topographically-induced wind flows do vary within the Albuquerque Basin and can be enhanced or negated by synoptic weather systems. Diurnal and seasonal wind patterns occur across the basin. Daytime up-slope flows are usually coupled with down-slope flows during the night.

In general, areas closer to the mountains or canyons experience greater frequency of winds coming from an easterly direction at night. Daytime wind patterns are not as pronounced, but generally flow toward the mountains or along the Rio Grande Valley. The Rio Grande Valley experiences the greatest frequency of calm conditions and the lowest average wind speed. In most areas, the nighttime wind direction frequency produces the most dominant average annual direction.

3.2.1 Regional Meteorology

The meteorological conditions affect dispersion and dilution of pollutants within the Albuquerque Basin. Seasonal and diurnal variation in the wind pattern can provide diverse effects. Meteorological patterns produce different effects along the mesa top, near canyons and mountains, and within (the floor of) the Rio Grande Valley. Synoptic or large-scale weather systems may in turn negate regional and microscale influences.

Meteorological data was gathered from 12 meteorological stations within the Albuquerque Basin, including six stations located within the City of Albuquerque. Additional data was gathered from Rio Rancho, Bernalillo, Los Lunas, Socorro, and Los Alamos. These stations extend the complete range of the basin. Figure 4-4 shows the location of the six Albuquerque meteorological stations, and Figure 4-5 shows the location of meteorological stations from Bernalillo to Socorro. Table 4-4 lists the meteorological stations, the station measured parameters, location, and elevation.

All data was collected at the 10-meter level above ground, unless noted. Five years of data was collected from each station (1992 to 1996). Elevations of the six City of Albuquerque stations range from 5,000 to 6,000 feet above sea level. The 12 meteorological stations are briefly described below.

ALQ 2R Station - This monitoring station is located at the Southwest Lift Station on the Pueblo of Isleta, approximately one mile to the west of the Rio Grande and three miles south of downtown Albuquerque. The Albuquerque Environmental Health Department (AEHD) collects meteorological and ambient air quality data at this station. Light winds from the north and south and low minimum temperatures occur at this site.

ALQ 2ZF Station - This station, located at Tramway Boulevard, is the closest station to the Sandia Mountains and is about 12 miles northeast of downtown Albuquerque. The Albuquerque Environmental Health Department (AEHD) collects meteorological and air quality data at this station, which receives moderate winds from the north and east, showing the influence of the mountains and canyons. The highest average wind speeds within the basin occur at this station.

Figure 4-4. Meteorological Stations within the City of Albuquerque

Figure 4-5. Meteorological Stations within the Albuquerque Basin

Table 4-4. Summary of Meteorological Stations

Station	UTM-E (Meters)	UTM-N (Meters)	Elevation (Feet)	Parameters	Period of Measurement
ALQ 2R	346,439	3,876,000	4,925	WD, WS, TP, AQD	1992 to 1996
ALQ 2ZF	361,625	3,895,502	6,020	WD, WS, TP, AQD	1992 to 1996
ALQ 2ZK	355,463	3,886,195	5,220	WD, WS, TP, AQD	1992 to 1996
ALQ 2ZL	350,000	3,896,500	5,000	WD, WS, TP, AQD	1992 to 1996
ALQ 2ZN	355,770	3,881,575	5,270	WD, WS, TP, AQD	1992 to 1996
Sierra	345,447	3,891,234	5,308	WS, TP, PRE	1992,1993, 1995,1996
National Weather Service (NWS)	353,600	3,879,505	5,310	WD, WS, TP, PRE	1992 to 1996
Los Lunas	339,856	3,848,368	4,843	WD, WS, TP, PRE	1992 to 1996
Bernalillo (2ZJ)	359,220	3,907,150	5,250	WD, WS, TP	1992 to 1996
Los Alamos (Tech Area 49)	382,665	3,963,817	7,045	WD, WS, TP, PRE	1992 to 1996
Los Alamos (Tech Area 6)	380,907	3,969,182	7,424	WD,WS,TP	1992 to 1996
Socorro	325,500	3,771,000	4,775	WD, WS, TP, PRE	1995,1996
AQD = air quality data TP = temperature PRE = precipitation UTM-E = Universal Transverse Mercator Easting UTM-N = Universal Transverse Mercator Northing WD = wind direction WS = wind speed					

ALQ 2ZK Station - This station is located near the intersection of San Mateo Boulevard and Menaul Boulevard, approximately seven miles east of the Rio Grande and downtown Albuquerque. The Albuquerque Environmental Health Department (AEHD) collects meteorological and ambient air quality data at this station. It was chosen primarily for the air quality data, given its proximity to several shopping malls and other traffic congestion. Light winds from the southeast and northwest occur most often at this station. Some of the highest temperatures in the monitoring network occur at this station.

ALQ 2ZL Station - This station is located west of the Rio Grande at the U.S. West Facility on Coors Boulevard, approximately 10 miles north of downtown Albuquerque. The Albuquerque Environmental Health Department (AEHD) collects meteorological and air quality data at this station. Influenced by the Rio Grande Valley, westerly and northerly winds are most dominant.

ALQ 2ZN Station - This station is located at the Wilson Middle School on Anderson Street, approximately seven miles east of the Rio Grande and southeast of downtown Albuquerque. The Albuquerque Environmental Health Department (AEHD) collects meteorological and air quality data at this station. Light winds from the west occur at this monitoring station. This

location represents a midpoint between the Rio Grande Valley and mountains, but with a great influence from the urban environment. This station is the closest offsite station to SNL/NM.

Sierra Station - This station is located east of the Rio Grande at the Sierra Vista West Swim and Tennis Club on Montañito Road, approximately five miles to the north of downtown Albuquerque. New Mexico State University (NMSU) collects meteorological data at this station, but only wind speed, precipitation, and temperature were available. Very light winds, relatively low precipitation, and lower temperatures occur at this site.

National Weather Service (NWS) Station - The NWS station has been collecting meteorological data since 1894. Surface and upper air measurements are collected at the Albuquerque International Sunport, southeast of downtown Albuquerque. In addition to standard meteorological measurements, the NWS station collects precipitation, cloud amounts, and cloud ceiling levels. This monitoring station provides a transition between the Rio Grande Valley and mountain conditions. Data from the station indicates a high frequency of winds from the north, but also a component of strong easterly winds.

Los Lunas Station - This station is located about 20 miles south of Albuquerque and three miles south of Los Lunas at the Agricultural Science Center. New Mexico State University (NMSU) collects meteorological data only at this station. Conditions at this location are influenced by the Rio Grande Valley, with winds characteristically very light and variable. Annual precipitation is significantly less than amounts at the National Weather Station (NWS) in Albuquerque.

Bernalillo (2ZJ) Station - This station is located at the Highway Department Yard on Route 44 in Bernalillo. The New Mexico Environment Department (NMED) collects only meteorological data at this station. This station is located on the mesa to the west of the Rio Grande, and conditions are influenced by the valley flow to a greater extent than the other two valley stations, ALQ 2R and ALQ 2ZL. Most winds come from the northeast or southwest.

Los Alamos Stations - Meteorological data from two sites (Tech Area 49 and Tech Area 6) in Los Alamos was examined. Although conditions at these stations are greatly influenced by local terrain, this data was included to represent the northern boundary of the Albuquerque Basin. The station in Tech Area 49 includes a 46-meter tower and is located on the Pajarito Plateau on high ground between two small tributaries of Ancho Canyon. The station in Tech Area 6 consists of a 92-meter tower, located on the Pajarito Plateau in a narrow east-west meadow on Two-Mile Mesa. The Los Alamos National Laboratory collects data at these sites.

Socorro Station - This station was included to represent the southern extent of the Albuquerque Basin, approximately 65 miles south of Albuquerque. Annual precipitation at this

station is comparable to Albuquerque. Winds tend to be directly from the north or south, following the Rio Grande Valley. The New Mexico Institute of Mining and Technology collects data at this station.

Table 4-5 displays a summary of the meteorology characteristics of each station in the Albuquerque Basin. Those stations within the valley or near the mountains tend to record the lowest temperatures. Stations near the mountains and on mesa tops tend to record the highest wind speeds. Average and maximum temperatures are slightly warmer in the basin valley and at the southern locations, but there is not a great variation in annual mean temperature between stations during the 5-year period studied (1992 to 1996).

Table 4-6 shows the monthly variations in meteorological conditions for the National Weather Service (NWS) station. The warmest temperatures occur during June, July, and August, with the coldest temperatures occurring in December. The windiest months are March, April, and May due to the easterly canyon-influenced flow. It has been noted that these springtime months also produce the lowest relative humidity, possibly due to the easterly flow causing adiabatic down-slope warming.

Wind flow within the basin is affected by a combination of synoptic, large-scale weather patterns, regional, topographic features (i.e., mountains, valleys, canyons), and microscale conditions (i.e., buildings, arroyos). Windroses were produced to show the influences on the basin flow. Figure 4-6 displays the period windroses (i.e., five years) for the basin meteorological stations within the City of Albuquerque, and Figure 4-7 displays the windroses for some of the stations. For further details and additional meteorological data to support windroses in the Albuquerque Basin, see Attachment 4-1.

The wind flow is very complex within the basin. The pattern shows a convergence of wind into the City of Albuquerque during spring, winter, and nighttime (colder periods), and a divergence during the warmer periods of summer, fall, and in the daytime hours. During both the warmer and colder periods, the south valley stations (ALQ 2R and National Weather Station [NWS]) show a tendency for southerly winds. The canyon-influenced stations (ALQ 2ZN and ALQ 2ZK) show a tendency for easterly winds with a slight southerly component, whereas the north valley stations (ALQ 2ZL and Bernalillo) show a northwesterly wind vector. This wind pattern tends to trap pollutants in the basin during the colder periods and helps disperse pollutants during warmer periods. Figures 4-8 and 4-9 show the windroses for day and night periods, respectively. Daytime has been defined as 7 a.m. through 7 p.m. Figures 4-8 and 4-9 represent the trajectory of air pollutants during the respective periods for many of the stations; wind trajectories reverse between summer and winter, and day to night periods.

Table 4-5. Summary of Meteorological Data (1992 - 1996)

Station	Temperature (0°C)			Wind Speed (m/s)		Average Wind Direction*	Mean Precipitation (Inches)
	Maximum	Mean	Minimum	Maximum	Average		
ALQ 2R	39	11	-17	12.1	1.80	N	Unavailable
ALQ 2ZF	38	11	-14	18.3	3.51	SSE/W	Unavailable
ALQ 2ZK	40	14	-13	9.83	1.69	SSE	Unavailable
ALQ 2ZL	35	9	-18	13.4	2.23	ENE	Unavailable
ALQ 2ZN	39	13	-13	11.2	1.83	W	Unavailable
Sierra	38	4	-18	5.27	0.33	Unavailable	4.73
NWS	40	15	-18	19.6	3.31	S	9.54
Los Lunas	43	14	-15	8.67	1.06	WSW	6.64
Bernalillo (2ZJ)	41	13	-13	12.6	2.60	SSW	Unavailable
Los Alamos (Tech Area 49)	42	9	-19	13.2	2.92	N	Unavailable
Los Alamos (Tech Area 6)	33	Unavailable	Unavailable	15.0	2.28	ESE	19.2
Socorro	42	16	-11	10.3	1.68	S	8.22

*Wind direction is the direction from which the wind is blowing.

°C = degrees(s) Celsius

ENE = east-northeast

ESE = east southeast

m/s = meters per second

N = north

S = south

SSE = south-southeast

SSE/W = south-southeast/west

SSW = south-southwest

W = west

WSW = west-southwest

Table 4-6. Monthly Climatology for the National Weather Service (NWS) Station

Month	Maximum Temperature (°C)	Average Temperature (°C)	Minimum Temperature (°C)	Maximum Wind Speed (m/s)	Average Wind Speed (m/s)
January	20.5	2.9	-8.9	17.5	3.16
February	21.6	6.5	-7.8	15.4	3.48
March	26.6	9.4	-5.1	18.5	3.63
April	30.5	14.3	-1.7	17.5	3.58
May	34.4	19.3	7.2	18.0	3.80
June	41.1	24.4	12.2	15.4	3.54
July	39.4	25.9	14.9	17.5	3.27
August	39.2	24.3	16.1	17.0	2.98
September	34.4	20.3	6.1	14.9	2.90
October	30.0	14.2	-2.7	19.6	3.14
November	22.7	6.8	-2.7	15.4	3.23
December	19.4	3.0	-12.3	17.5	3.04
Extremes	40.8	N/A	-12.2	19.6	N/A
Averages	N/A	14.8	N/A	N/A	3.31
°C = degree(s) Celsius m/s = meters per second N/A = not applicable					

Average wind speeds tend to be lower in the valley locations, higher in the mesa and mid-basin stations, and much higher close to the canyons or mountains. This difference is most dramatic during springtime. Wind speeds tend to be lower during colder periods and higher during warmer periods.

Stability class frequencies were calculated from the NWS station data. The Turner method was used to categorize stability class as a function of cloud cover and wind speed. Stability classes range from extremely unstable (A) to moderately stable (F). These classes are used in dispersion models to estimate how much a plume will spread over time and space. In general, the more stable the atmosphere is, the less potential for plume spread, creating higher plume concentrations.

Figure 4-6. Period Windroses for the City of Albuquerque (1992 - 1996)

Figure 4-7. Period Windroses for the Albuquerque Basin

Figure 4-8. Daytime Windroses for the City of Albuquerque

Figure 4-9. Nighttime Windroses for the City of Albuquerque

Table 4-7 shows the percentage of occurrences for each stability class at the NWS station. When wind speeds exceed 6.0 meters per second, the stability class defaults to D. E and F stabilities occur only during the night. A majority of the hours involve neutral stability with a predominance of stable conditions.

Table 4-7. Stability Frequency Distribution at the National Weather Service (NWS) Station

Stability Class	Stability Description	Occurrence (%)
A (1)	Extremely unstable	2.4
B (2)	Moderately unstable	10.9
C (3)	Slightly unstable	14.1
D (4)	Neutral	32.1
E (5)	Slightly stable	18.0
F (6)	Moderately stable	22.5

3.2.2 Site-Specific Meteorology and Climatology

Current meteorological monitoring commenced at SNL/NM in January 1994. A historical monitoring network existed in the 1960s, but, as a result of the operational forecasting use of the towers and the technology of the era, little electronic data was recorded. The current 8-tower meteorological monitoring network consists of six 10-meter towers, one 60-meter tower, and one 50-meter tower. All towers are instrumented at the 3- and 10-meter levels. Instrumentation is also installed at the top of the tall towers. Figure 4-10 shows the meteorological monitoring stations located at SNL/NM.

Meteorological variables measured at all tower levels include wind speed, wind direction, and temperature. The standard deviation of the horizontal wind speed (σ_{θ}) is calculated for all levels for use in stability calculations. Relative humidity is measured at all towers at the 3-meter level. There are also three rain gauges and two atmospheric pressure sensors in the meteorological network. Barometric pressure is measured at the A36 and A21 towers. Rain gauges are located at the SC1, A36, and A21 towers.

The short climatological record presented in the following sections should not be used as long-term climatological data. This data should be used for standard modeling analysis. For a long-term record, National Weather Service (NWS) data taken at the Albuquerque International Sunport may be used for temperature and relative humidity. Precipitation and wind information in the NWS data varies from SNL/NM data, depending on the specific location in question at SNL/NM. Explanations of the variability will be provided throughout the following sections.

Because of its central geographic location and the availability of data at all three instrument levels, the A36 tower was designated as the official tower to describe general meteorology at SNL/NM. Summarized differences for temperature, precipitation, and humidity data across the network are provided using all tower information. The following sections present wind summaries for all locations that show differences.

Table 4-8 lists the cumulative climatology for the three-year record at the A36 tower. The general trends to note include the large average daily temperature ranges, as illustrated by the daily maximum and minimum temperatures; the windy season, that produces low relative humidity between April and June; and the warm season precipitation pattern. Attachment 4-2 summarizes data such as temperature, relative humidity, precipitation, wind, and barometric pressure for the other towers.

Table 4-8. Three-Year Descriptive Climatology for SNL/NM A36 Tower

Data	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)												
Daily maximum	9.5	13.5	16.1	20.0	27.8	31.6	32.9	31.5	26.2	20.6	14.3	10.3
Daily minimum	-2.4	0.5	2.2	5.5	11.3	16.7	18.5	18.2	13.1	6.8	1.1	-1.3
Average	3.7	7.2	9.3	13.0	19.6	24.3	25.5	24.4	19.8	14.7	8.6	4.8
Extremes (°C)												
Record high	19.8	20.8	25.0	29.8	34.4	39.3	38.4	36.0	34.1	28.3	22.5	19.5
Record low	-10.1	-11.2	-6.1	-2.6	3.1	7.8	11.5	14.8	3.5	-4.5	-7.6	-13.6
Relative Humidity (%)												
Relative	46.1	43.4	39.6	30.1	27.9	28.7	35.8	47.6	48.4	42.2	48.9	50.6
Precipitation (Centimeters)												
Average	1.78	2.29	1.78	1.02	6.35	4.06	5.33	18.54	8.38	10.16	4.83	2.03
Maximum	3.30	3.81	3.81	3.05	18.29	9.40	6.35	29.46	11.18	19.30	9.65	5.33
Minimum	0.00	1.27	0.25	0.00	0.00	0.25	3.81	7.62	5.08	0.00	0.51	0.00
24-hour maximum	2.54	2.79	1.02	1.52	4.32	4.06	6.10	8.89	4.32	7.11	4.83	2.79
Wind (Miles per Second)												
Monthly Average	1.48	1.61	1.83	1.97	2.01	1.83	1.74	1.56	1.48	1.61	1.48	1.30
24-hour maximum	3.80	3.62	5.01	4.34	4.74	4.07	29.50	2.86	402.75	5.19	3.35	3.17
Maximum gust	11.31	9.88	11.31	10.59	11.31	12.02	12.02	12.38	8.81	11.31	10.59	12.02
Barometric Pressure												
Pressure	838.2	836.9	834.8	832.4	830.7	832.2	833.7	834.5	835.4	835.2	837.0	837.6

°C = degree(s) Celsius

In general, the cumulative statistics for the towers are similar; however, daily meteorology varies at each monitoring station. Table 4-9 lists some of the variations found in meteorological measurements across SNL/NM.

Table 4-9. SNL/NM Meteorological Network Variations and Extremes

Parameters	Locations	Values
Temperature Variability		
Record temperature extremes	39.7 (MW1), 14.5 (CW1)	54.2°C
Greatest average temperature range	14.6 (A36), 13.7 (SC1)	0.9°C
Maximum daily average difference	N/A	4.6°C
Greatest daily minimum difference	N/A	9.8°C
Greatest daily maximum difference	N/A	8.0°C
Precipitation Variability		
Greatest annual variation	28.59 (SC1), 24.39 (A21)	4.20 centimeters
Greatest daily rainfall variation	N/A	3.98 centimeters
Greatest monthly difference	Jul 2.35 (SC1), 1.53 (A21)	0.82 centimeter
Maximum 24-hour rainfall	A21	4.01 centimeters
Wind Variability		
Greatest average wind speed variation	4.1 (CW1), 2.9 (A15)	1.2 meters per second
Average range of daily average speeds	(Includes all towers)	1.4 meters per second
Greatest daily average difference	N/A	4.1 meters per second
Greatest daily wind gust difference	N/A	15.2 meters per second
N/A = not applicable		

Temperature variability on an annual basis is less than 1.0°C, but on a daily basis can be quite large, as seen in the maximum difference in daily averages (4.6°C). Generally, larger daily differences are apparent when comparing conditions at the canyon station (toward the foothills) with the conditions occurring across open, less vegetated areas by stations toward the west. However, the warmest minimum temperatures generally occur at the A15 tower, where the urban heat island tends to offset or reduce the amount of radiant cooling. Urban building effects also produce lower wind speeds as seen in A15's greatest average variation in wind speed. The lowest average wind speeds occur at the A15 tower. Terrain effects produce precipitation variation across the network. The greatest annual precipitation occurs toward the foothills at the SC1 tower.

The most important implication of meteorological variation across SNL/NM is the wind variability impact on transport and dispersion of pollutants. In addition to the aforementioned wind variations, wind directions vary throughout the network as well. Figure 4-11 depicts the three-year windroses for monitoring stations at SNL/NM and an overview of climatology wind direction. For a detailed analysis identifying diurnal differences and seasonal patterns that differ from Figure 4-11, see "3.3.2 Factors Influencing Circulation."

Legend

- Meteorological Tower
- Kirtland Federal Complex (KFC) Boundary
- Road
- 40-Foot Elevation Contour
- SNL/NM Tech Area

0 1 2

Scale in Miles

0 5600 11200

Scale in Feet

0 1344 2688

Scale in Meters

Project Location Map

Sandia National Laboratories, New Mexico
Environmental Geographic Information System

Figure 4-11. Three-Year Wind Climatology at SNL/NM

Transverse Mercator Projection, New Mexico State Plane Coordinate System,
Central Zone, 1927 North American Horizontal Datum,
1923 North American Vertical Datum

1:67200

MAPID=980583

Unclassified

SNL GIS ORG. 6804

S Morrison

sm980583.aml

04/13/99

Predominant wind directions vary across SNL/NM; this variance is evident in the data based on the proximity of the station to canyons, mountains, and arroyos. Wind speeds, also shown in the windroses, vary along with the wind direction. Attachment 4-2 presents average wind speeds for each station and month.

Atmospheric stability classes are calculated using the standard deviation of the horizontal winds (σ_{θ}). Table 4-10 presents the stability classes for the A36 tower. Stability class frequencies vary across SNL/NM, with the greatest differences noted at towers A15 and SC1. All other locations are within 5% of A36 class frequencies. The differences in stabilities will affect atmospheric dispersion modeling calculations and concentrations. The major differences in stability frequencies are as follows: SC1 classes E and F were 8.7% and 18.2%, A15 classes A, D, and F were 20.1%, 27.7% and 21.2%, respectively. Dispersion of pollutants will vary between these three locations in both modeled and actual scenarios based on the wind and stability variations between the sites.

Table 4-10. Stability Frequency Distribution at Tower A36

Stability Class	Stability Description	Occurrence (%)
A (1)	Extremely unstable	11.9
B (2)	Moderately unstable	8.1
C (3)	Slightly unstable	9.1
D (4)	Neutral	44.8
E (5)	Slightly stable	18.2
F (6)	Moderately stable	8.0

3.3 Transport and Dispersion Characteristics

3.3.1 Overview of Physical Phenomena

Pollutants dispersion in the Albuquerque Basin is a result of wind patterns developing from the complex interactions of the urban system, valley drainage flows, canyon circulation, mountain slope transport mechanisms, and stagnation periods. The following subsections describe these phenomena and their relationship to pollutants dispersion.

When pollutants are emitted to the atmosphere, they are carried away from the source by wind transport and diluted by mixing with the ambient air. Several factors (i.e., local terrain, meteorological conditions, and source characteristics) affect the impact of the pollutant when the plume comes in contact with a ground-based receptor.

3.3.2 Factors Influencing Circulation

Interaction between the valley, mountains, and the urban environments with the turbulent mixed layer and synoptic flow creates a circulation that transports, accumulates, and disperses air pollutants in the Albuquerque Basin. Meteorological and topographic influences are discussed in the following sections.

Valley Flow - Terrain influences both wind trajectory, which transports constituents, and turbulence, which disperses the constituents. Valleys channel wind flow (see Figure 4-12). The plume trajectory in valley terrain is a function of the location of the emission source relative to the valley. Buoyancy effects dominate, and up-valley flows are established in the daytime. During nighttime, light wind and stable conditions exist, winds in the valley reverse, and valley flows become established as dense cold air drains. During stable nighttime conditions, the valley may act as a large tank, effectively trapping constituents within its walls. Conditions at the ALQ 2R, Bernalillo, and Socorro stations are influenced by the Rio Grande Valley.

Figure 4-12. Generalized Flow Within a Valley

Obstruction Effects - A dividing streamline is established as wind approaches a hillside. Air below the height of the dividing streamline flows around the hillsides; air above flows over the hill. Where the dividing streamline intersects the hill, a flow stagnation point occurs. The height of the dividing streamline is a function of the hill height and shape, the wind speed, the ambient temperature, and the temperature lapse rate. A turbulent downwash occurs in the wake of the hill, where dispersion is generally enhanced. Conditions at the Los Alamos and ALQ 2ZF stations are influenced by the surrounding mountains and hillsides.

Figure 4-13 shows the flow pattern around an obstruction. As the flow approaches an obstruction, air is first displaced upward; then layers nearest the obstruction become caught in the cavity zone, with its high turbulence and recirculating flow pattern. Conditions at the ALQ 2ZN station may be influenced by flow obstructions.

Figure 4-13. Illustration of Building-Induced Downwash Flow

Emissions into the cavity zone become rapidly mixed and remain trapped, creating high concentrations within the zone. Above the aerodynamic cavity zone is the wake zone, where dispersion is characterized by increased turbulence without recirculation. A plume emitted into either one has a rapid trajectory toward the surface. To escape the downwash influences of a flow obstacle, a plume should be emitted or should rise (from momentum) to at least the obstacle height plus 1.5 times its height or width, whichever measurement is less. This is known as the good engineering practice (GEP) stack height.

Heat Island Effects - Urban areas tend to be warmer than rural regions nearby because city pavement and roofs heat more rapidly than vegetated land surface. Cities also stay warmer at night because of stored heat energy. This creates a heat island effect, with warm air rising over the city and cool air sinking over the nearby rural regions. The presence of structures and this enhanced buoyant motion tend to increase dispersion rates over cities or large industrial complexes.

Mixed Layer - Most emissions are discharged into the mixed layer, and it is this layer for which dispersion modeling is generally performed. The mixed layer is dominated by the characteristics of the underlying surface and responds to surface temperature and frictional influences. The mixed layer depth can range from less than 100 meters on a calm, clear night with rapid surface cooling (trapping constituents near the surface) to several thousand meters on a sunny day, when surface heating leads to vertical convection throughout the lower troposphere.

The continual turbulence of the mixed layer is a primary mechanism that causes dispersal. Within the mixed layer, two processes drive turbulent mixing: frictionally induced turbulence and buoyancy-induced turbulence. Roughness (houses, trees, and grasses) interrupts smooth wind flow and creates frictionally induced turbulence. The intensity of this turbulence is a direct function of size (of the rough element) and of wind speed. Frictional influences dominate turbulent mixing near the surface, but decrease rapidly away from the surface. Above the surface, buoyancy-induced turbulence dominates mixing processes. Solar heating of the surface causes the air at the surface to be warm and less dense than the air aloft. The surface air rises, replaced by cooler air from aloft. Buoyancy-induced turbulence, at a maximum on low-wind days with strong sunshine, causes deep mixing throughout the mixed layer. Buoyancy-induced turbulence decreases rapidly after sunset, because cooling at the surface produces a stable layer.

The mixed layer is generally capped by an elevated inversion (i.e., a layer in which the temperature increases with height). The altitude of this capping inversion (the mixing height) limits the vertical depth of turbulent diffusion. In the day, the sun heats the surface and the air layer nearest the surface becomes unstable. During the evening, radiation cools the surface, and the atmosphere at the surface cools. The stable layer depth increases from the surface upward and an inversion (particularly on clear, calm nights) replaces the mixed layer, leaving a stably stratified layer. Generally, the mixed layer height rises and falls in a daily cycle (highest in the early afternoon and lowest before sunrise). The emission dispersal rate in the atmosphere depends on the:

- Intensity of the ambient turbulence
- Wind velocity
- Source position relative to flow obstacles
- Dilutions attributable to the source

The most important factor leading to plume spread in the atmosphere is the amount of ambient turbulence. Average seasonal mixing heights (in meters) for Albuquerque appear in Table 4-11.

Table 4-11. Climatological Mixing Heights for Albuquerque by Season

Period	Winter*	Spring*	Summer*	Fall*	Average Annual Mixing Height*
Morning	400	550	600	400	500
Afternoon	1,450	3,450	3,950	2,300	2,750
*Mixing heights are measured in meters.					

Turbulent Mixing - Figure 4-14 shows turbulent dispersion effects on a plume. In a stable atmosphere, the horizontal and vertical turbulence is limited. The plume remains near its emission height and mixes minimally, usually during the nighttime and early morning hours. If the layer below the plume height becomes neutral or unstable, the plume mixes rapidly to the surface (a fumigation condition) and can cause high ground-level impacts. This condition occurs for short durations in the early morning. As surface heating persists, an unstable mixing layer develops, and the plume loops up and down in response to large-scale convective eddies. A neutrally stable atmosphere yields moderate turbulence and results in a cone-shaped plume. If an inversion occurs below the emission height, a lofting condition exists, and the plume is cut off from ground-level impacts.

A rising pollutant plume reacts with the environment in several ways before it levels off. First, the plume's own turbulence interacts with atmospheric turbulence to entrain ambient air. This mixing process reduces and eventually eliminates the density and momentum differences that cause the plume to rise. Second, the wind transports the plume during its rise and entrainment process. Higher winds mix the plume more rapidly, resulting in a lower final rise. Third, the plume interacts with the vertical temperature stratification of the atmosphere, rising as a result of buoyancy in the unstable-to-neutrally stratified mixed layer. However, after the plume encounters the mixing lid and the stably stratified air above, its vertical motion is dampened.

A plume with sufficient energy will penetrate the inversion layer above the mixing lid, perhaps even overshooting its final rise, and then sink to a relatively constant height. In this situation, some emissions will remain in the mixed layer and undergo turbulent dispersion. However, the plume portion above the mixing height is effectively cut off from the mixed layer. A plume without sufficient buoyancy will not penetrate the mixing lid, but remain in the mixed layer and be dispersed by ambient turbulence. In unstable conditions, with deep convection throughout the mixed layer, the plume's center of mass loops up and down in response to large-scale convective turbulence, and the equilibrium plume height becomes very difficult to define.

Figure 4-14. Effect of Turbulent Dispersion on a Plume

Terrain often increases turbulence but sometimes leads to stagnation and low mixing, particularly in valleys. Plume trajectories near terrain obstacles are modeled as a function of atmospheric stability. In unstable and neutral conditions, the terrain deflects the plume centerline trajectory upward. The plume height remains above the terrain by at least one-half of the original predicted plume height. In stable conditions, the plume centerline does not deflect, but approaches within 10 meters above the terrain. In modeling, this assumption predicts high concentrations on elevated terrain features. A dividing streamline height is used to characterize air flow near terrain obstacles under stable conditions.

Circulation Phenomena - The factors described above all interact to create the circulation that occurs within the Albuquerque Basin. The circulation is made up of the drainage flow, return flow, and stagnation, which are all affected by the mountains. The canyons create a second flow that is described below.

A simple explanation of the pollution meteorology in the winter is that cold, heavier air settles in the valley, while warm winds blow from the southwest over the top of the pool of cold air. The strong temperature inversion caused by the contrast between warm air aloft and cold air near the surface traps pollutants near the surface. Figure 4-15 shows pollutants stagnation, but stagnation is not the only physical phenomenon associated with pollutants accumulation.

Figure 4-15. Illustration of Pollutant Stagnation

Drainage Flow - Cold air drains through Albuquerque from the Sandia and Manzano Mountains, primarily during clear nights, carrying pollutants westward into the valley. Figure 4-16 illustrates the cold air drainage condition. These air flow currents are 200 meters to 400 meters deep, moving from two to five miles per second downslope. These drainage flows slowly spread and merge within the Rio Grande Valley. These flows can traverse more than 100 kilometers downvalley, and transport pollutants throughout the basin.

Figure 4-16. Cold Air Drainage Representation

There is normally little vertical mixing because a strong inversion forms at a level of about 200 meters. Drainage winds continue to carry emissions from surface sources (e.g., mobile vehicles) toward the valley. These winds usually begin in the evening and continue through early morning. Ground-level emissions accumulate to a peak just after sunrise. Data from the ALQ 2ZK station shows this nighttime drainage flow, and an upslope, return flow during the daytime.

Return Flow - Return flow brings air from downvalley back to the foothills (Figure 4-17). If return flow follows the drainage flows, then pollutants transferred downvalley return upslope, possibly to the emission sources.

Return flow often occurs during summertime and daytime. Heating of the mountain slopes and the subsequent upward motion of the air account for this up-valley flow. In winter, snow cover and the lower sun angle limit the intensity and frequency of return flow. However, return flow can still occur in winter, generally resulting from the passage of large-scale weather systems.

Pollutants often mix together rapidly during the return flow. The temperature inversion is weakened, and winds become stronger as surface heating destroys the inversion. Surface pollutants are often lifted, resulting in elevated pollutant layers. This lifting mechanism keeps the pollutants in the layer relatively intact, while turbulent mixing disperses and dilutes ground-based pollutants.

Figure 4-17. Illustration of Outflow/Stagnation/Return Flow Cycle

Stagnation Periods - Stagnation periods, with light and variable winds, usually occur following up-valley flow. Large-scale pressure gradient forces cause the cold air layer accumulated in the valley to move uphill toward the mountains. As this denser air mass follows the slope, an internal pressure force develops and begins to counteract the external one. The air mass slows down as it approaches the mountains, and stagnation follows. The Los Lunas station experiences frequent light and variable winds, which develop into long stagnation periods.

When the forces involved are fairly weak, the period of calm air may last many hours before formation of the return flow. Light winds, small wind shear, and stronger temperature inversion inhibit vertical mixing during the stagnation period.

Canyon Flows - Strong, easterly flows blowing from the eastern plains and through the canyons can cause a rapid cleaning of the Albuquerque Basin. Synoptic conditions (high pressure northeast of New Mexico) and microscale conditions (thunderstorms east of the mountains) cause these winds. Light, canyon winds may enhance pollution levels because of the contrast between the warmer easterlies aloft, and the cool, shallow, up-valley nighttime winds. Conditions at the ALQ 2ZF station are influenced by Juan Tabo Canyon, just to the north. More than 16% of the annual winds blow from the north. The station also experiences down-slope flows during night and winter that are attributable to Sandia Crest to the east.

3.3.3 Local Transport

Information in “3.3.1 Overview of Physical Phenomena” identified the factors that determine or influence the wind characteristics at each monitoring station. Wind characteristics vary across SNL/NM as a result of topographical and urban features. The predominant influence on local transport at SNL/NM is topography. The mountains and canyons to the east create the predominant wind directions at SNL/NM.

Canyons tend to channel drainage or return flows. Two canyons have the heaviest influence on circulation at SNL/NM. Tijeras Canyon affects the northern areas, Tech Area I, Tech Area II, and the CL1 tower down toward the KU1 tower. Lurance Canyon affects circulations near Tech Area III; Tech Area V, and remote and southern locations. At times, the Rio Grande Valley flow influences transport across SNL/NM.

Diurnal Variations - Winds at SNL/NM tend to blow down from the mountains toward the Rio Grande Valley at night, as shown in the frequency distributions for nighttime wind in Figure 4-18. Night is defined as 7 p.m. through 7 a.m.; at most locations, the winds blow from a 60° sector direction over 40% of the time at night. The exceptions to this trend are conditions at towers CL1 and KU1. CL1 is near Tijeras Arroyo, which affects the cold air drainage pattern, with a predominant drainage into the arroyo from the north. Tijeras and Lurance Canyons influence the pattern near tower KU1. For the three-year climatology, Lurance Canyon is the primary influence as shown by the higher percent frequency from the southeast and south-southeast. Tijeras Canyon affects the flow at times as evident from the east-northeast frequency.

Because the nighttime flows are cold air drainages that sink into the canyons and lower terrain, the canyons have a pronounced channeling effect on the cold air. As cold air leaves a canyon, it will spread and fan out onto more level terrain. Lurance Canyon has this effect on conditions at towers SC1 and A36 (Figure 4-18). Predominant winds at SC1 are from the northeast and east-northeast, but as the cold air fans out, tower A36 picks up southeast winds. The cold air fanning from Tijeras Canyon is evident at towers A15 and A21. Cold air drainage winds can be very shallow, with the depth occasionally between 50 and 100 meters, an important concept in pollutants dispersion.

Figure 4-19 shows that winds blow generally toward the mountains during the day. Daytime is defined as 7 a.m. through 7 p.m. There is a Rio Grande Valley flow influence to the local transport at SNL/NM. Figure 4-19 also shows a larger south-southwest pattern to the daytime flow. Some predominant wind directions during daytime result from the topographic forcing of air into a canyon as shown by conditions recorded at A15 (west) and SC1 (southwest). The predominant wind direction at all other sites is from the south-southwest.

Winds from the south-southwest and the southwest are influenced by the Rio Grande Valley flow. The farther away from other topographic influences (mountains and arroyos), the greater the influence of the valley flow, producing south-southwest and southwest winds during the day. This flow pattern is evident at towers CW1, KU1, A21, and A36. Data collected at tower CL1 shows valley flow influences. However, Tijeras Arroyo produces a strong secondary frequency component. Daytime winds are also stronger than nocturnal winds at SNL/NM, with fewer calm periods. Exceptions to this trend occur when intense synoptic systems pass through, producing strong winds at night and transient features (short periods of strong nocturnal winds).

Seasonal Trends - Although the predominant influence on wind patterns at SNL/NM is topography, wind patterns do change during seasons with stronger synoptic weather systems. The predominant direction occurring at most locations does not change, but the frequency the wind blows from a certain direction does change seasonally. The two most notable changes occur during the spring and fall. The seasons are defined as follows:

- Winter (January through March [JFM in Table 4-12])
- Spring (April through June [AMJ in Table 4-12])
- Summer (July through September [JAS in Table 4-12])
- Fall (October through December [OND in Table 4-12])

Table 4-12 summarizes seasonal variation data taken at three meteorological towers at SNL/NM. Attachment 4-3 contains more detailed site data on wind direction, frequency, and speed. From April through June, dry humidity and windy conditions prevail. (Strong winds can start in March but, due to the cooler temperatures, the humidity is not as low.) Spring seasonal wind directions show a marked increase in winds from the west sector when compared to other seasons.

Table 4-12. Seasonal Wind Frequency Distributions for the A15, CW1, and KU1 Towers

CW1*					A15*					KU1*				
WD	JFM	AMJ	JAS	OND		JFM	AMJ	JAS	OND		JFM	AMJ	JAS	OND
N	0.052	0.036	0.040	0.059	N	0.061	0.040	0.047	0.060	N	0.070	0.050	0.055	0.072
NNE	0.043	0.030	0.033	0.045	NNE	0.028	0.030	0.040	0.042	NNE	0.042	0.033	0.042	0.051
NE	0.040	0.030	0.039	0.045	NE	0.042	0.043	0.062	0.067	NE	0.045	0.038	0.047	0.053
ENE	0.107	0.098	0.126	0.117	ENE	0.097	0.080	0.105	0.125	ENE	0.060	0.054	0.069	0.062
E	0.096	0.087	0.121	0.113	E	0.117	0.121	0.164	0.100	E	0.060	0.060	0.089	0.054
ESE	0.079	0.075	0.091	0.086	ESE	0.039	0.035	0.050	0.045	ESE	0.040	0.050	0.080	0.052
SE	0.063	0.068	0.071	0.064	SE	0.034	0.036	0.044	0.031	SE	0.077	0.075	0.082	0.080
SSE	0.047	0.046	0.047	0.045	SSE	0.053	0.047	0.045	0.039	SSE	0.087	0.076	0.071	0.082
S	0.054	0.066	0.055	0.045	S	0.067	0.065	0.048	0.063	S	0.069	0.078	0.062	0.073
SSW	0.073	0.084	0.073	0.075	SSW	0.058	0.064	0.055	0.062	SSW	0.081	0.094	0.082	0.085
SW	0.070	0.079	0.074	0.060	SW	0.047	0.060	0.049	0.044	SW	0.067	0.076	0.067	0.056
WSW	0.058	0.070	0.056	0.045	WSW	0.065	0.088	0.050	0.043	WSW	0.062	0.072	0.053	0.045
W	0.059	0.082	0.046	0.044	W	0.069	0.100	0.060	0.055	W	0.060	0.079	0.049	0.046
WNW	0.043	0.052	0.039	0.039	WNW	0.061	0.067	0.061	0.058	WNW	0.046	0.056	0.045	0.048
NW	0.052	0.047	0.041	0.049	NW	0.076	0.068	0.064	0.077	NW	0.057	0.052	0.051	0.056
NNW	0.063	0.049	0.047	0.069	NNW	0.086	0.054	0.056	0.090	NNW	0.075	0.057	0.057	0.084

*Directions in bold are the predominant wind directions.
WD = wind direction, the direction from which the wind is blowing.
JFM = January through March
AMJ = April through June
JAS = July through September
OND = October through December

During winter and fall, a different pattern occurs as synoptic systems bring more weather from the north, i.e., winds from the north and north-northwest increase. Again, some flow is channeled by topography that reduces or enhances the frequency distribution. July through September weather does not vary greatly from the climatological average. Pressure gradients are generally much weaker, allowing topographic effects to dominate wind patterns.

3.4 Meteorological Data Processing for Modeling Input

SNL/NM maintains several meteorological towers and monitoring stations. Tower locations and SNL/NM climatology are described in “3.2.2 Site-Specific Meteorology and Climatology.” The towers meet U.S. Environmental Protection (EPA) specifications for siting, equipment, and the processing of raw data. The following subsections explain the procedures and methods used to create meteorological data files for input to dispersion models. Meteorological monitoring stations provide various information including:

- Wind speed (in meters per second)
- Wind direction (converted to flow vector in degrees for the data set)
- Ambient temperature (in degrees Celsius [°C]) (converted to Kelvin [K] for the data set)
- Sigma theta (δ_θ) or standard deviation of the horizontal wind direction (in degrees), which was used to compute atmospheric stability

The tower at Tech Area I, located about three miles east of the National Weather Service (NWS) station at the Albuquerque International Sunport, records data that is more representative of onsite ambient conditions. Therefore, onsite data was processed for use in dispersion models. SNL/NM emission sources range from ground level to 25 meters; onsite stations have the capability to collect meteorological data within this vertical range.

3.4.1 Overview of Technical Approach

Data was processed from eight meteorological towers for calendar year 1996 (CY1996). These eight monitoring sites encompass all SNL/NM tech areas. Most sites collect data at heights of three and 10 meters. Tower A15 also collects measurements at 50 meters, and tower A36 collects measurements at 60 meters. Given the height range of the emission sources, data was processed from the 10-meter towers and from both levels of the multilevel towers.

Although meteorological data exists for multiple years, only one year of meteorological data was collected and analyzed in support of the SWEIS. A single year of meteorological data is preferred when modeling actual emission rates, and has been recommended by EPA in lieu of a five-year data set. In addition, the data quality for multiple years is not as reliable as the 1996 data set.

The meteorological monitoring stations are located within three general topographic regions: a mountain and canyon region, a valley-influenced region, and an intermediate region. Several stations are also influenced by areas of buildings or structures. All stations are considered to be located in rural environments. The data from the eight stations reflects two distinct wind patterns, influenced to various degrees by Tijeras and Lurance Canyons. Most sites are influenced by nocturnal canyon drainage flows (synoptically enhanced at times).

Hourly, sequential meteorological data was processed according to the U.S. Environmental Protection Agency's (EPA's) *Onsite Meteorological Program Guidance for Regulatory Modeling Applications* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 1987). Information extracted from this guide is cited in each procedure discussion. The algorithms shown were coded using FORTRAN-77 programming language. The measurement data was input to the programmed routines to obtain the processed parameters. Data was processed in a format suitable to the Industrial Source Complex-3 (ISC3) air quality dispersion model.

3.4.2 Processing Procedure

The meteorological data required by the Industrial Source Complex-3 (ISC3) dispersion model includes hourly, sequential values of wind speed, flow vector (direction toward which the wind is blowing), ambient temperature, atmospheric stability, and mixing height. To process onsite meteorological data, the following general steps were conducted (each step is discussed in more detail in the remainder of this section):

1. Computation of 1-hour averages from 15-minute data.
2. Substitution of missing data.
3. Identification of calm wind speed hours.
4. Calculation of atmospheric stability.
5. Determination of the mixing height.
6. Calculation of site-specific wind profile exponents.
7. Summarization of the complete meteorological data sets.

1-Hour Averages - This analysis was based on the procedures in Section 6.1.2 of *On-Site Meteorological Program Guidance for Regulatory Modeling Applications* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards,

1987). All parameters are reported as 15-minute averages. At least 75% of the data capture (three of four 15-minute values) was required for a valid 1-hour average. The wind speed and wind direction are reported as scalar values. The 15-minute wind speed averages were computed into an hourly average as follows:

$$WS = 1/N \sum S_i \text{ for } i = 1, N$$

Wind direction is a circular function with values between 1° and 360°. The wind direction discontinuity at the beginning and end of the scale requires some special processing to compute the mean value. Hourly wind direction was generated from the raw 15-minute data using the single-pass technique of Mitsuta. This method is best when the difference between consecutive 15-minute values is less than 180°. Using the Mitsuta method, the scalar mean wind direction is computed as:

$$WD = 1/N \sum D_i \text{ for } i = 1, N$$

where $D_i = WD_i$ for $i=1$

and $D_i = D_{i-1} + d_i + 360$; for $d_i < -180$ and $i > 1$
 $D_i = D_{i-1} + d_i$; for $d_i < 180$ and $i > 1$
 $D_i = D_{i-1} + d_i - 360$; for $d_i > 180$ and $i > 1$

D_i is undefined for $d_i = 180$ and $i > 1$

$d_i = WD_i - D_{i-1}$; for $i > 1$

WD_i the azimuth angle of the wind vane for the i th sample.

The average hourly deviation of the wind direction (sigma theta) was required to determine atmospheric stability. To minimize the effects of wind direction meander, a common occurrence under stable, light wind conditions, the four 15-minute values of sigma theta were averaged as follows:

$$\delta_\theta (1\text{-hour}) = [(\delta_{\theta 15}^2 + \delta_{\theta 30}^2 + \delta_{\theta 45}^2 + \delta_{\theta 60}^2)/4]^{1/2}$$

The hourly, average temperature was derived from the 15-minute averages as follows:

$$T = 1/N \sum T_i, \text{ for } i = 1, N$$

Missing Data - This analysis was based on the procedures within Sections 5.3 and 6.5.3 of *On-Site Meteorological Program Guidance for Regulatory Modeling Applications* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and

Standards, 1987). The initial procedure was to assess data capture and to fill in any missing data, if possible. All data capture was above 90%, as required by the U.S. Environmental Protection Agency (EPA) guidelines. The 90% requirement applies on a monthly basis such that 12 consecutive months with 90% recovery are required. The requirement also applies to each individual parameter and to the joint frequency of wind direction, wind speed, and stability. The data capture meets all these requirements. A single hour is considered valid if at least 75% of the 15-minute averages are available.

Periods of one or two consecutive hours of a missing parameter were replaced by linear interpolation. There were several periods of large blocks of missing data, and these periods were left as missing. The missing program (MSGPRO) control option must be set to perform Industrial Source Complex-3 (ISC3) dispersion modeling with the data sets produced because there will still be some missing data after processing. Predicted concentration during missing hours will be set to zero by the ISC3 model per EPA guidance. Missing data was not replaced by data from another monitoring station because the other stations were considered to be unrepresentative.

Calm Wind Speeds - This analysis was based on the procedures within Section 6.5.2 of the *On-Site Meteorological Program Guidance for Regulatory Modeling Applications* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 1987). Identification of calm hours for modeling purposes was done considering the characteristics of the meteorological instrumentation. Winds were considered calm if the reported speeds were less than the instrument starting threshold (e.g., 0.5 meters per second). Wind speeds during calm hours are set to 0.0 meters per second. The Industrial Source Complex-3 (ISC3) model does not calculate an impact concentration for hours with a wind speed of 0.0 meters per second. For any hour in which the wind speed was between the sensor starting threshold and one meter per second, the wind speed was set to one meter per second. These procedures are consistent with U.S. Environmental Protection Agency (EPA) guidelines.

Atmospheric Stability - A turbulence-based method was used for determining atmospheric stability. This method was based on the procedures outlined in Section 6.4.4.4 of the *On-Site Meteorological Program Guidance for Regulatory Modeling Applications* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 1987). Sigma theta and wind speed measurements from the 10-meter level were used as the stability classification technique. Classification was based on U.S. Environmental Protection Agency (EPA) guidelines, including day, night, and wind speed correction factors. Site-specific roughness lengths (Z_0) were used, based on the physical characteristics of the vicinity of each station. A value of 40 centimeters was used for towers A15, A21, and SC1, and a value of 30 centimeters was used for all other towers. The default roughness length value of 15

centimeters was used for the National Weather Service (NWS) station. Towers A15, A21, and SC1 are in areas with greater obstructions (buildings and vegetation); thus, the roughness lengths for those tower sites were set slightly higher than the other tower sites.

The EPA guidelines suggest the following Z_0 values for various land use types:

- Desert shrub land (0.30 meter)
- Grassland (0.10 meter)
- Coniferous forest (1.30 meters)
- Urban (1.00 meter)

In accordance with EPA guidelines, hourly stability classes were smoothed so that the stability did not change by more than one category from one hour to the next. For comparison only, atmospheric stability determinations for the NWS station were made using the Turner method, which is based on wind speed, ambient temperature, and cloud cover observations (*On-Site Meteorological Program Guidance for Regulatory Modeling Applications* [U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, 1987]).

All data sets are dominated by neutral conditions and have normal (bell-curve) distributions of stable and unstable conditions. The NWS station is represented with a much greater occurrence of very stable conditions (low-wind speeds and clear skies at night). The NWS station has a greater frequency of low-wind speeds during the nighttime.

Mixing Height - This analysis was based on the procedures within Section 2.8 of the *On-Site Meteorological Program Guidance for Regulatory Modeling Applications* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 1987). The depth of the mixed layer, or mixing height, is an important variable in U.S. Environmental Protection Agency (EPA) dispersion models. The mixing height determines the vertical extent of the dispersion process for releases below the mixing height, while releases above the mixing height are assumed to have no ground-level impacts.

Mixing heights are determined using the surface observations and twice-daily upper air soundings from the Albuquerque International Sunport (soundings at 1200 and 0000 Greenwich Mean Time [GMT]). Processed, twice-daily mixing heights were obtained from the National Climatic Data Center (NCDC). These mixing heights are determined based on the sounding data and surface maximum temperature for the National Weather Service (NWS) station.

The processing of hourly mixing heights requires: (1) morning and afternoon estimates of mixing heights, (2) the local standard time sunrise and sunset, and (3) hourly estimates of atmospheric stability. The times of sunrise and sunset are calculated based on the date, latitude, longitude, and time zone, using known earth-sun relationships.

Estimates for morning and afternoon mixing heights are based on Holzworth's method, which interpolates mixing heights using the afternoon mixing heights from the preceeding day and the morning and afternoon mixing heights from the following day (Holzworth, 1972). Nocturnal inversions generally form at approximately sunset and dissipate about one to two hours after sunrise.

Wind Profile Exponents - The wind speed usually varies logarithmically with height from the surface. The nature of this profile determines the dispersion of pollutants. Power-law exponents for the wind profile are a function of stability, surface roughness, and the height range over which they are determined. Therefore, wind profile exponents are determined using two or more levels of onsite wind measurements and categorized by stability. Wind profile exponents typically vary from about 0.1 on a sunny afternoon to about 0.6 during a cloudless night. The larger the exponent, the larger the vertical gradient in the wind speed.

Table 4-13 shows the default wind profile exponents used in regulatory models for urban and rural locations. The table also displays calculated profiles from the two multilevel towers at SNL/NM (A15 and A36). These onsite wind profile exponents are input into the Industrial Source Complex-3 (ISC3) dispersion model to replace the default values.

Table 4-13. SNL/NM Wind Profile Exponents

Stability Class	Urban Default	Rural Default	A15 Calculated	A36 Calculated
A	0.15	0.07	0.096	0.026
B	0.15	0.07	0.159	0.050
C	0.20	0.10	0.208	0.064
D	0.25	0.15	0.296	0.158
E	0.30	0.35	0.390	0.129
F	0.30	0.55	0.438	0.183

Data collected at tower A15, closer to the most populous part of SNL/NM, shows microscale urbanization effects not recorded at the rest of the meteorological stations. Data from the multilevel tower at A36, located in open space, shows rural wind profile exponents.

Summary of the Meteorological Model Data Files - A total of eight meteorological input files for the Industrial Source Complex-3 (ISC3) model were produced. Table 4-14 shows the format and parameters within the meteorological data sets.

Table 4-14. Description of the Meteorological Data Sets

Parameter	Format
Year (last two digits)	I2
Month	I2
Day	I2
Hour	I2
Flow vector (degrees)	F9.4
Windspeed (meters per second)	F9.4
Ambient temperature (Kelvin)	F6.1
Stability class (A=1, B=2, ..., F=6)	I2
Rural mixing height (meters)	F7.1
Urban mixing height (meters)	F7.1

4.0 CURRENT AIR QUALITY

4.1 Criteria Pollutant Emissions

This section identifies all facilities at SNL/NM that emit criteria pollutants. Criteria pollutant emissions, data collection, modeling, and associated methodology are discussed. Results for ambient air sampling of the Albuquerque Basin for these emissions are also presented.

4.1.1 Overview

Table 4-15 summarizes the most significant sources of criteria pollutants at SNL/NM in 1996. Figures 4-20 through 4-24 show the building locations of the sources of criteria, hazardous, and radionuclide air pollutants.

Table 4-15. Emission Sources of Criteria Pollutants at SNL/NM

Source	CO*	NO _x *	SO ₂ *	PM ₁₀ *	VOC*
Steam Plant boilers	14.20	153.00	0.22	2.93	N/A
Building 862 generators	0.23	0.90	0.06	0.01	N/A
Fire testing facilities	0.78	0.02	0.04	0.71	N/A
Chemical usage	N/A	N/A	N/A	N/A	~4.01
*Tons per year CO = carbon monoxide NO _x = nitrogen oxides SO ₂ = sulfur dioxide PM ₁₀ = particulate matter less than 10 microns in diameter VOC = volatile organic compound N/A = not applicable					

4.1.2 Steam Plant

The Steam Plant produces steam heat for buildings in Tech Area I and the east portion of Kirtland Air Force Base (KAFB). During 1996, all five boilers at the plant operated and consumed a total of 0.74 billion (740,000,000) standard cubic feet of natural gas. These boilers can also be run on diesel oil; they consumed approximately 15,000 gallons of oil during 1996.

SNL/NM has recently started tracking fuel throughput for the Steam Plant boilers in anticipation of meeting future Title V operating permit compliance with self-imposed fuel caps. SNL/NM has proposed an annual fuel throughput limit in the operating permit application. The proposed annual fuel limit corresponds to 4,380 hours of operation firing natural gas. The proposed annual fuel limit for the boilers is 2.76 billion (2,760,000,000) standard cubic feet for natural gas and 2.6 million (2,600,000) gallons for diesel.

Emissions from boilers include carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and particulate matter less than 10 microns in diameter (PM₁₀). Volatile organic compound (VOC) emissions are negligible. Emissions from SNL/NM boilers were calculated using U.S. Environmental Protection Agency (EPA)-approved emission factors and calculations as provided in AP-42, *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 1995). Emissions were calculated using the diesel and natural gas fuel throughput. Emission factors used in the calculations were taken from Sections 1.3 and 1.4 of AP-42. Table 4-15 lists emissions associated with the boilers for 1996.

Figure 4-20. Tech Area I Sources

Figure 4-21. Northeast Section Tech Area III Sources

Figure 4-22. Tech Area IV Sources

Figure 4-23. Tech Area V Sources

Figure 4-24. Lurance Canyon Burn Site Sources

4.1.3 Electrical Power Generator Plant

SNL/NM operates four standby generators, each with a 600-kilowatt capacity. The generators are diesel-fired and located in Building 862, Tech Area I. A local air quality permit limits operation to 500 hours per year per generator. These generators are started up monthly for maintenance and testing, and during electrical power outages in Tech Area I.

In anticipation of Title V operating permit fuel caps, SNL/NM has proposed a fuel usage cap based on 500 hours per year per generator operation that will be totaled and include all other generators located on site. During 1996, the generators used 4,194 gallons of diesel fuel. The proposed annual fuel limit for the generators is 80,500 gallons of diesel fuel.

Emissions from the generators include carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and particulate matter less than 10 microns in diameter (PM₁₀). Volatile organic compound (VOC) emissions are negligible. Emissions from the SNL/NM generators were calculated using U.S. Environmental Protection Agency (EPA)-approved emission factors and calculations as provided in AP-42, *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 1995). Emissions were calculated using the diesel fuel throughput. Emission factors used in the calculations were taken from Sections 3.3 and 3.4 of AP-42. Table 4-15 presents emissions associated with the emergency generators for 1996.

4.1.4 Fire Testing Facilities

The fire testing facilities include several open pools, and the Fire Laboratory for the Accreditation of Model and Experiments (FLAME), and the Small Wind Shielded (SWISH) Facilities. The open pools emit directly to the atmosphere, whereas FLAME and SWISH are closed and emit through exhaust stacks. These facilities are located in Lurance Canyon in the east corner of the withdrawn area of the Kirtland Federal Complex. The facilities use various fuels including jet fuel (JP-8), sawdust, a sawdust-propellant-acetone (SPA) mixture, explosives, and urethane foam.

These facilities support the main research and development goals of the laboratory and are used to subject nuclear weapon mockups, nonnuclear weapon components, and related shipping containers to postulate accident environments as part of SNL/NM's mission to ensure nuclear safety. The facilities are also used to test the response of shipping containers, aerospace components, and other items to high-temperature conditions.

The facilities typically average 42 tests per year, with each test lasting approximately 30 minutes, although some tests can last up to four hours. The proposed operating permit limits are based on fuel throughput. The annual limits are 18 tons for sawdust, six tons for the SPA mixture, 200.1 tons for JP-8, 7.2 tons for urethane foam, and 0.05 tons for explosives. During 1996, the fire testing facilities used 10,400 gallons of JP-8 and 16,050 pounds of sawdust (or wood).

Emissions from the fire testing facilities include carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO₂), and particulate matter less than 10 microns in diameter (PM₁₀). Emission factors for these facilities were developed specifically for the SNL/NM operating permit application. Emissions were calculated by using the fuel throughputs and emission factors. Table 4-15 summarizes the emissions associated with the fire testing facilities for 1996.

4.1.5 Chemical Usage

Because SNL/NM's primary mission is research and development, personnel associated with various laboratories, facilities, and programs purchase and use a wide variety of chemicals. SNL/NM uses the Chemical Information System (CIS) to track chemicals. The CIS contains an extensive material safety data sheet (MSDS) library and an integrated chemical inventory system. Chemicals, or products containing chemicals, ordered by and delivered to SNL/NM are tracked in the CIS. Based on the chemical inventory and MSDS library, SNL/NM calculates the mass of the chemical constituent from the specific gravity and concentration of the chemical in the material purchased.

Emissions from chemical operations are hazardous air pollutants (HAPs) and volatile organic compounds (VOCs). For information on HAP emissions operations, see "4.2 Hazardous Air Pollutants." Table 4-15 lists VOC emissions associated with chemical operations for 1996.

Except in the case of large chemical users (e.g., greater than 2,000 pounds per year), SNL/NM emissions calculations are based on the conservative assumption that 100% of the purchased quantity of the chemical or constituent is emitted. For large users of chemicals, SNL/NM calculates emissions using process knowledge and mass balance methodologies. During 1996, large users of chemicals included the fire testing facilities (purchased jet fuel) and the Microelectronics Development Laboratory (MDL) (purchased large quantities of hydrochloric and hydrofluoric acids). Table 4-15 lists actual 1996 emissions associated with fire testing facilities. Actual VOC emissions for 1996 associated with the MDL are negligible (i.e., less than 0.1 ton per year). Attachment 4-4 provides summary tables of VOC and HAP emissions.

The annual VOC emission limit proposed in the operating permit application is based on the historical VOC emissions associated with the chemical users. These emissions were increased by a factor related to hours of operation (e.g., 2,080 hours vs. 8,760 hours or a factor of 4.21). The proposed operating permit limit for chemical users is 32 tons of VOCs per year.

4.1.6 Input Data for Emissions Modeling

The Industrial Source Complex-3 (ISC3) dispersion model accepts hourly emission data and hourly meteorological data. Fuel-burning devices do not normally run continuously or always at 100% of operating load. Variations in operating load produces differences in the source exit parameters: emission rate, exit gas velocity, and exit temperature. These differences are not usually linearly related to the operating load and should be determined on a source-by-source-basis.

The Steam Plant represents more than 90% of the total emissions of criteria pollutants at SNL/NM. Thus, input data for hourly emissions modeling was only compiled for the Steam Plant. Potential emissions for Building 862 generators and the fire testing facilities should be used as input in any dispersion modeling analysis.

Hourly emission rates, gas exit velocities, and exit temperatures for each of the Steam Plant boilers were determined based on the daily fuel usage and operating load conditions. Fuel usage data was collected and processed for the baseline year of 1996. Figure 4-25 shows the monthly fuel usage for each of the boilers during 1996. Boilers 1, 2, and 3 were used most often during the summer; Boiler 5 was used most during the fall and winter; and Boiler 6 was used most frequently during the winter and spring. Use of No. 2 fuel oil was limited to a few days in December in Boiler 5. Attachment 4-5 contains additional information concerning the fuel usage and data for the determination of the hourly source parameters for the Steam Plant.

Table 4-16 displays the source parameters for the five Steam Plant boilers during a 100% load condition. Gas exit velocities vary between natural gas and No. 2 fuel oil usage.

Boiler Number	Stack Height (Meters)	Stack Diameter (Meters)	Exit Velocity (Meters per Second)	Exit Temperature (°C)	UTM-E (Meters)	UTM-N (Meters)	Base Elevation (Feet)
1	19.8	1.14	13.9 ^a	117.8	358,672	3,879,647	5,405
			12.8 ^b				
2	19.8	1.14	14.4 ^a	134.8	358,680	3,879,647	5,405
			12.9 ^b				
3	19.8	1.14	14.5 ^a	158.8	358,694	3,879,647	5,405
			13.7 ^b				
5	19.8	1.52	13.4 ^a	194.8	358,708	3,879,647	5,405
			12.4 ^b				
6	19.8	1.52	31.5 ^a	281.8	358,718	3,879,639	5,405
			26.9 ^b				

^a During natural gas usage
^b During fuel oil usage
°C = degrees(s) Celsius
UTM-E = Universal Transverse Mercator Easting
UTM-N = Universal Transverse Mercator Northing

Table 4-17. SNL/NM Steam Plant Potential Emission Rates

Boiler Number	PM ₁₀ (TPY)	PM ₁₀ (PPH)	SO ₂ (TPY)	SO ₂ (PPH)	NO _x (TPY)	NO _x (PPH)	CO (TPY)	CO (PPH)
1 (NG)	1.20	2.62	0.0524	0.115	12.2	26.8	3.05	6.69
1 (Oil)	1.23	0.617	19.2	9.62	12.3	6.17	3.08	1.54
2 (NG)	1.20	2.62	0.0524	0.115	12.2	26.8	3.05	6.69
2 (Oil)	1.23	0.617	19.2	9.62	12.3	6.17	3.08	1.54
3 (NG)	1.20	2.62	0.0524	0.115	12.2	26.8	3.05	6.69
3 (Oil)	1.23	0.617	19.2	9.62	12.3	6.17	3.08	1.54
5 (NG)	0.650	1.42	0.0781	28.7	71.5	157	5.20	11.4
5 (Oil)	1.84	0.918	0.171	14.3	18.4	9.18	4.59	2.30
6 (NG)	1.19	2.61	0.143	52.4	131	287	9.52	20.8
6 (Oil)	3.36	1.68	0.313	26.2	33.6	16.8	8.40	4.20

NG = natural gas
 PM₁₀ = particulate matter less than 10 microns in diameter
 SO₂ = sulfur dioxide
 NO_x = nitrogen oxides
 CO = carbon monoxide
 TPY = tons per year
 PPH = pounds per hour

Figure 4-25. Monthly Fuel Usage for the SNL/NM Steam Plant Boilers

Figure 4-26 shows gas exit velocity as a function of operating load for each boiler. The gas exit velocity increases with increasing operating load. Figure 4-27 shows the exit temperature as a function of operating load for each boiler. The exit temperature also increases with increasing operating load. These figures are based on several periods of monitoring data acquired from the Steam Plant during various operating loads, mostly ranging from 20% to 70% of total capacity. The operational data also included information from the boilers such as fuel usage, steam production, and oxygen content to determine boiler efficiency.

Figure 4-26. Relationship Between Exit Velocity and Operating Load for the Steam Plant

Figure 4-27. Relationship Between Exit Temperature and Operating Load for the Steam Plant

Daily steam production and fuel usage data were acquired from the Steam Plant for 1996. Daily operating loads (actual steam production divided by potential) were calculated from this data, and the boilers were assumed to run at that load for the entire day. Variable stack parameters were determined for each 10% of load capacity based on stoichiometric values. Those exit parameters from the nearest 10% of operating load were set for each hour of that day. That is, if the daily operating load was determined to be 27%, then those exit parameters associated with the 30% operating load condition were used to create the hourly dispersion modeling emission file and the emission rate was considered to be 30% of the hourly emission rate (see Table 4-17).

Table 4-18 displays the variable stack parameters for 20%, 50%, and 80% of load capacity. This table provides the variability of gas exit velocity and exit temperature as a function of operating load. These exit parameters were based on fuel efficiencies ranging from 60% to 80%. The efficiency of a steam boiler is defined as the ratio of the heat transferred to the water (steam) to the higher heating value of the fuel.

Table 4-18. Relationship Between Source Parameters and Operating Load for the Steam Plant

Description	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
Operating at 20% of Load					
Exit temperature (°C)	77.8	64.8	46.8	65.8	89.8
Exit velocity (m/s)	2.76	2.66	2.63	2.22	4.23
Operating at 50% of Load					
Exit temperature (°C)	92.8	91.8	88.8	114.8	172.8
Exit velocity (m/s)	6.91	6.89	6.86	6.02	12.8
Operating at 80% of Load					
Exit temperature (°C)	107.8	117.8	130.8	162.8	254.8
Exit velocity (m/s)	11.1	11.3	11.4	10.3	23.8
°C = degree(s) Celsius m/s = meters per second					

The small boilers (Boilers 1, 2, and 3) operate a high percentage of the time at lower loads (and lower efficiency); these boilers are used to supplement the larger steam generators (Boilers 5 and 6) during the winter months and meet all of the relatively small steam demand during the summer months. These results were based on limited operational data and should be used for information purposes only.

Although emissions data from Building 862 generators and from fire testing facilities were also collected, hourly parameters were not determined for these sources. Potential emission rates were assumed for these sources because of their minor contribution to the overall pollutant impact in the region. Tables 4-19 and 4-20 display the source parameters and emission rates

for Building 862 generators, respectively. Open pool burning is conducted at the Lurance Canyon Burn Site with pool dimensions of 20 feet by 20 feet. Tests generally generate temperatures in excess of 900 degrees Celsius ($^{\circ}\text{C}$). Potential emissions are:

- 4.02 tons per year of particulate matter less than 10 microns in diameter (PM_{10})
- 0.21 tons per year of sulfur dioxide (SO_2)
- 4.45 tons per year of carbon monoxide (CO)
- 2.29 tons per year of nitrogen oxides (NO_x)

Table 4-19. Source Parameters for SNL/NM Building 862 Generators

Stack Height (m)	Stack Diameter (m)	Exit Velocity (m/s)	Exit Temperature ($^{\circ}\text{C}$)	UTM-E (m)	UTM-N (m)	Elevation (Feet)
11.9	0.204	85.3	215.8	359,205	3,879,742	5,397
m = meter m/s = meters per second $^{\circ}\text{C}$ = degree(s) Celsius UTM-E = Universal Transverse Mercator Easting UTM-N = Universal Transverse Mercator Northing						

Table 4-20. Potential Emission Rates for SNL/NM Building 862 Generators

Emission Rate	PM_{10}	SO_2	NO_x	CO
Tons per year	1.13	5.00	70.5	18.4
Pounds per hour	(0.282)	(1.25)	(17.6)	(4.61)
PM_{10} = particulate matter less than 10 microns in diameter SO_2 = sulfur dioxide NO_x = nitrogen oxides CO = carbon monoxide				

4.1.7 Modeling Methodology

This section provides a broad overview of the methodology that should be followed in performing a dispersion modeling analysis; a detailed modeling protocol would be required before applying any proposed source for a permit application. The methodology should be used to determine the ability of SNL/NM to add new facilities based on predicted existing and future air quality impacts. This section addresses all the fundamental components of an air dispersion modeling analysis, including:

- Model selection and options
- Receptor spacing and location
- Meteorological data
- Building wake effects
- Correction of ambient standards for temperature and elevation
- Nitrogen oxides (NO_x) to nitrogen dioxide (NO₂) partial conversion

An air quality analysis using dispersion models would be required to demonstrate compliance with ambient air quality standards (AAQS) for criteria pollutants. The dispersion modeling analysis would be conducted in two phases: screening and refined. A screening analysis would be conducted to determine the relative magnitude of impacts associated with emissions. The screening analysis uses simple dispersion modeling tools that employ very conservative assumptions. Results of the screening analysis would be compared with the significance levels. If the screening results do not exceed any of these thresholds, no further dispersion modeling would be required. If any of the thresholds are exceeded, a refined dispersion modeling analysis and averaging periods showing excesses would be required for those pollutants.

Model Selection and Options - The SCREEN3 model (Version 95250) should be used to estimate the impacts on a screening level. The SCREEN3 model incorporates the methodology presented in *Screening Procedures for Estimating the Air Quality Impact of Stationary Sources* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air and Radiation, Office of Air Quality Planning and Standards, 1992), and is a standard screening procedure for regulatory modeling of stationary sources.

The Industrial Source Complex-3 (ISC3) model (Version 96113) should be used to estimate ambient impacts on a refined level. The ISC3 model is an appropriate model for this analysis, based on the:

- Large coverage of simple terrain near SNL/NM.
- Potential need to incorporate building wake effects.
- Need to predict both short- and long-term (annual) average concentrations.

- Model's ability to incorporate impacts from multiple sources and intermediate or complex terrain.

The ISC3 model should be executed using the regulatory default options (stack-tip downwash, buoyancy-induced dispersion, final plume rise), default potential temperature gradients, and no pollutant decay. Exponents for the site-specific wind speed profile should be used based on the information provided in "3.4.2 Processing Procedure."

The INPUFF (Version 2.3) model should be used to predict impacts from open detonation and open burning. The release puffs are assumed to be circular with the highest concentration in the center of the plume. The puff is then transported by the wind, growing in size as it entrains ambient air. The mass of the gas in the cloud does not change as the cloud moves downwind, but its concentration decreases as more ambient air is entrained.

Complex terrain modeling is not required at SNL/NM because SNL/NM is located on the high plains and the Rio Grande River Valley within central New Mexico. The elevation within Kirtland Air Force Base (KAFB) ranges from about 5,300 to 5,800 feet and the terrain gradually rises to 9,000 feet to the east. The elevations of the nearest fence line location and most emission sources are nearly equal (i.e., flat terrain).

The 7.5-minute U.S. Geological Survey (USGS) maps indicate SNL/NM is within a rural area. This rural, three-kilometer area includes the following locations:

- Single family housing on KAFB (west of SNL/NM).
- Areas near the Albuquerque International Sunport (west).
- Santa Fe Railway (south).
- Single family residential area near the state fairgrounds (north).
- Tijeras Canyon (east).

The urban land uses are limited to the sporadic structure clusters within and nearby SNL/NM. Therefore, most areas within three kilometers of any source at SNL/NM should be classified as rural for dispersion modeling analyses.

The SCREEN3 model calculates a one-hour concentration. Maximum concentrations for longer averaging periods should be determined by multiplying the one-hour maximum by the factors

given in the *Permit Modeling Guidelines, Air Pollution Control Division* (Albuquerque Environmental Health Department, 1995). Table 4-21 presents these factors, given as a function of atmospheric stability and averaging period.

Table 4-21. SCREEN3 Model Conversion Factors

Stability	3-Hour	8-Hour	24-Hour	Annual
A (1)	1.00	0.45	0.15	0.08
B (2)	1.00	0.60	0.20	0.08
C (3)	1.00	0.67	0.26	0.08
D (4)	1.00	0.67	0.53	0.08
E (5)	1.00	0.67	0.34	0.08
F (6)	1.00	0.67	0.30	0.08
Source: New Mexico Air Pollution Control Bureau, 1996.				

Receptor Spacing and Location - As a screening technique, the SCREEN3 model assumes that maximum impacts are predicted in any direction from the source. Therefore, receptors are simply expressed in terms of distances downwind of the source. Once a user defines the minimum and maximum distances from the source, the model automatically calculates impacts at distances within that range and can interpolate to find the maximum value and the associated distance. For a screening analysis, the minimum distance to an SNL/NM fence line should be used in the estimation of impacts. A maximum downwind distance of 10 kilometers should be used to ensure that the maximum concentration would be identified. Sensitive receptors such as schools and hospitals should be included at their exact distance from the source. Terrain elevations should be input as the receptor height above the source base.

In a refined analysis, a Cartesian receptor grid should be used. This Cartesian grid is designed to determine the maximum impact location and the extent to which SNL/NM significantly impacts the area. Receptors should be placed at 100-meter intervals along the SNL/NM fence line and out to a distance of 250 meters from the fence line. From 250 meters to a distance of one kilometer, a 250-meter receptor grid spacing should be used. From one kilometer to five kilometers, a 500-meter receptor grid spacing should be used. Any maximum impact occurring beyond the fence line should be refined with a 100-meter interval grid centered on the location of the maximum impact predicted in the model runs. Receptor locations should be input as Universal Transverse Mercator (UTM) coordinates. Terrain elevations should be determined from U.S. Geological Survey (USGS) topographic maps and input for each receptor modeled. In addition to the receptor array, a set of discrete receptors should be placed at sensitive receptor locations including schools, hospitals, and family housing.

Meteorological Data - The SCREEN3 model uses a range of stability classes and wind speeds to identify those meteorological conditions (i.e., combinations of wind speed and stability) resulting in maximum ground-level concentrations. The choice of meteorology recommended

for most applications of SCREEN3, that of full meteorology, should be used in this analysis. This choice utilizes all six stability classes and their associated wind speeds. These meteorological variables, shown in Table 4-22, are incorporated in the model, eliminating the need to input site-specific meteorological data. The ambient temperature should be assumed to be 68 degrees Fahrenheit (°F) (293 Kelvin [K]), the default value used in the SCREEN3 model.

Table 4-22. Screening Meteorology Wind Speed/Stability Array

Pasquill Stability Class	Wind Speed (Meters per Second)
A	1.0, 1.5, 2.0, 2.5, 3.0
B	1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0
C	1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 8.0, 10.0
D	1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 8.0, 10.0, 15.0, 20.0
E	1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0
F	1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0

In a refined analysis, a full year of actual onsite meteorological data should be used. Data should include wind direction, wind speed, temperature, atmospheric stability, and mixing height. Eight onsite locations collect meteorological data; the location that is most representative of the emission source should be determined and evaluated for dispersion modeling analysis. For a description of the processing for this hourly meteorological data, see "3.4 Meteorological Data Processing for Modeling Input."

Building Wake Effects - To comply with 20 NMAC 11.43 (stack height requirements) and determine the potential for building wake effects, a good engineering practice (GEP) stack height evaluation should be conducted. The procedures should be in accordance with those described in *Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations)* (U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards, 1985). Emission stacks subject to building wake effects are prone to elevated concentration impacts.

GEP stack height, as defined by 40 CFR 51, is expressed as:

$$\text{GEP} = H_b + 1.5L$$

where H_b = the building height

and L = the lesser of the building height or maximum projected width (where maximum projected width may be regarded as the greatest horizontal distance covered by the building when viewed from any angle).

This formula defines the stack height at which building wake effects on the stack plume may be considered insignificant. A building or structure is considered sufficiently close to a stack to cause wake effects when the minimum distance between the stack and the building is less than or equal to five times the lesser of the height or projected width of the building (5L). This distance is commonly referred to as the building's "region of influence."

To account for downwash, the SCREEN3 model requires input of a building (structure) height and the corresponding maximum and minimum horizontal dimensions of the building. Building downwash is considered using either the Huber-Snyder or Schulman-Scire downwash assumptions, depending on the height of the stack and the nearby building(s). The most severe form of downwash is associated with stack heights below that defined by the Schulman-Scire assumptions.

The Industrial Source Complex-3 (ISC3) refined model requires input of building heights and projected building widths for 36 wind directions. The U.S. Environmental Protection Agency's (EPA's) Building Profile Input Program (BPIP) should be used to determine the direction-specific building dimensions. Buildings and/or structures located within a distance of 5L from each emission source should be considered. The BPIP determines the direction-specific dimensions based on the coordinates of the corners, height of the building(s), and the coordinates of the emission source.

Correction of Ambient Standards for Temperature and Elevation - Most ambient standards are defined in units of parts per million (ppm) rather than micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). For direct comparison, modeled concentrations should be converted to the same units as the ambient standards. This conversion should be performed using the procedure outlined in *Dispersion Modeling Guidelines* (New Mexico Air Pollution Control Bureau, 1996). Table 4-3 in "2.0 REGULATORY SETTING" displays the ambient air quality standards (AAQS) based on an average summertime temperature of 530 Kelvin (K) and the elevation of SNL/NM (5,405 feet). The following equation displays the conversion from ppm to $\mu\text{g}/\text{m}^3$:

$$\mu\text{g}/\text{m}^3 = [(\text{ppm} \cdot \text{Mw})/T] / 4.553 \cdot 10^{-5} \cdot 10^{(Z \cdot 1.598 \cdot 10^{-5})}$$

where, $\mu\text{g}/\text{m}^3$ = concentration in micrograms per cubic meter

ppm = concentration in parts per million

Mw = molecular weight

T = average summertime temperature in Rankine
(absolute temperature scale)

Z = elevation in feet

Nitrogen Oxides (NO_x) to Nitrogen Dioxide (NO₂) Modeling - A technique to estimate nitrogen dioxide (NO₂) concentrations from nitrogen oxides (NO_x) sources should be employed. The U.S. Environmental Protection Agency (EPA) has approved several techniques to determine the partial conversion of NO_x to NO₂ for averaging periods less than one year. Annual impacts assume total conversion of NO_x to NO₂, and therefore refined calculations are not required. A partial conversion rate of 40%, applicable to 24-hour impacts only, can be used for NO_x to NO₂. Therefore, if the 24-hour NO_x concentration is 200 micrograms per cubic meter (µg/m³), the NO₂ concentration would be 80 µg/m³. This technique should not be used to reduce the NO₂ radius of impact (i.e., the radius of impact should be determined based on the NO_x 5-µg/m³ isopleth). Another method is the Ambient Ratio Method (ARM) based on actual monitored data. Hourly data for NO₂ and NO_x from a nearby monitoring station is used to determine the average daily ratio of the two pollutants. To note, an ambient monitoring station is located onsite and should be used to develop ARM conversion values. To determine the impact of NO₂, the ratio is applied to the maximum-modeled results of NO_x. The EPA guidance to determine ARM is liberal, whereas several studies suggest determining the ratio only based on daytime monitoring data, with NO_x values of at least 20 parts per million (ppm). The suggestion reflects that NO_x conversion is dependent on daylight. The ARM based on the SNL/NM monitoring data yields 63% with unfiltered data (e.g., daylight and nighttime data) and 55% with filtered data (e.g., daylight data only). A third method is the Ozone Limiting Method (OLM). EPA has accepted the OLM method on a case-by-case determination, and the state and local regulatory agencies continue to accept the method. The OLM uses a variation of the Industrial Source Complex-3 (ISC3) dispersion model and, because of the interaction of ozone and NO_x, the method uses monitored NO₂ and ozone concentrations. The nearest ozone monitoring station is located in Rio Rancho, and the preferred NO₂ monitoring station is located south of Albuquerque. The NO₂ monitored data is added to the modeled data as background. EPA requires that concurrent periods of meteorological, ozone, NO₂, and emissions data be used when applying the OLM.

4.1.8 Ambient Sampling

Ambient air sampling at SNL/NM began in 1994. The objectives of the Ambient Air Sampling Program are to qualify and quantify the effects of SNL/NM operations on the environment and to monitor the local air with respect to state and national ambient air quality standards (NAAQS). The Criteria Pollutant Sampling Project, one element of ambient sampling, was developed using instrumentation, processes, and procedures that conform to state and federal standards and guidelines for environmental monitoring. The three main regulations outlining methods and procedures used within the Criteria Pollutant Sampling Project are:

- 40 CFR 50, *National Ambient Air Quality Standards (NAAQS)*

- 40 CFR 53, *Ambient Air Monitoring Reference and Equivalent Methods*
- 40 CFR 58, *Ambient Air Quality Surveillance*

The Ambient Air Sampling Program generally relies on all applicable regulations and guidelines documented by local, state, and federal agencies, including guidelines recommended by DOE.

Sampling Locations - Figure 4-28 shows the ambient air sampling locations at SNL/NM. A Criteria Pollutant Monitoring Station (CPMS) is used to monitor all criteria pollutants, and five additional stations are used to monitor particulate matter less than 10 microns in diameter (PM₁₀) and/or volatile organic compounds (VOCs). The CPMS is:

- Near a busy intersection that includes a traffic light.
- Across from base housing, across the street from Fleet Services where vehicle maintenance is performed.
- Approximately 750 meters away from the Steam Plant.

Based on the above location description and 40 CFR 58, Subpart C, the site would be classified as representative of a microscale and middle scale of air quality surveillance (depending on the particular pollutant).

Data for most pollutants measured at the CPMS will generally be conservative; that is, higher concentrations of pollutants will be monitored at this location than would be monitored at other locations across SNL/NM. Conditions at this station do not represent SNL/NM area-wide average air quality, because station readings are influenced by mobile sources.

Additional sampling stations are located near potential fugitive sources of pollutants or near potential receptors. The monitors are spread across SNL/NM and give a general representation of air quality variance, with respect to PM₁₀ and VOCs, across SNL/NM.

Criteria Pollutant Results for 1996 - Table 4-23 lists the 1996 criteria pollutant monitoring results and the federal and state standards for each pollutant. The federal standards, National Ambient Air Quality Standards (NAAQS), are codified in 40 CFR 51. The New Mexico air quality standards are codified in 20 NMAC 2.03. Both federal and state annual standards may not be exceeded. Short-term standards may be exceeded, generally once, before a violation of the standard must be reported. The preamble of the state regulation (Section 108) allows for excesses over short periods of time due to unusual meteorological conditions. Air quality standards were not exceeded at SNL/NM in 1996.

Table 4-23. Criteria Pollutant Monitoring Results for 1996 and Current Regulatory Standards

Criteria Pollutant	Averaging Time	Unit	NMAAQs Standard	NAAQS Standard	Maximum Concentration	Second Highest Value
CO	1 hour	ppm	13.1	35	8.30	8.00
	8 hours	ppm	8.7	9	2.86	2.80
	Annual	ppm	N/A	N/A	0.78	N/A
NO ₂	24 hours	ppm	0.10	N/A	0.035	0.031
	Annual	ppm	0.05	0.053	0.012	N/A
SO ₂ ^a	3 hours	ppm	N/A	0.50	0.009	0.009
	24 hours	ppm	0.10	0.14	0.003	0.003
	Annual	ppm	0.02	0.03	0.0001	N/A
O ₃	1 hour	ppm	0.12	0.12	0.103	0.099
	Annual	ppm	N/A	N/A	0.033	N/A
PM ₁₀	24 hours	µg/m ³	150	150	49 ^b	36
	Annual	µg/m ³	N/A	50	14.76 ^c	N/A
TSPs	7 days	µg/m ³	110	N/A	NA	N/A
	30 days	µg/m ³	90	N/A	N/A	N/A
Pb	30 days	µg/m ³	N/A	N/A	0.0021	N/A
	Any quarter	µg/m ³	N/A	1.5	0.0010	N/A

^a Standards are defined in micrograms per cubic meter (µg/m³) and converted to parts per million (ppm).
^b Highest 24-hour particulate loading measured at the KUMMSC Pollutant Monitoring Station (KUPM) site in August 1996.
^c Highest annual particulate loading measured at the Criteria Pollutant Monitoring Station (CPMS).
CO = carbon monoxide
NO₂ = nitrogen dioxide
SO₂ = sulfur dioxide
O₃ = ozone
PM₁₀ = particulate matter less than 10 microns in diameter
TSPs = total suspended particulates
Pb = lead
N/A = not applicable

Particulate matter was collected at a total of six locations. The U.S. Environmental Protection Agency (EPA) sampling schedule of one 24-hour sample starting and ending at midnight every sixth day was used to facilitate data comparison with EPA-approved stations.

Table 4-24 shows average quarterly and annual PM₁₀ concentrations for each location (for station locations, see Figure 4-28). This table identifies two details in describing particulate matter at SNL/NM. First, sampling locations closer to the most populated areas of SNL/NM generally reveal higher particulate matter concentrations. A greater anthropogenic component to the particulate matter contributes to higher concentrations at these sampling locations. Second, particulate matter concentrations generally increase during the windy season due to the resuspension of soil particles. This trend of increased concentration during windy periods will be enhanced under dry weather conditions. Analyses of the particulate matter collected at the stations indicate the particulate is generally resuspended soil particles.

Table 4-24. Quarterly and Annual Averages of PM₁₀ at SNL/NM in 1996

Stations	January to March	April to June	July to September	October to December	Annual
CPMS	16.00	16.21	16.0	10.85	14.76
PVPM	11.93	16.29	12.0	11.00	12.8
A2PM	10.40	15.07	11.0	10.36	11.7
KUPM	12.64	14.50	13.0	8.29	12.11
CWPM	7.60	14.36	13.0	7.79	10.69
MWPMM	7.73	13.64	9.3	6.79	9.36
CPMS = Criteria Pollutant Monitoring Station PVPM = Photovoltaic Particulate Monitoring (Station) A2PM = A2PM tower KUPM = KUMMSC Pollutant Monitoring (Station) CWPM = Chemical Waste Landfill Particulate Monitoring (Station) MWPMM = Mixed Waste PM ₁₀ Monitoring (Station)					

4.2 Hazardous Air Pollutants (HAPs)

This section describes sources of hazardous air pollutants (HAPs) at SNL/NM. Hazardous chemical emissions, data collection, modeling, and associated methodology are discussed. Results for ambient air sampling of the Albuquerque Basin for these emissions are also presented.

4.2.1 Overview

Hazardous air pollutants (HAPs) are those compounds listed in Title III of the *Clean Air Act* (CAA). HAPs emissions are regulated by the U.S. Environmental Protection Agency (EPA) and the Albuquerque Environmental Health Department (AEHD).

4.2.2 Hazardous Chemical Emissions

Miscellaneous chemical operations are the significant source of hazardous chemical emissions at SNL/NM. Chemical uses and the corresponding emissions occur throughout SNL/NM in each of the five tech areas and outlying test areas.

SNL/NM estimates hazardous air pollutant (HAP) emissions from chemical operations using the quantities of chemicals purchased. SNL/NM tracks chemical purchases with the Chemical Information System (CIS) and calculates emissions of specific chemicals from the physical properties listed on the various material safety data sheets (MSDSs). Except in the case of large users of chemicals (e.g., greater than 2,000 pounds per year), SNL/NM conservatively assumes that 100% of the purchased quantity of the chemical or constituent is emitted. For large users of chemicals, SNL/NM calculates emissions using process knowledge and mass balance methods.

During 1996, large users of chemicals included the fire testing facilities, which purchased large quantities of jet fuel, and the Microelectronics Development Laboratory (MDL), which purchased large quantities of hydrochloric and hydrofluoric acids. However, actual HAP emissions for 1996 associated with the MDL are negligible (i.e., less than 0.1 ton per year). Attachment 4-4 provides a summary table of HAP emissions by chemical. Total HAP emissions for 1996 associated with chemical users is 4,823 pounds.

SNL/NM proposed an emissions limit on HAPs in the Title V operating permit application. The proposed limit is based on regulatory significance levels for the definition of a major source of HAPs. The permitted emission rate proposed for chemical users is to remain below 25 tons per year for total HAP emissions and 10 tons per year for each individual HAP.

4.2.3 Major Emitter Input

Although SNL/NM is a research and development complex with large variations in both the types of chemicals emitted and the corresponding emission rates, SNL/NM does not track chemical emissions at individual point sources. Instead, SNL/NM uses a sitewide database, the Chemical Information System (CIS), to track chemical purchases and then calculate emissions based on the purchase data. Although this is an extremely conservative methodology for estimating chemical emissions, the large number of sources emitting low, widely variable quantities of HAPs preclude using a point source inventory.

Point source emission data and stack parameters required for modeling low, widely variable quantities of hazardous air pollutants (HAPs) emissions are not readily available. Given the large numbers and complicated operations associated with chemical usage at SNL/NM, the

methodology for developing the information required for modeling is based on the large purchasers of chemicals. Attachment 4-4 presents the SNL/NM buildings with organizations purchasing HAPs totaling 100 pounds or more.

4.2.4 Ambient Sampling Results

Volatile organic compound (VOC) samples were collected at four monitoring stations in 1996 (see Figure 4-28 for sampling locations). These locations were selected for proximity to known VOC emission sources. One 24-hour sample was collected each month at each station. Samples were sent to an offsite laboratory for analysis of 25 VOCs and total non-methane hydrocarbons (TNMHC). Monthly results for detected compounds were averaged and reported as average concentrations in Table 4-25; these concentrations are not annual averages because they are calculated only when the compound is detected. This method prevents dilution of the reported average. Note that the concentrations are in the parts per billion range.

Table 4-25. Results of Volatile Organic Compound (VOC) Analysis in 1996

Compound	Sampling Sites (Parts per Billion by Volume)			
	CPMS	CWL	MWL	Tech Area II
1,1,1-Trichloroethane	0.342	0.155	44.745	0.281
1,4-Dioxane+2,2,4-TMP	0.450	N/A	N/A	0.150
1-Butene	0.244	0.098	0.108	0.247
2,2,4-Trimethylpentane	0.142	0.031	0.030	0.072
3-Methylpentane	0.255	0.030	0.047	0.126
Acetone	6.675	3.262	5.073	5.522
Benzene	0.558	0.098	0.118	0.283
Bromodichloromethane	N/A	N/A	0.032	N/A
Carbon tetrachloride	0.103	0.092	0.119	0.100
Chloromethane	0.457	0.418	0.419	0.456
Dichlorodifluoromethane	0.629	0.546	0.593	0.589
Ethylbenzene	0.137	0.032	0.025	0.051
Halocarbon 113	0.096	0.097	0.090	0.093
Isobutene	0.183	0.216	0.184	0.187
Isobutene + 1-Butene	0.400	N/A	N/A	N/A
Isohexane	0.475	0.086	0.113	0.322
Isopentane	1.842	0.513	0.550	1.456
m/p-Xylene	0.299	0.036	0.041	0.110
Methylene chloride	0.064	0.036	0.047	0.086
n-Butane	1.822	0.417	0.632	1.082
n-Hexane	0.277	0.037	0.080	0.159
n-Pentane	0.832	0.220	0.284	0.464
n-Undecane	0.010	0.011	0.021	0.073
o-Xylene	0.145	0.022	N/A	0.051
Tetrachloroethene	0.042	0.007	N/A	0.029

Table 4-25. Results of Volatile Organic Compound (VOC) Analysis in 1996 (Continued)

Compound	Sampling Sites (Parts per Billion by Volume)			
	CPMS	CWL	MWL	Tech Area II
Toluene	1.039	0.119	0.148	0.479
Trichloroethene	0.018	0.122	N/A	0.032
Trichloroethene+BDC methane	N/A	0.065	N/A	N/A
Trichlorofluoromethane	0.277	0.226	0.235	0.257
TNMHC	39.725	11.538	86.397	14.039
CPMS = Criteria Pollutant Monitoring Station CWL = Classified Waste Landfill MWL = Mixed Waste Landfill TNMHC = total non-methane hydrocarbons N/A = not applicable				

The analytical laboratory refined the equipment used for analyses in 1996, resulting in better speciation of compounds; thus, some compounds appear in the table separately and in combination with other analytes. Aside from the large concentration of 1,1,1-trichloroethane (TCA) and TNMHC at the Mixed Waste Landfill (MWL), slightly higher average concentrations of VOCs are recorded at the Criteria Pollutant Monitoring Station (CPMS).

The high average concentration of TCA at the MWL is the result of exploratory drilling that was performed in May 1995. Since that time, concentrations of TCA increase in the summer and decrease in the winter, remaining above the baseline concentrations taken in 1994. The 1996 TCA concentrations ranged from 174 parts per billion by volume in August to 4.04 in November. At the MWL, the TNMHC is high because it represents all the carbon in the parts per billion by volume sample, including the TCA results.

For these pollutants, there are no regulatory standards for ambient air quality; however, a threshold limit value (TLV) may be used to correlate the ambient air concentrations to a health hazard index. The TLV-time-weighted average (TLV-TWA) for TCA is 350 parts per million (350,000 parts per billion), three orders of magnitude higher than the maximum concentration found at the MWL. The TLV-TWA represents the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek to which nearly all workers may be repeatedly exposed, day after day, without adverse effect. All concentrations shown in Table 4-25 are below health hazard indices. The compounds detected at SNL/NM are generally found in fossil fuels, by-products of the combustion of fossil fuels, and cleaning solvents.

4.3 Radiological Air Pollutants

This section identifies all facilities at SNL/NM that emit radiological air pollutants. Radiological emissions, data collection, modeling, and associated methodology are discussed. Results for ambient air sampling of the Albuquerque Basin for these emissions are also presented.

4.3.1 Radiological Emissions

The *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy (DOE) Facilities* regulation (40 CFR 61, Subpart H) requires all DOE installations that potentially emit radionuclides into the air to evaluate the resulting dose to the public. This regulation requires that radionuclides released to the ambient air do not exceed those amounts that would cause any member of the public to receive an effective dose equivalent (EDE) of 10 millirems per year.

Each of SNL/NM's five tech areas has its own distinctive operation(s) and consists of either point radiological sources or diffuse radiological sources that are evaluated for NESHAP compliance (Sandia National Laboratories, 1997a).

Point releases are characterized as sources that discharge material into the atmosphere through a facility's exhaust stack or roof-top vent. During 1996, there were 14 point sources of radionuclide discharge from SNL/NM facilities. The SNL/NM point sources (grouped by tech area) that released radionuclides under routine conditions into the atmosphere in 1996 are:

- **Tech Area I:** TANDEM Accelerator, Metal Tritide Shelf-Life Lab, Integrated Materials Research Laboratory (IMRL), Neutron Generator Facility (NGF), Calibration Lab, Radiation Lab, and Explosive Components Facility (ECF)
- **Tech Area III:** Chemical Processing Lab and Radioactive and Mixed Waste Management Facility (RMWMF)
- **Tech Area IV:** High-Energy Radiation Megavolt Electron Source (HERMES) III and Particle Beam Fusion Accelerator (PBFA) II
- **Tech Area V:** Annular Core Research Reactor (ACRR), Sandia Pulsed Reactor (SPR), and Hot Cell Facility (HCF)

Airborne radionuclide emissions could result from wind resuspension of contaminated surface soil. In addition, radioactive gases migrating through the soil surface from buried waste are also diffuse radiological sources.

Several areas at SNL/NM are known to possess surface and/or subsurface radionuclide contamination. Although site characterization programs continue at SNL/NM, the Mixed Waste Landfill (MWL) has received the most attention as a diffuse source because it is believed to have the greatest potential for radionuclide dispersal. Tritium is the most prevalent radionuclide detected at the MWL. Surface soil sampling and flux chamber measurements have confirmed areas of elevated tritium contamination in the soil and air in and around this landfill.

Another potential diffuse source is the Classified Waste Landfill (CWL), located in Tech Area II. In its undisturbed state, the CWL did not produce any airborne emissions. However, the site could become a potential diffuse source of air emissions with the start of remediation activities.

For this reason, NESHAPS air monitoring is being conducted during environmental remediation activities, and no air emissions have been detected. A similar situation existed with the Radioactive Waste Landfill located in Tech Area II. Prior to remediation in 1996, no radionuclide emissions were associated with the Radioactive Waste Landfill. However, during remediation, radiological emissions were detected.

As required by *National Emission Standards for Hazardous Air Pollutants (NESHAP)* regulations, continuous air monitoring is required for any source that contributes 0.1 millirem per year or more to the maximally exposed individual (MEI). The results indicate that under routine and normal operations, there are no current sources at SNL/NM that require continuous air monitoring. However, as part of SNL's best management practice, the HCF, RMWMF, and the HERMES III are each equipped with a stack monitor capable of continuous monitoring. Also required by NESHAP regulations, sources contributing less than 0.1 millirem per year to the MEI require periodic confirmatory measurements. Periodic monitoring has been performed at the HCF, the ACRR, the HERMES III, and the SPR.

For other sources, the ability to perform confirmatory monitoring is precluded because the emissions are too low to monitor reliably. To resolve the question of the detectability of low radionuclide air concentrations, a study was conducted to determine the feasibility of monitoring low levels of radionuclide emissions. Estimated emissions were compared to the minimum detection levels for currently available radionuclide monitors. Due to low radionuclide inventory, the physical form of the potential contaminants, and nature of the process potentially emitting contaminants, SNL/NM determined that the concentration of radionuclides in the air effluent from these sources would be indistinguishable from background levels. Consequently, periodic confirmatory monitoring is considered to be unfeasible for the small sources. The feasibility-of-monitoring assessment conducted for small radionuclide sources is an alternative methods

proposal (i.e., calculations), as provided for in 40 CFR 61 for meeting the requirement of periodic confirmatory measurements (Sandia National Laboratories, 1997a).

New or Modified Radiological Sources - Three radiological sources, the Explosive Components Facility (ECF), Radioactive Waste Landfill, and the Radioactive and Mixed Waste Management Facility (RMWMF), have been added to the SNL/NM NESHAP 1996 dose assessment. The Radioactive Waste Landfill existed prior to 1996, but had no reported radionuclide emissions. The ECF and RMWMF are new sources. A NESHAP source permit application was not required for the ECF or RMWMF because the estimated dose impact was several orders-of-magnitude below the NESHAP dose limit. The U.S. Environmental Protection Agency (EPA) approved source modification applications for conducting remedial action activities at the Radioactive Waste Landfill in 1995 and the Classified Waste Landfill in 1996.

Radiological Releases in 1996 - A total of 16 facilities or sites at SNL/NM released airborne quantities of radionuclides in 1996; 14 were point source releases, and two were diffuse source releases. Table 4-26 summarizes the radionuclide release inventory for 1996. Reported emissions are based on measurements, on calculations based on measured parameters, and on worst case estimates. No credit is taken for mathematical reduction of emissions based on effluent controls and efficiency of the control devices.

Table 4-26. Summary of Radionuclide Releases for 1996

Source	Description	Type	Monitoring Method	Nuclides Emitted	Release (Curies per Year)
Hot Cell Facility (HCF), Tech Area V, Building 6580	Facility provides full capability to handle and analyze radioactive material	Point	Periodic	I-131	1.96×10^{-3}
				I-132	1.29×10^{-4}
				I-133	9.51×10^{-3}
				I-135	1.32×10^{-3}
				Kr-83m	9.57×10^{-5}
				Kr-85	1.53×10^{-3}
				Kr-85m	5.87×10^{-1}
				Kr-87	2.94×10^{-2}
				Kr-88	5.27×10^{-1}
				Xe-131m	3.45×10^{-4}
				Xe-133	1.75×10^{-1}
				Xe-133m	7.68×10^{-1}
				Xe-135	1.47×10^{-1}
				Xe-135m	9.76×10^{-1}

Table 4-26. Summary of Radionuclide Releases for 1996 (Continued)

Source	Description	Type	Monitoring Method	Nuclides Emitted	Release (Curies per Year)
Annular Core Research Reactor (ACRR), Tech Area V, Building 6588	Facility is used to perform in-pile experiments for research projects on severe reactor accidents and is planned for conversion to produce medical radioisotopes	Point	Periodic	Ar-41	3.54×10^1
Sandia Pulsed Reactor (SPR), Tech Area V, Building 6590	Facility provides intense neutron bursts for effects testing of material and electronics	Point	Calculation	Ar-41	9.51×10^0
High-Energy Radiation Megavolt Electron Source (HERMES) III, Tech Area IV, Building 970	Facility uses gamma simulator primarily to generate test conditions on the effects of prompt radiation from a nuclear burst on electronics and complete military systems	Point	Periodic	N-13 O-15	2.85×10^{-4} 2.85×10^{-5}
Particle Beam Fusion Accelerator (PBFA) II, Tech Area IV, Building 983	<ul style="list-style-type: none"> • Experimental facility used for research on light ion inertial confinement fusion • Facility capable of storing large amounts of electrical energy over a period of minutes and then releasing this energy in an intense, concentrated burst at a target 	Point	Calculation	N-13 O-15	4.2×10^{-2} 5.0×10^{-3}
Neutron Generator Facility (NGF), Tech Area I, Building 870	Facility serves as principal production site for neutron generators	Point	Calculation	H-3	1.1×10^{-1}
TANDEM Laboratory, Tech Area I, Building 884	Laboratory serves as an ion solid interaction and defect physics accelerator facility	Point	Calculation	H-3 C-11 N-13 O-15 F-17 F-18	1.0×10^{-6} 5.3×10^{-3} 9.3×10^{-8} 2.1×10^{-2} 8.0×10^{-4} 4.4×10^{-5}
Radiation Laboratory, Tech Area I, Building 827	Laboratory is used to perform small-scale experiments	Point	Calculation	H-3 N-16 N-13 Ar-41	1.0×10^{-5} 2.0×10^{-7} 1.0×10^{-8} 1.0×10^{-9}

Table 4-26. Summary of Radionuclide Releases for 1996 (Continued)

Source	Description	Type	Monitoring Method	Nuclides Emitted	Release (Curies per Year)
Mixed Waste Landfill, Tech Area III	Environmental restoration (ER) site that acts as a diffuse source of tritium emissions into the atmosphere	Diffuse	Periodic	H-3	2.94×10^{-1}
Calibration Laboratory, Tech Area I, Building 869	Laboratory is used to perform radiation detection equipment calibration	Point	Calculation	H-3	2.51×10^{-4}
Chemical Processing Laboratory, Tech Area III, Building 6600	Laboratory is used to conduct small-scale laboratory operations	Point	Calculation	Na-22 Am-241 U-232 Pu-241	2.4×10^{-12} 1.0×10^{-13} 1.0×10^{-13} 1.0×10^{-13}
Integrated Materials Research Laboratory (IMRL), Tech Area I, Building 897	Laboratory is used for research and development of new and superior material for government and industrial needs	Point	Calculation	C-14	2.21×10^{-5}
Metal Tritide Laboratory, Tech Area I, Building 891	Laboratory is used for research and development on tritium	Point	Calculation	H-3	5.0×10^{-9}
Explosive Components Facility (ECF), Tech Area I, Building 905	Facility is used for testing neutron generator design and manufacturing	Point	Calculation	H-3	7.0×10^{-4}
Radioactive Waste Landfill, Tech Area II	<ul style="list-style-type: none"> Environmental restoration (ER) site that acted as a diffuse source of radiological air emissions Remediated site is no longer a NESHAP source 	Diffuse	Calculation and Continuous Emissions Monitoring ^a	Am-241 Pu-239/240 Pu-238	4.7×10^{-13} 3.9×10^{-15} 7.9×10^{-15}
Radioactive and Mixed Waste Management Facility (RMWMF), Tech Area III, Building 6920	Facility handles radioactive and mixed waste products	Point	Periodic	H-3 ^b	4.12×10^{0b}
^a Continuous monitoring was performed during remedial activities. Remediation of the landfill has been completed. ^b The tritium was emitted in two forms: tritium vapor and metallic tritide. The CAP88-PC code does not differentiate between the two tritium forms. As a result, a combined tritium vapor and metallic tritide emission activity is provided. Scientific notation: $2.94 \times 10^{-1} = 0.294$					

Table 4-27 summarizes the facility locations and release parameters.

Table 4-27. Release Parameters for 1996 SNL/NM Radiological Sources

Facility	Tech Area	Building	Release Height ^a (m)	Stack Diameter (m)	Release Temperature (°C)	Exhaust Velocity (m/sec)
Radiation Lab	I	827	0.0	0.0	21	0.0
TANDEM Laboratory	I	884	0.0	0.0	21	V ^b
Calibration Lab	I	869	2.6	0.3	21	8.4
Metal Tritide Shelf-Life Lab	I	891	24.4	0.61	21	9.14
ECF	I	905	3.0	0.5	21	15.4
NGF	I	870	10.6	0.305	21	10.8
IMRL	I	897	27.1	0.91	21	24.0
RWL	II	N/A	0.0	0.0	21	0.0
Chemical Processing Lab	III	6600	0.0	0.0	21	0.0
RMWMF	III	6920	16.8	0.61	19.3	11.2
MWL	III	N/A	0.0	0.0	21	0.0
HERMES III	IV	970	13.5	0.46	13	7.64
PBFA II	IV	983	0.0	0.0	21	0.0
HCF	V	6580	38.1	1.8	21	8.7
ACRR	V	6588	16.5	0.20	21	11.1
SPR	V	6590	8.2	0.54	21	38.6

^aIncludes building height
^bExhaust velocity is variable, depending on the heating/cooling demand of the building. Ventilation occurs through the building's heating, ventilation, and air conditioning (HVAC) system. A zero velocity was used.
ECF = Explosive Components Facility
NGF = Neutron Generator Facility
IMRL = Integrated Materials Research Laboratory
RWL = Radioactive Waste Landfill
RMWMF = Radioactive Mixed Waste Management Facility
MWL = Mixed Waste Landfill
HERMES = High-Energy Radiation Megavolt Electron Source
PBFA = Particle Beam Fusion Accelerator
HCF = Hot Cell Facility
ACRR = Annular Core Research Reactor
SPR = Sandia Pulsed Reactor
m = meter
°C = degree(s) Celsius
m/sec = meters per second

In 1996, the largest dose-related releases from point sources were produced by the Annular Core Research Reactor (ACRR), Sandia Pulsed Reactor (SPR), and the Hot Cell Facility (HCF) in Tech Area V. A combined 44.9 curies of argon (Ar-41) was released from the ACRR and SPR in 1996. A total of 35.1 curies of radioactive iodine (I-131, I-132, I-133, and I-135), krypton (Kr-83m, Kr-85, Kr-85m, Kr-87, and Kr-88), and xenon (Xe-131m, Xe-133, Xe-133m, Xe-135, and Xe-135m) were released from the HCF in 1996. The Particle Beam Fusion Accelerator (PBFA) II and the High-Energy Radiation Megavolt Electron Source (HERMES) III in Tech Area IV released small amounts of short half-life (≤ 10 minutes) air activation products in 1996.

The only other facilities that released radionuclides in 1996 included small sources that result from laboratory testing, chemical processing, facility decontamination, and waste management in Tech Area I and Tech Area III.

The largest release from a diffuse source at SNL/NM occurred at the Mixed Waste Landfill (MWL). Approximately 0.29 curie of tritium was estimated to have been released from the MWL in 1996. All tritium present at the MWL is conservatively assumed to be of an aqueous chemical form (Sandia National Laboratories, 1997a). The other diffuse source, the Radioactive Waste Landfill in Tech Area II, released an estimated total of 4.8×10^{-13} curie of transuranic radionuclides (americium-241 [Am-241], plutonium-238 [Pu-238], Pu-239, and Pu-240) during remediation in 1996. No unplanned or accidental radiological releases from any SNL/NM facility occurred in 1996.

4.3.2 Input Data for Dispersion Modeling

In 1989, the U.S. Environmental Protection Agency (EPA) issued final rules for radionuclide emissions to the air under 40 CFR 61. Compliance procedures for DOE facilities [40 CFR 61.93(a)] require the use of CAP88-PC or other approved procedures to calculate effective dose equivalents (EDEs) to members of the public. All dose assessments presented in this chapter were calculated using the EPA CAP88-PC computer code.

The CAP88-PC computer code is a set of computer programs, databases, and associated utility programs for estimating dose and risk from point sources of radionuclide air emissions. The code provides for menu-driven data set formulation and execution. The code consists of modified versions of the AIRDOS-EPA and DARTAB computer models. CAP88-PC allows for the assessment of dose for *National Emission Standards for Hazardous Air Pollutants (NESHAP)* compliance in a personal computer environment. CAP88-PC is intended for use by qualified personnel experienced in dose assessment and environmental analysis.

Summary of CAP88-PC Input Data - Site-specific data required by the CAP88-PC computer code include meteorological, demographic, radiological, receptor location, and facility release parameters. This subsection summarizes the required user-supplied data for running the CAP88-PC code.

Meteorological data used in the 1996 dose assessment was obtained from onsite meteorological stations located near the emission sources. This data, which consists of over 35,000 hourly meteorological observations of wind direction, wind speed, and stability class (inferred from wind and solar insolation data), form a normalized distribution from which all wind and stability frequency-of-occurrence data are derived. The 1996 data for SNL/NM

meteorological stations was used to create shock thermodynamics applied research (STAR) data files that were incorporated into the CAP88-PC code for the dose assessment.

Data from SNL/NM meteorological towers CW1, A21, A36, and MW1 was used for the dose assessment. These stations were selected based on distance from radiological source locations, tower height (all data was obtained at a height of 10 meters), and data availability. Data from station A21, located in Tech Area II, was used to model radionuclide dispersion from the following:

- Metal Tritide Shelf-Life Lab
- Calibration Lab
- Radioactive Waste Landfill
- Explosive Components Facility (ECF)
- Particle Beam Fusion Accelerator (PBFA) II
- Radiation Lab
- TANDEM Accelerator
- Neutron Generator Facility (NGF)
- Integrated Materials Research Laboratory (IMRL)
- High-Energy Radiation Megavolt Electron Source (HERMES) III

Data from station A36, in the northeast sector of Tech Area III, was used to model radionuclide dispersion from the Chemical Processing Lab, Annular Core Research Reactor (ACRR), Hot Cell Facility (HCF), and Sandia Pulsed Reactor (SPR). Data from station CW1, in the southeast sector of Tech Area III, was used to model radionuclide dispersion from the Radioactive and Mixed Waste Management Facility (RMWMF). Station MW1 data was used to model tritium dispersion from the Mixed Waste Landfill. The meteorological data for the four stations is summarized in *Radiological Dose Calculations and Supplemental Dose Assessment Data for NESHAP Compliance for Sandia National Laboratories, New Mexico, 1996* (Sandia National Laboratories, 1997b).

Additional radiological data, including dose conversion factors, decay constants, and dry deposition velocity, plus other radionuclide-specific parameters are provided in the CAP88-PC computer code. Sixteen radionuclide emission sources at SNL/NM, spread across five tech areas, were evaluated in 1996. As a result, many different receptor locations were evaluated as suspected locations of maximum exposure. A total of 28 receptor locations, in either onsite or offsite areas where members of the public are known to abide or reside, were evaluated. For compliance purposes, the term "receptor" was conservatively assumed to include members of the military, their dependents, contractors, and other non-SNL/NM personnel who work at locations around Kirtland Air Force Base (KAFB). This definition is consistent with current DOE guidance and U.S. Environmental Protection Agency (EPA) regulations. The distance and direction estimated from each radionuclide emission source to each of the 28 receptor locations

are tabulated in *Radiological Dose Calculations and Supplemental Dose Assessment Data for NESHAP Compliance for Sandia National Laboratories, New Mexico, 1996* (Sandia National Laboratories, 1997b).

Demographic data includes population, beef cattle, dairy cattle, and food crops. The population dose for each KAFB housing unit was calculated as the product of the housing unit population and the housing unit individual dose (calculated by the CAP88-PC computer code). Housing unit population doses were then summed to obtain a composite KAFB population dose. The gridded demographic data and methodology used to derive the data is provided in *Radiological Dose Calculations and Supplemental Dose Assessment Data for NESHAP Compliance for Sandia National Laboratories, New Mexico, 1996* (Sandia National Laboratories, 1997b). A single-grid location centered on Tech Area V was used to estimate the regional 80-kilometer-radius population dose. Other user-defined data employed in the dose assessment includes the 1996 radionuclide releases summarized in Table 4-26 and the release parameters summarized in Table 4-27.

Emission Release Parameters – Point-source emissions from facilities are released through stack exhausts or vents. For those releases, the CAP88-PC code calculates a momentum-type plume rise from the stack diameter and exhaust velocity. Table 4-27 lists stack characteristics for point sources. Thermally hot exhausts associated with much higher plume rises do not exist at any of the individual SNL/NM facilities. Exhaust from the Radiation Lab and the TANDEM Accelerator in Tech Area I occur near the ground and near receptor locations. Because the plume rise makes it difficult to determine the point of maximum ground-level exposure, these Tech Area I releases were conservatively assumed to be ground-level releases to ensure that a maximum dose was assessed. Releases from the Chemical Processing Lab, Particle Beam Fusion Accelerator (PBFA) II, Radioactive Waste Landfill, and the Mixed Waste Landfill were also assumed to be at ground level. In all ground-level release scenarios, exhaust parameters (stack height, diameter, and exhaust velocity) were selected as zero so that the CAP88-PC code could calculate a ground-level release height.

4.3.3 Dispersion Modeling Results

Dose to the Maximally Exposed Individual (MEI) - As previously stated, a calculation of the maximally exposed member of the public is required annually under *National Emission Standards for Emission Standards of Radionuclides Other Than Radon From Department of Energy (DOE) Facilities* regulations, 40 CFR 61, Subpart H. The regulation requires that the cumulative effective dose equivalent (EDE) from exposure to all sitewide radionuclide releases does not exceed 10 millirems per year.

Each of the 16 independent release sources contribute to the Maximally Exposed Individual (MEI) dose. The dose contribution from each radionuclide source was combined to yield the overall dose to the MEI. Release amounts from individual facilities at SNL/NM were determined from either calculations based on measured stack parameters or from calculations based on the radionuclide inventory.

The MEI was determined to be located northwest of the Annular Core Research Reactor (ACRR) in Tech Area V. The Kirtland Underground Munitions Maintenance and Storage Complex (KUMMSC) receptor EDE calculated for the MEI was estimated to be 7.0×10^{-3} millirems per year, resulting primarily from exposure to argon-41 (Ar-41) released from the Sandia Pulsed Reactor (SPR) and ACRR. The cumulative MEI dose of 7.0×10^{-3} millirems per year is well below the NESHAP dose standard of 10 millirems per year. The individual dose at each of the 28 receptor locations for which the dose assessment was done are tabulated in *Radiological Dose Calculations and Supplemental Dose Assessment Data for NESHAP Compliance for Sandia National Laboratories, New Mexico, 1996* (Sandia National Laboratories, 1997b).

Dose to the Regional Population - A population dose was calculated by the CAP88-PC code for the 50-mile (80-kilometer) radius surrounding SNL/NM using a single, common grid analysis for all SNL/NM sources. The common grid was located at Tech Area V because the majority of the 1996 source term originates from there. Because the analysis area is so large, the relatively small distance between sources has a minimal impact on the resulting 50-mile-radius regional population dose.

The population dose from 1996 SNL/NM operations was calculated to be 0.14 person-rem effective dose equivalent (EDE) for the surrounding population residing outside Kirtland Air Force Base (KAFB). The population dose results primarily from exposure to Ar-41. A detailed analysis of the population dose assessment is contained in *Radiological Dose Calculations and Supplemental Dose Assessment Data for NESHAP Compliance for Sandia National Laboratories, New Mexico, 1996* (Sandia National Laboratories, 1997b).

Dose to Kirtland Air Force Base (KAFB) Residents - A population dose resulting from exposure to all SNL/NM routine radiological emissions was calculated for Kirtland Air Force Base (KAFB) residents. Because there are only a few residential neighborhoods on KAFB, the KAFB population dose was determined based on the maximum individual dose calculated for each of the KAFB housing compounds.

An annual composite population dose of 4.0×10^{-3} person-rem was estimated for KAFB. This population dose results primarily from exposure to Ar-41. A detailed analysis of the KAFB population dose assessment is contained in *Radiological Dose Calculations and Supplemental*

Dose Assessment Data for NESHAP Compliance for Sandia National Laboratories, New Mexico, 1996 (Sandia National Laboratories, 1997b).

4.3.4 Ambient Sampling

SNL/NM's eight meteorological towers are currently in use at selected locations across Kirtland Air Force Base (KAFB). The dose assessment for SNL/NM *National Emission Standards for Hazardous Air Pollutants (NESHAP)* compliance was performed using onsite meteorological data. Future plans for onsite meteorological data include a semiautomated emergency preparedness system for mitigating the effects from an unplanned release. In the event of an unplanned or accidental release, better estimates of areas potentially affected will be generated using very recent meteorological conditions. Some programs were designed to benchmark levels of pollutants that may exist in the local environment. These programs are of finite duration and are terminated as questions are answered. Other surveillance programs supplement environmental restoration (ER) activities, which include a potential fugitive dust source term associated with drilling and digging activities.

In 1996, the ambient air sampling of total uranium, gross alpha, gross beta, beryllium-7, and potassium-40 were measured to quantify the effect of SNL/NM operations on the environment. The particulate monitoring stations included the following:

- Tech Area I (Photovoltaic Particulate Monitoring Stations [PVPM1 and PVPM2] and Criteria Pollutant Monitoring Station [CPMS])
- Tech Area II (A2PM tower)
- Tech Area III (stations Chemical Waste Landfill Particulate Monitoring [CWPM], Mixed Waste PM₁₀ Monitoring [MWPMM], and MWPME)
- KUMMSC (station KUPM)

A description of the sampling locations and conditions is provided in "4.1.8 Ambient Sampling." Attachment 4-6 describes monthly samples that were collected for air quality in the Albuquerque Basin. Table 4-28 summarizes collections of various concentrations.

Table 4-28. Summary of Concentration Collections

Type of Concentration	Sampling Stations	Samples Taken	Concentration Results		
			Average	Minimum	Maximum
Total uranium concentrations ($\mu\text{g}/\text{m}^3$)	<ul style="list-style-type: none"> • KUPM (KUMMSC) • MWPM (Tech Area III) 	26	$1 \times 10^{-4} \pm 1 \times 10^{-4} \mu\text{g}/\text{m}^3$	Equivalent to background	$5 \times 10^{-4} \mu\text{g}/\text{m}^3$
Gross beta concentrations (pCi/m^3)	<ul style="list-style-type: none"> • A2PM (Tech Area II) • CWPM (Tech Area III) • KUPM (KUMMSC) • MWPMW (Tech Area III) • PVPM1 (Tech Area I) • PVPM2 (Tech Area I) 	74	$1.84 \times 10^{-2} \pm 1.22 \times 10^{-2} \text{pCi}/\text{m}^3$	Equivalent to background	$5.16 \times 10^{-2} \text{pCi}/\text{m}^3$
Gross alpha concentrations (pCi/m^3)	<ul style="list-style-type: none"> • A2PM (Tech Area II) • CWPM (Tech Area III) • KUPM (KUMMSC) • MWPMW (Tech Area III) • PVPM1 (Tech Area I) • PVPM2 (Tech Area I) 	74	$6.3 \times 10^{-3} \pm 5.0 \times 10^{-3} \text{pCi}/\text{m}^3$	Equivalent to background	$2.53 \times 10^{-2} \text{pCi}/\text{m}^3$
Beryllium-7 concentrations (pCi/m^3)	<ul style="list-style-type: none"> • A2PM (Tech Area II) • CWPM (Tech Area III) • KUPM (KUMMSC) • MWPMW (Tech Area III) • PVPM1 (Tech Area I) • PVPM2 (Tech Area I) 	38	$0.16 \pm 0.08 \text{pCi}/\text{m}^3$	Equivalent to background	$0.29 \text{pCi}/\text{m}^3$
Potassium-40 concentrations (pCi/m^3)	<ul style="list-style-type: none"> • A2PM (Tech Area II) • CWPM (Tech Area III) • KUPM (KUMMSC) • MWPMW (Tech Area III) • PVPM1 (Tech Area I) • PVPM2 (Tech Area I) 	57	$2.4 \times 10^{-2} \pm 3.5 \times 10^{-2} \text{pCi}/\text{m}^3$	Equivalent to background	Maximum concentration of $0.18 \text{pCi}/\text{m}^3$
KUPM = KUMMSC Pollutant Monitoring (Station) MWPM = Mixed Waste PM_{10} Monitoring (Station) CWPM = Chemical Waste Landfill Particulate Monitoring (Station) PVPM = Photovoltaic Particulate Monitoring (Station) CPMS = Criteria Pollutant Monitoring Station PVPM = Photovoltaic Particulate Monitoring (Station) A2PM = A2PM tower $\mu\text{g}/\text{m}^3$ = micrograms per cubic meter pCi/m^3 = picocuries per cubic meter					

4.4 Ambient Sampling for the Geographic Region

The Albuquerque Environmental Health Department (AEHD) and the New Mexico Environment Department (NMED) monitor the ambient air within the Albuquerque Basin to determine air quality in neighborhoods, background locations, expected maximum impact locations, and to estimate impacts from mobile vehicles. The objectives of the ambient air monitoring network are to:

- Collect data to establish pollutant background concentrations levels.
- Show compliance with ambient air quality standards (AAQS) and local AAQS.
- Evaluate the impacts of emission from existing and proposed industrial facilities and roadways.

There are 14 monitoring stations throughout the Albuquerque Basin measuring criteria pollutants, including particulate matter less than 10 microns in diameter (PM_{10}), ozone (O_3), carbon monoxide (CO), and nitrogen dioxide (NO_2). There are no monitoring stations for sulfur dioxide (SO_2) or lead (Pb). Figures 4-29 and 4-30 show the monitoring network. Several stations within the network measure pollutants and collect meteorological data (see "3.0 CLIMATE AND METEOROLOGY" for more information).

4.4.1 Ambient Monitoring Stations

The following stations monitor the ambient concentrations for carbon monoxide (CO), particulate matter less than 10 microns in diameter (PM_{10}), nitrogen dioxide (NO_2), and ozone (O_3):

- 2G (PM_{10}), located near I-25 and San Mateo Boulevard, about six miles north of downtown
- 2R (PM_{10} , CO, O_3), within the south valley of Albuquerque about one mile west of the Rio Grande and three miles south of downtown (provides a background location for O_3)
- 2ZE (PM_{10} , CO, O_3), within the northeast heights of Albuquerque about five miles east of downtown (designed to determine neighborhood population exposure)
- 2ZF (O_3), located in the far northeast heights of Albuquerque about 12 miles to the northeast of downtown (provides a likely location for O_3 maximum)

Figure 4-29. Air Quality Stations Within the City of Albuquerque

Figure 4-30. Air Quality Stations Within the Albuquerque Basin

- 2ZH (PM₁₀, O₃), within the north valley about two miles east of the Rio Grande (provides neighborhood exposure estimates)
- 2ZK (PM₁₀, CO), within the northeast heights of Albuquerque about four miles east of downtown (located near a busy intersection and several shopping malls)
- 2ZL (PM₁₀, CO), within the north valley of Albuquerque along the Rio Grande and eight miles north of downtown
- 2ZM (PM₁₀, CO, O₃, NO₂), within the northeast heights near the busy intersection of Montgomery and San Mateo Boulevards (provides mobile source impacts)
- 2ZN (PM₁₀, CO), located in the southeast region of Albuquerque (site nearest SNL/NM)
- 2ZO (PM₁₀), located in the downtown area (provides a likely maximum impact site)
- 2ZQ/2ZR (NO₂, O₃, CO), located in Rio Rancho to the west of Albuquerque on the mesa (an area rapidly growing in population)
- 2U (PM₁₀, O₃), located in Bernalillo (provides impacts within an expanding area)
- 2ZP (O₃), located in Bosque Farms about 20 miles to the south of Albuquerque (provides an analysis of the transport extent)
- 3ZC (NO₂, O₃, PM₁₀), located at Bandelier National Monument (provides background concentrations)

The PM₁₀ sampling schedule is consistent with the U.S. Environmental Protection Agency's (EPA's) National Air Sampling Program. The sampling frequency for PM₁₀ monitoring is a 24-hour sample, starting and ending at midnight, every day, every other day, or every sixth day depending on the type of monitoring station. The three types of PM₁₀ monitoring sites involve those where emissions have a probability of exceeding standards greater than 95%, between 20% and 95%, and less than 20%.

The sampling systems compile gaseous pollutant information in hourly averages. The daily concentration of PM₁₀ is calculated by the difference in weight gained by the filter, divided by the volume of air sampled (see Table 4-3 for a summary of applicable state and federal air quality standards). Federal annual standards cannot be violated, but short-term standards may

be exceeded once a year. State standards represent objectives to preserve air resources and may be exceeded for short periods of time as a result of meteorological conditions.

Table 4-29 shows the monitoring results during the baseline year of 1996. Attachment 4-7 contains the data used to compile these results. Table 4-29 shows the average maximum measured values and the average second highest measured values, determined from all measurements throughout the basin. A comparison between these values shows whether the maximum measured event was an isolated episode (i.e., due to abnormal meteorological conditions). This table also shows the maximum concentration measured within the basin and the lowest maximum measure to indicate the range of the highest values throughout the basin.

Table 4-29. Summary of 1996 Air Quality Data Within the Albuquerque Basin

Pollutant (# of Sites)	Averaging Period	Units	Average Highest	Average 2nd High	Minimum Highest	Maximum Highest	Location
CO (7)	1-Hour	ppm	8.60	7.60	3.50	12.0	2ZK
	8-Hour	ppm	4.30	3.90	1.60	8.30	2ZK
NO ₂ (2)	24-Hour	ppm	0.037	0.034	0.029	0.045	2ZM
	Annual	ppm	0.015	N/A	0.008	0.022	2ZM
O ₃ (10)	1-Hour	ppm	0.090	0.084	0.080	0.111	2ZF
PM ₁₀ (11)	24-Hour	µg/m ³	62	56	35	96	2R
	Annual	N/A	27	N/A	18	37	2R
CO = carbon monoxide NO ₂ = nitrogen dioxide O ₃ = ozone PM ₁₀ = particulate matter less than 10 microns in diameter ppm = parts per million µg/m ³ = micrograms per cubic meter							

The CO concentrations were highest at the station located near the intersection of San Mateo and Menaul Boulevards, which is near several shopping malls (2ZK). The ALQ 2ZK station showed CO concentrations much greater than the Albuquerque Basin average (12.0 versus 8.60 parts per million for one-hour, and 8.30 versus 4.30 parts per million for eight-hours), which displays the microscale impacts of CO. The monitoring station closest to SNL/NM was slightly above the basin average impact. No stations exceeded the ambient air quality standards (AAQS).

The highest PM₁₀ concentrations were recorded at station 2R in the rural south valley of Albuquerque. The PM₁₀ concentrations at station 2R were much greater than the basin average (96 versus 62 parts per million for 24 hours, and 37 versus 27 parts per million annually), which also shows the localized effect of PM₁₀. Data collected at the station closest to SNL/NM was below the basin average values. Background values were about 25% of the basin average, and no stations exceeded the AAQS.

The highest NO₂ concentrations were recorded at the station near the intersection of Montgomery and San Mateo Boulevards (ALQ 2ZM). However, the monitoring network showed a small deviation between measurements, and the NO₂ impacts were very low compared to the AAQS.

The highest ozone (O₃) concentrations were recorded at the station in the far northeast heights (2ZF), and many values were greater than 90% of the AAQS. Elevated O₃ impacts (greater than 0.09 parts per million) were found widespread throughout the monitoring network. These O₃ concentrations are formed through a photochemical reaction involving hydrocarbons and nitric oxide. The highest measured values do not commonly occur near the sources of these precursors. The 2ZF monitoring station is 12 miles from downtown Albuquerque.

The impacts of CO and NO₂ tend to be microscale in nature, while the impacts of O₃ and PM₁₀ tend to occur on the regional scale. High CO events also usually occur during the winter on calm, cold nights. PM₁₀ concentrations are highest during the springtime with windy conditions. The NO₂ and O₃ are affected by photochemical processes, and the highest values of each occur during the summer.

5.0 SUMMARY OF AIR QUALITY TRENDS

5.1 Criteria Pollutant

This section presents the five-year trend data for criteria pollutant emissions at SNL/NM. The three-year trend for ambient sampling, a comparison of criteria pollutant emissions to regulatory standards, the local source influence on pollutant concentrations, and seasonal trends are also presented.

5.1.1 Emissions Trend

Table 4-30 and the corresponding figures (Figures 4-31 through 4-34) provide emissions data for 1992 through 1996 from the significant criteria pollutant sources at SNL/NM. Details on source locations and factors influencing emissions are described in "4.1 Criteria Pollutant Emissions."

Table 4-30. Criteria Pollutant Emissions From 1992 Through 1996

Pollutant	Source	1992*	1993*	1994*	1995*	1996*
NO _x	Fire testing facilities	0.07	0.02	0.02	0.02	0.02
	Steam Plant	47.78	155.08	148.06	126.00	153.00
	862 generators	0.03	5.55	0.61	1.11	0.90
	Total	47.88	160.65	148.69	127.13	153.92
CO	Fire testing facilities	2.87	0.77	0.79	0.75	0.78
	Steam Plant	4.44	16.25	15.60	13.80	14.20
	862 generators	0	0.28	0.02	0.29	0.23
	Total	7.31	17.30	16.41	14.84	15.21
PM ₁₀	Fire testing facilities	2.60	0.70	0.71	0.69	0.71
	Steam Plant	1.76	3.90	3.75	3.45	2.93
	862 generators	0.00	0.93	0.02	0.02	0.01
	Total	4.36	5.53	4.49	4.16	3.65
SO ₂	Fire testing facilities	0.14	0.04	0.04	0.04	0.04
	Steam Plant	2.12	0.33	0.26	0.22	0.22
	862 generators	0	0.87	0.13	0.08	0.06
	Total	2.26	1.24	0.43	0.34	0.32

*Tons per year
 NO_x = nitrogen oxides
 CO = carbon monoxide
 PM₁₀ = particulate matter less than 10 microns in diameter
 SO₂ = sulfur dioxide

Figure 4-31. Trend of Nitrogen Oxides (NO_x) Emissions

Figure 4-32. Trend of Carbon Monoxide (CO) Emissions

Figure 4-33. Trend of Total Suspended Particles (TSP) Emissions

Figure 4-34. Trend of Sulfur Dioxide (SO₂) Emissions

As discussed previously, the Steam Plant is the largest source of emissions at SNL/NM. The Steam Plant is fired with both diesel fuel and natural gas; however, natural gas is the primary fuel. The primary pollutant emitted from boilers fired with natural gas is nitrogen oxides (NO_x). Therefore, nitrogen oxide emissions are more significant than the other pollutants.

Over the five years for which data has been summarized, NO_x emissions have accounted for approximately 87% of the total SNL/NM criteria pollutant emissions, and the Steam Plant is responsible for approximately 99% of the NO_x emissions. Emissions from the fire testing facilities and Building 862 generators are insignificant compared to Steam Plant emissions.

SNL/NM emissions of criteria pollutants vary as the operation of the Steam Plant increases or decreases. The operation of the Steam Plant depends on the severity of weather and the corresponding heating loads for SNL/NM office space. Table 4-31 summarizes several trends or specific points regarding the historical data.

Table 4-31. Emissions Trends for the Steam Plant

Type of Emission	Year	Trend
NO _x	1992	A low usage of natural gas results in low NO _x emissions.
	1996	A greater usage of the larger Boiler 6 at the Steam Plant results in greater NO _x emissions.
	1993 to 1996	The average NO _x emissions are roughly constant (140 tons per year).
CO	1992	The CO emissions from the Steam Plant are low, and the fire testing facilities contribute nearly equal emissions.
	1992	A much greater CO emission at the fire testing facilities shows increased operation.
	1993 to 1996	The CO emissions are roughly constant or slightly decreasing (about 14 tons per year).
PM ₁₀	1992	The fire testing facilities had PM ₁₀ emissions four times greater than the years 1993 to 1996.
	1992	The facility PM ₁₀ emissions are dominated by the fire testing facilities; however, 1993 to 1996 are dominated by the Steam Plant.
	1993	The 862 generators operated five times as many hours as during any other year, and PM ₁₀ emissions are much greater.
	1993 to 1996	The PM ₁₀ emissions are roughly constant or slightly decreasing (about four tons per year).
SO ₂	1992	The Steam Plant SO ₂ emissions are five times greater than any other year due to much greater fuel oil usage.
	1993	The 862 generators operated five times as many hours as other years and SO ₂ emissions are much greater.
NO _x = nitrogen oxides CO = carbon monoxide PM ₁₀ = particulate matter less than 10 microns in diameter SO ₂ = sulfur dioxide		

Because of the methodology SNL/NM uses to calculate emissions associated with the chemical users/sources, chemical operations are the largest emitters of volatile organic compounds (VOCs) at SNL/NM. Chemical operation emissions are based on the purchased quantity of chemicals for the majority of chemical users. VOC emissions from these operations are calculated using the specific gravity and percentage of VOCs listed in the corresponding material safety data sheet (MSDS). Table 4-32 lists the VOC emissions from chemical operations for 1993 through 1996.

Table 4-32. Chemical Volatile Organic Compound (VOC) Emissions

Emission	1993*	1994*	1995*	1996*
VOC	63.32	24.00	9.8	6.07
* Tons per year				

Historically, the largest purchaser of chemicals has been the fire testing facilities, which purchase jet fuel. Currently, the fire testing facilities use JP-8 for testing; historically, the

facilities used JP-4. Comparing the speciated chemical constituents for JP-4 and JP-8 reveals that JP-8 is formulated with less volatile compounds. The decrease in VOCs for SNL/NM exhibited in Table 4-32 is a direct result of the change from JP-4 to JP-8. The emissions reflected in 1995 and 1996 are representative of future emissions for the chemical users. The data used to compile the annual emission trend was generated using the Chemical Information System (CIS); Attachment 4-3 lists the backup data.

5.1.2 Ambient Sampling Trend

Criteria pollutants have been monitored since 1994 at the locations presented in Figure 4-28. Results of criteria pollutant monitoring are summarized and published in an annual site environmental report. Detailed analyses for some constituents are not documented in the annual reports, but are provided in the sections below. Attachment 4-6 provides information by month and year for the gaseous pollutants, which was collected through SNL/NM's Clean Air Network (CAN) Program for the monitored period (1994 through 1996).

Criteria Pollutants and Regulatory Standards - Table 4-33 lists the highest pollutant concentration found at SNL/NM over the three-year period compared to the most stringent standard. As stated in "4.1.8 Ambient Sampling," the annual standards may not be exceeded. The preamble (Section 108) of the *New Mexico Ambient Air Quality Control Act* allows for exceedances over short periods of time due to unusual meteorological conditions. There were exceedances of the New Mexico ambient air quality standards (NMAAQS) for carbon monoxide (CO) in 1995 due to unusual meteorological conditions. In late October 1995, there were four separate occasions within a 36-hour period when hourly CO concentrations were 14.95, 15.25, 13.9, and 13.3 parts per million. Table 4-33 shows that, while the hourly standards were exceeded, the eight-hour averages during that timeframe were not close to the standard. The CO hourly data was much lower than the NAAQS of 35 parts per million.

**Table 4-33. Criteria Pollutant Results From 1994 to 1996
Compared to the Most Stringent Standard**

Criteria Pollutant	Standard Average Time	Unit	Most Stringent Standard	Maximum	Second Highest Concentration	Average ^a Maximum
CO	1 hour	ppm	13.1	15.25 (1995)	14.95 (1995)	10.54
	8 hours	ppm	8.7	4.8 (1995)	4.8 (1995)	3.98
NO _x	24 hours	ppm	0.10	0.041 (1994)	0.041 (1994)	0.036
	Annual	ppm	0.05	0.016 (1994)	0.013 (1995)	0.014
SO ₂	3 hours	ppm	0.5	0.010 (1994/5)	0.010	0.009
	24 hours	ppm	0.1	0.003 (1996)	0.003 (1996)	0.002
	Annual	ppm	0.02	0.0003 (1994/6)	0.0003	0.0003
O ₃	1 hour	ppm	0.12	0.103 (1996)	0.099 (1996)	0.095
	8 hours ^b	ppm	0.09	0.076 (1994)	0.076 (1994)	0.075

**Table 4-33. Criteria Pollutant Results From 1994 to 1996
Compared to the Most Stringent Standard (Continued)**

Criteria Pollutant	Standard Average Time	Unit	Most Stringent Standard	Maximum	Second Highest Concentration	Average ^a Maximum
PM ₁₀	24 hours	µg/m ³	150	89 (1995)	79 (1995)	60.7
	Annual	µg/m ³	50	19.49 (1995)	15.92 (1994)	16.72
TSPs	7 days	µg/m ³	110	NA	NA	NA
	30 days	µg/m ³	90	NA	NA	NA
Pb	7 days	µg/m ³	110	NA	NA	NA
	30 days	µg/m ³	90	NA	NA	NA

^aUsing highest and second highest values for each year.

^bCalculated due to potential change in national standards.

CO = carbon monoxide

NO_x = nitrogen oxides

SO₂ = sulfur dioxide

O₃ = ozone

PM₁₀ = particulate matter less than 10 microns in diameter

TSPs = total suspended particulates

Pb = lead

ppm = parts per million

µg/m³ = micrograms per cubic meter

Local Source Influence on Pollutant Concentrations - As defined in "4.1.8 Ambient Sampling," the Criteria Pollutant Monitoring Station (CPMS) is near a major road and across the street from base housing. Each source has its own contribution to the concentrations recorded at the CPMS. A diurnal trace of pollutant concentrations may indicate the sources influencing the recorded concentrations by identifying the time and pattern of higher concentrations. Figure 4-35 is a diurnal trace of concentrations where the plotted concentrations are averaged for Monday through Friday over a two-year period (pollutants are shown in parts per billion [ppb] to accommodate graphical presentation). The time stamp is the end time of the hour (concentration plotted at 2 is the concentration average from 1 to 2).

Figure 4-35. Criteria Pollutant Monitoring Station (CPMS) Diurnal Concentrations Averaged for Each Hour (1995 Through 1996)

The highest concentration of carbon monoxide (CO) occurs around the morning commute time. The time is kept in Mountain Standard Time (MST), not daylight savings time, so that the 7 o'clock hour (on the graph) from April through October is 8:00 Mountain Daylight Time (MDT). The afternoon peak of CO occurs during the evening commute. This trace is indicative of the influence of the mobile sources on the concentrations recorded at the station. As shown in the daily plot, pollutant concentrations start increasing early in the morning, well before operations at SNL/NM begin for the day. Fossil fuel combustion from the Kirtland Air Force Base (KAFB) housing across the street starts the increasing trend of pollution in the early morning hours and is what keeps the concentrations elevated past the evening commute into the late evening hours. If the KAFB housing did not impact the monitoring station, concentrations would fall more rapidly after the evening commute.

The ozone (O₃) trace is fairly typical for the photochemically produced pollutant. The sulfur dioxide (SO₂) trace, barely visible above zero, shows the early morning commute time maximum.

Seasonal Trends - In addition to diurnal changes in pollutant concentrations, the concentrations vary with the seasons because of fossil fuel energy demands and meteorological conditions. Meteorological conditions are equally as important as fossil fuel combustion in influencing the formation and concentration of pollutants. Days in the same season, with the same amount of energy demand, may produce different pollutant concentrations due to wind, stability, and mixing height parameters. Conversely, days with different totals for fossil fuel combustion may produce similar concentrations. As stated

previously, short-term concentrations within each season follow a general trend: maximum carbon monoxide (CO) and nitrogen dioxide (NO₂) concentrations occur in the fall or winter, and maximum ozone (O₃) production occurs in the summer. Due to the small concentrations of sulfur dioxide (SO₂) (shown in Table 4-32 and Figure 4-34), seasonal trending data is not presented for this constituent.

Figure 4-36 presents the maximum CO concentrations detected each month for each of the short-term regulatory standards. Analysis of the figure reveals the highest CO concentrations occur between October and February, consistent with the Bernalillo County high pollution season for which air pollution alerts (yellow or red) are issued. The exceedance of the one-hour New Mexico ambient air quality standard (NMAAQS) in October 1995 stands out in the graph. The one-hour concentrations of CO are far below the national ambient air quality standards (NAAQS). Figure 4-36 also shows that the trend (aside from the October 1995 episode) for the eight-hour concentration is steady to slightly decreasing over time. The trend for the monthly averages is also steady to slightly decreasing.

Figure 4-36. Monthly Maximum Short-Term Carbon Monoxide Concentrations Plotted Over Time and Compared to Regulatory Standards

Figure 4-37 presents the maximum 24-hour NO₂ concentrations for each month between January 1994 and November 1996, and the monthly NO₂ average. While the NO₂ monthly average is not a standard, it can show trending and reflect the monthly average distance from the annual standard. NO₂ concentrations are well below regulatory standards. The trend for monthly averages in the high pollution season (fall and winter) and 24-hour maximums is slightly decreasing; however, the trend for monthly averages in the low pollution season is steady to slightly increasing.

Figure 4-37. Monthly and Maximum 24-Hour Average Nitrogen Dioxide (NO_2) Concentrations Plotted Over Time and Compared to Regulatory Standards

Figure 4-38 presents the maximum one-hour average and monthly O_3 concentrations. (As stated previously, the high pollution season for the photochemically produced pollutant is summer.) This graph shows maximum concentrations of ozone are produced in July and August. Maximum O_3 concentrations recorded each July and August average approximately 78% of the one-hour standard. The trend for the hourly maximums in the high pollution season and the monthly averages is steady to slightly increasing.

Figure 4-38. Monthly and 1-Hour Maximum Ozone (O_3) Concentrations Plotted Over Time and Compared to Regulatory Standards

Particulate matter less than 10 microns in diameter (PM_{10}) was collected at a total of six locations. The U.S. Environmental Protection Agency (EPA) sampling schedule of one 24-hour sample every sixth day, starting and ending at midnight, was used to facilitate data comparison with EPA-approved stations. Due to the relatively low concentrations, data from each station was composited to show general trends at SNL/NM, instead of detailing differences in the small values at each specific site. Data for the six stations was composited for each month and plotted over the time period in Figure 4-39, which shows an average of 30 observations per data group (month).

Figure 4-39. Monthly Average PM_{10} and Minimum and Maximum 24-Hour Concentrations for SNL/NM

The average concentration of particulate matter across SNL/NM was relatively low. The highest average concentrations occurred between April and August of each year, during windy and dry or hot conditions. Seven of the eight cases (87%), when average PM_{10} concentrations were greater than or equal to 14 micrograms per cubic meter, occurred during this period. The highest average concentration across SNL/NM occurred during dry, hot, and windy conditions in June, during the 1995 drought. Conversely, lower concentrations were generally found during the fall or winter. Seven of the eight cases (87%), when average concentrations were less than or equal to 10 micrograms per cubic meter, occurred between September and March.

Figure 4-39 also shows maximum and minimum 24-hour concentrations for each month of the sampling period. Maximum 24-hour concentrations occurred throughout the year, with only a slight majority (53%) of the maximums greater than 24 micrograms per cubic meter occurring between April and August. Section "4.1.8 Ambient Sampling" identifies the trend that higher average concentrations were detected closer to the most populated areas, near Tech Area I. Two sampling locations, the Criteria Pollutant Monitoring Station (CPMS) and Photovoltaic Particulate Monitoring (PVPM) station, are near Tech Area I. Maximum 24-hour concentrations occurred in this vicinity approximately 61% of the time. There were 17 cases when minimum

concentrations were below four micrograms per cubic meter; 82% occurred between September and March.

5.2 Hazardous Air Pollutants (HAPs)

This section presents the four-year trend data for hazardous air pollutants (HAPs) emissions at SNL/NM. The three-year trend for ambient sampling of volatile organic compounds (VOCs) is also discussed.

5.2.1 Emissions Trend

Hazardous air pollutants (HAPs) are estimated from purchase records maintained by the Chemical Information System (CIS) (as discussed previously in "4.2.2 Hazardous Chemical Emissions"). Except for large chemical users, SNL/NM's methodology assumes that 100% of the purchased quantity of chemicals is released. Emissions from large chemical users are calculated using process knowledge and mass balance engineering principles. Table 4-34 lists HAP emissions from chemical users for 1993 through 1996.

Table 4-34. Hazardous Air Pollutant Emissions at SNL/NM (1993 Through 1996)

Pollutant	1993*	1994*	1995*	1996*
Hazardous air pollutants (HAPs)	50.75	17.79	5.52	2.4
*Tons per year				

Historically, emission trends for SNL/NM volatile organic compounds (VOCs) show that the fire testing facilities purchase the most chemicals, i.e., jet fuel. The switch from JP-4 to JP-8 fuel by these facilities over the four-year period resulted in decreased HAP emissions and VOC emissions (previously discussed in "5.1.1 Emissions Trend"). The decreased HAP emissions can also be attributed to changes and reductions in activities at several facilities. The data used to compile the annual emission trend was generated using the CIS; Attachment 4-3 lists the backup data.

5.2.2 Ambient Sampling Trend

Since March 1994, volatile organic compound (VOC) samples were collected at four locations. Figure 4-28 shows the sampling locations. One 24-hour sample was collected each month. Attachment 4-6 lists the results and statistics for compounds detected over the sampling period. The sampling averages in the attachment and this section are not true averages from the three-year period. Averages are calculated only when the compound is detected; this method

prevents diluting the reported average. VOC concentrations are low, with all analytical values in the parts per billion range.

As with the particulate matter data (described in “4.1.8 Ambient Sampling” and “5.1.2 Ambient Sampling Trend”), the proximity of the sampling site to a source region or populated area influences sampling results. The source region for many VOC compounds is Tech Area I. The Criteria Station VOC (CSVOC) is off a busy road, near Fleet Services, and across the street from Kirtland Air Force Base (KAFB) housing. Comparison of the averages listed in Table 4-35 shows slightly higher concentrations at the CSVOC Station. The exceptions to this are 1,1,1-trichloroethane (TCA), acetone, carbon tetrachloride, and chloromethane, which are found in higher concentrations at the Mixed Waste VOC (MWVOC) station, located just outside the fenced area near an old mixed waste landfill.

The high average concentration of TCA at the MWVOC station is the result of exploratory drilling performed in May 1995. Since that time, concentrations of TCA increase in the summer (from baseline data taken in 1994) and decrease in the winter. The average for total non-methane hydrocarbons (TNMHC) is high at the MWVOC station because it represents all the carbon in the sample, including TCA results. If it were not for inclusion of the TCA, the TNMHC values at MWVOC station would be similar to the Tech Area II and Classified Waste VOC (CWVOC) sites.

Statistical analyses were performed to determine whether the concentrations were increasing or decreasing over time. Significant trends are noted in Table 4-35. Acetone, carbon tetrachloride, and TNMHC concentrations have increased slightly over time at several sites. While the trend is increasing, these compounds were detected in very small quantities that do not pose health or environmental threats. Decreasing concentrations of benzene were detected at the CWVOC station. The decreasing trend may be a result of the movement of the site away from the original location that was used as an overflow parking area.

5.3 Radiological Pollutants

This section presents the four-year trend data for radiological pollutants emissions at SNL/NM. The two-year trend for ambient sampling is also discussed.

Table 4-35. Summary of Volatile Organic Compounds (VOC) Sample Analyses at SNL/NM

Compound	Criteria Station VOC (CSVOC)					Classified Waste Landfill (CWVOC)				
	# Hits	Average*	Std Dev*	Max*	Trend	# Hits	Average*	Std Dev*	Max*	Trend
1,1,1-Trichloroethane	28	0.220	0.380	2.06	None	28	0.136	0.093	0.398	None
3-Methylpentane	30	0.290	0.176	0.8	None	7	0.030	0.023	0.0675	None
Acetone	31	3.636	5.875	30.4	Increasing	25	2.562	2.085	7.6	None
Benzene	33	0.625	0.392	2	None	27	0.179	0.105	0.4	Decreasing
Carbon tetrachloride	28	0.087	0.021	0.121	Increasing	26	0.082	0.036	0.2	Increasing
Chloromethane	32	0.420	0.165	0.9	None	28	0.396	0.221	1.3	None
Dichlorodifluoromethane	33	0.752	0.653	3.4	None	30	0.537	0.218	1.2	None
Halocarbon 113	29	0.091	0.039	0.2	None	27	0.094	0.055	0.3	None
Isopentane	31	2.157	1.377	7.5	None	27	0.798	1.167	5.3	None
n-Butane	31	1.743	1.326	5.6	None	26	0.484	0.360	1.3	None
n-Hexane	27	0.299	0.170	0.721	None	4	0.078	0.082	0.2	None
TNMHC	33	47.136	130.828	752	None	32	7.273	6.619	30.6	Increasing
Toluene	33	0.992	0.643	2.7	None	24	0.213	0.161	0.8	None
Trichlorofluoromethane	33	0.244	0.094	0.53	None	32	0.228	0.145	0.9	None
	Mixed Waste Landfill (MWVOC)					Tech Area II (A2VOC)				
1,1,1-Trichloroethane	26	37.432	65.653	242	Increasing	26	0.184	0.338	1.77	None
3-Methylpentane	10	0.107	0.149	0.5	None	18	0.172	0.104	0.4	None
Acetone	32	4.600	6.548	27.6	Increasing	28	3.369	5.232	26.1	Increasing
Benzene	28	0.199	0.092	0.4	None	29	0.325	0.160	0.7	None
Carbon tetrachloride	16	0.101	0.035	0.2	Increasing	25	0.080	0.030	0.117	Increasing
Chloromethane	27	0.522	0.531	3	None	27	0.486	0.310	1.7	None
Dichlorodifluoromethane	32	0.535	0.231	1.39	None	32	0.580	0.295	1.3	None
Halocarbon 113	28	0.078	0.035	0.2	None	24	0.085	0.034	0.2	None
Isopentane	29	1.002	2.258	12.6	Decreasing	27	1.822	3.155	16.6	None
n-Butane	27	0.598	0.484	2.2	None	27	1.045	0.806	3	None
n-Hexane	6	0.157	0.129	0.4	None	16	0.202	0.085	0.4	None
TNMHC	33	40.911	127.484	734	Increasing	32	11.220	8.803	44.7	Increasing
Toluene	25	0.249	0.224	1.2	None	29	0.478	0.261	1	None
Trichlorofluoromethane	33	0.200	0.077	0.4	Increasing	32	0.207	0.085	0.4	None

*Parts per million (ppm)
Std Dev = standard deviation
Max = maximum

5.3.1 Emission Trend

From 1993 through 1996, the mean effective dose equivalent (EDE) was 2.65×10^{-3} millirems per year, ranging from 8.54×10^{-4} millirems per year in 1995 to 7.01×10^{-3} millirems per year in 1996. The EDE increase for 1996 is attributable to Annular Core Research Reactor (ACRR) activities, whereas most sources (81%) had no impact on the EDE. In general, 16 facilities contributed to the source term, compared to 12 facilities in 1995, 11 facilities in 1994, and only 8 facilities in 1993.

In 1993, the ACRR contributed approximately 95% of the total annual EDE to onsite receptors. Argon (Ar-41) was the primary radionuclide contributing to the source term (in curies per year); krypton (Kr-85m), Kr-87, Kr-88, rubidium-88 (Rb-88), xenon (Xe-135), and Xe-135m also contributed to the source term. The SPR contributed approximately 3.5% from Ar-41. All other facilities in operation contributed to less than 1% of the total annual EDE.

In 1994, the ACRR and Sandia Pulsed Reactor (SPR) contributed approximately 47% each to the total annual EDE to onsite receptors, including contributions of 2.7% each from the High-Energy Radiation Megavolt Electron Source (HERMES) II and the Particle Beam Fusion Accelerator (PBFA) II. The primary radionuclide contributing to the source term (in curies per year) from the ACRR and SPR was Ar-41. The primary radionuclides contributing to the source term (in curies per year) from HERMES II and PBFA-II were nitrogen-13 (N-13) and oxygen-15 (O-15). All other facilities in operation contributed to less than 1% of the total annual EDE.

In 1995, the ACRR contributed approximately 70% of the total annual EDE to onsite receptors. The primary radionuclide contributing to the source term (in curies per year) was Ar-41, with minor contributions from Kr-85m, Kr-88, and Xe-133. The SPR contributed approximately 29%, also from Ar-41. All other facilities in operation contributed to less than 1% of the total annual EDE.

In 1996, the ACRR contributed approximately 77% of the total annual EDE to onsite receptors. The primary radionuclide contributing to the source term (in curies per year) was Ar-41. The SPR contributed approximately 17%, also from Ar-41. The Hot Cell Facility (HCF) contributed less than 6%, primarily from Kr-85m, Kr-88, Xe-133, Xe-133m, Xe-135, and Xe-135m. All other facilities in operation contributed to less than 1% of the total annual EDE.

5.3.2 Ambient Sampling Trend

Ambient air sampling data was collected from January 1995 through December 1996. An analysis of variance was conducted to determine whether there were statistical differences between the data sets collected in 1995 and 1996.

From 1995 through 1996, samples of total uranium concentrations in micrograms per cubic meter were collected at the KUMMSC (Kirtland Underground Munitions Maintenance and Storage Complex) Pollutant Monitoring (KUPM) station and the Mixed Waste PM₁₀ Monitoring (MWPM) station (in Tech Area III). The analytical laboratory refined their internal procedures in 1995; therefore, total uranium concentrations were reported from August 1995 through December 1996.

Average concentrations for total uranium were equivalent to background levels in 1995 and 1×10^{-4} micrograms per cubic meter in 1996. The analysis of variance indicated there were no statistical differences among sampling locations, and for data sets collected in either 1995 or 1996. Natural uranium (U) is comprised of the following fraction of activities from U-238, U-235, and U-234; 48.2%, 2.24%, and 49.6%, respectively, which equates to 686.4 picocuries per milligram. Therefore, one gram of natural uranium contains approximately 0.33 microcuries of U-238, 0.015 microcuries of U-235, and 0.3 microcuries of U-234. The average background concentration in soil is 1.78 picocuries per gram for both U-238 and U-234, and 0.08 picocurie per gram for U-235 (National Council on Radiation Protection and Measurements, 1987).

From 1995 through 1996, gross beta concentrations (in picocuries per cubic meter) were collected at stations A2PM (in Tech Area II), Chemical Waste Landfill Particulate Monitoring (CWPM) (in Tech Area III), KUPM (at KUMMSC), MWPM (in Tech Area III), Photovoltaic Particulate Monitoring 1 (PVPM1), and PVPM2 (both in Tech Area I). Average concentrations were 2.34×10^{-2} picocuries per cubic meter in 1995 and 1.84×10^{-2} picocuries per cubic meter in 1996. The analysis of variance indicated that the air sampling concentrations were greater for data sets collected in 1995 than in 1996, but there were no statistical differences between sampling locations. Because of the presence of natural airborne radioactivity, for example, from uranium-238 and its decay products and potassium-40 (K-40), gross beta measurements are used primarily as a qualitative screening tool.

From 1995 through 1996, gross alpha concentrations (in picocuries per cubic meter) were collected at station A2PM (in Tech Area II), CWPM (in Tech Area III), KUPM (at KUMMSC), MWPM (in Tech Area III), PVPM1, and PVPM2 (both in Tech Area I). Average concentrations were 4.2×10^{-3} picocuries per cubic meter in 1995 and 6.3×10^{-3} picocuries per cubic meter in 1996. Although the mean concentration was higher in 1996 than in 1995, the analysis of variance demonstrated that there were no statistical differences among sampling locations, and none among data sets collected in either 1995 or 1996. Because of the presence of natural airborne radioactivity, for example, from U-238 and its decay products, gross alpha measurements are used primarily as a qualitative screening tool.

From 1995 through 1996, beryllium-7 (Be-7) concentrations (in picocuries per cubic meter) were collected at A2PM (in Tech Area II), CWPM (in Tech Area III), KUPM (at KUMMSC),

MWPMM station (in Tech Area III), PVPM1, and PVPM2 (both in Tech Area I). Average concentrations were 0.16 picocuries per cubic meter in 1995 and 0.16 picocuries per cubic meter in 1996. The analysis of variance demonstrated that there were no statistical differences among sampling locations and between data sets collected in either 1995 or 1996. This cosmogenic radionuclide is produced from the spallation of oxygen-16, carbon-12, and nitrogen-14. Precipitation scavenging is primarily responsible for the removal of nongaseous radionuclides from the atmosphere. In the process of precipitation scavenging, aerosol particles act as condensation nuclei for the formation of cloud droplets. These droplets later coagulate to form precipitation that washes out additional radionuclides. These processes efficiently remove cosmogenic radionuclides from the atmosphere and deposit them on the earth's surface in rain, hail, or snow. However, these deposited radionuclides represent only a small addition to the primordial radioactivity (e.g., uranium and thorium series) already present in the earth's surface. The estimated effective dose equivalent (EDE) for a reference adult from cosmogenic Be-7 for doses received over 50 years from one year's intake is three microrems (National Council on Radiation Protection and Measurements, 1987).

From 1995 through 1996, potassium-40 (K-40) concentrations (in picocuries per cubic meter) were collected at stations A2PM (in Tech Area II), CWPM (in Tech Area III), KUPM (at KUMMSC), MWPMM (in Tech Area III), PVPM1, and PVPM2 (both in Tech Area I). Average concentrations were 1.34×10^{-2} picocuries per cubic meter in 1995 and 2.4×10^{-2} picocuries per cubic meter in 1996. The analysis of variance indicated that combined concentrations from 1995 and 1996 were statistically higher for PVPM2 (in Tech Area I) than A2PM (in Tech Area II) and MWPMM (in Tech Area III), while the remainder of the other sampling locations revealed no statistical differences. Although the reported mean concentration for 1996 was higher than for 1995, the analysis of variance did not reveal any statistical differences between data sets collected in either 1995 or 1996. K-40 is a naturally occurring primordial nuclide with typical background concentrations yielding 10.8 picocuries per gram (National Council on Radiation Protection and Measurements, 1987).

Generally, sampling locations closer to populated areas of SNL/NM or field activities yield higher concentrations. These increases are likely to occur during windy seasons as a result of resuspension of soil particles. This trend of increased concentration during windy periods will be enhanced under dry weather conditions.

5.4 Geographic Region Ambient Trend

Table 4-36 shows the results of the monitoring network analysis for the five-year period from 1992 to 1996. Trends in air quality were analyzed by comparing the 1996 average maximum concentrations to averages during previous years. Ambient air quality standards (AAQS) were not exceeded within the Albuquerque Basin during the period between 1992 and 1996.

Figures 4-4 and 4-5 show the locations of the meteorological stations in the monitoring network, and "3.2 Climatology" provides a description of the sites.

Table 4-36. Summary of Five-Year Data Trends for Air Quality Within Albuquerque Basin

Pollutant (# of Sites)	Averaging Period	Units	Average Highest	Average Second Highest	Minimum Highest	Maximum Highest	Location of Highest
CO (7)	1-Hour	ppm	8.80	7.90	4.70	12.2	2ZK
	8-Hour	ppm	4.90	4.40	1.90	8.60	2ZK
NO ₂ (2)	24-Hour	ppm	0.0319	0.0294	0.0026	0.0508	2ZM
	Annual	ppm	0.0135	N/A	0.0018	0.0216	2ZM
O ₃ (10)	1-Hour	ppm	0.088	0.082	0.026	0.096	2ZJ
PM ₁₀ (11)	24-Hour	µg/m ³	66.9	53.7	16.0	101	2ZH
	Annual	µg/m ³	24.3	N/A	5.0	34.6	2R
CO = carbon monoxide NO ₂ = nitrogen dioxide O ₃ = ozone PM ₁₀ = particulate matter less than 10 microns in diameter ppm = parts per million µg/m ³ = microns per cubic meter N/A = not applicable							

Figure 4-40 displays the five-year trend in maximum carbon monoxide (CO) concentrations (averaged throughout the basin). Figures 4-41 and 4-42 display the trends for ozone (O₃) and particulate matter less than 10 microns in diameter (PM₁₀) respectively. No trending was plotted for nitrogen dioxide (NO₂) because only two stations within the network measure nitrogen oxides (NO_x).

Based on the trending analysis, maximum CO concentrations were steady or decreasing at most stations, especially for the eight-hour averaging period. The largest factor that influences this trend is the meteorological conditions during the previous several winters. Long periods of cold temperatures with calm wind speeds, especially during early morning hours, were less frequent and less severe in 1992 through 1996 than during previous winters.

Several stations show increasing concentrations of O₃. Stations 2ZE, 2ZF, and 2ZQ/2ZR, the shopping mall area, and Rio Rancho near Route 44, show O₃ concentrations only slightly below the AAQS. The PM₁₀ concentrations were highest at station 2ZH, near Alameda and the Rio Grande within the north valley. The trend for PM₁₀ and NO₂ has remained steady or increasing at many of the air quality monitoring stations during the past five years (1992 through 1996).

Figure 4-40. Air Quality Trends for CO Within the Albuquerque Basin

Figure 4-41. Air Quality Trends for O₃ Within the Albuquerque Basin

Figure 4-42. Air Quality Trends for PM₁₀ Within the Albuquerque Basin

6.0 REFERENCES

6.1 Regulations, Orders, and Laws

20 NMAC 11, *Environmental Protection*.

20 NMAC 2.03, *Ambient Air Quality Standards*.

40 CFR 50, *National Ambient Air Quality Standards (NAAQS)*.

40 CFR 51, *Requirements for Preparation, Adoption, and Submittal of Implementation Plans*.

40 CFR 53, *Ambient Air Monitoring Reference and Equivalent Methods*.

40 CFR 58, *Ambient Air Quality Surveillance*.

40 CFR 60, *Standards of Performance for New Stationary Sources*.

40 CFR 61, Subpart H, *National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities*.

40 CFR 63, *National Emission Standards for Hazardous Air Pollutants for Source Categories*.

40 CFR 70, *State Operating Permit Programs*.

40 CFR 71, *Federal Operating Permit Programs*.

40 CFR 80, *Regulation of Fuels and Fuel Additives*.

40 CFR 82, *Protection of Stratospheric Ozone*.

40 CFR 85, *Control of Air Pollution from Motor Vehicles and Motor Vehicle Engines*.

40 CFR 86, *Control of Air Pollution from New and In-Use Motor Vehicles and New and In-Use Motor Vehicle Engines: Certification and Test Procedures*.

40 CFR 93, *Determining Conformity of Federal Actions to State or Federal Implementation Plans*.

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6.2 General References

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ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN

Figure 4-43. Daytime Windroses for the Albuquerque Basin

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

Figure 4-45. Summer Windroses for the City of Albuquerque

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

Figure 4-46. Winter Windroses for the City of Albuquerque

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

Figure 4-47. Summer Windroses for the Albuquerque Basin

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

Figure 4-48. Winter Windroses for the Albuquerque Basin

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: Site 2R Period
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.054187	.024345	.003570	.002546	.000024	.000000	.084672
NNE	.033174	.012042	.000714	.000071	.000024	.000000	.046025
NE	.018943	.004617	.000309	.000048	.000000	.000000	.023917
ENE	.012184	.003903	.001666	.000405	.000000	.000000	.018158
E	.012351	.004760	.004355	.004355	.000524	.000000	.026344
ESE	.016801	.006568	.006259	.006878	.000738	.000071	.037315
SE	.026987	.006187	.003308	.001333	.000143	.000000	.037957
SSE	.042860	.018086	.001547	.000381	.000000	.000000	.062873
S	.056091	.041741	.010400	.002832	.000000	.000000	.111064
SSW	.035792	.016420	.003522	.000809	.000000	.000000	.056543
SW	.020537	.006830	.002023	.000500	.000000	.000000	.029890
WSW	.014588	.008639	.004474	.001237	.000000	.000000	.028938
W	.015683	.012970	.010066	.005164	.000262	.000000	.044145
WNW	.017301	.012113	.007211	.004593	.000524	.000024	.041765
NW	.021370	.011304	.006354	.002856	.000190	.000000	.042074
NNW	.033650	.013826	.006259	.002903	.000167	.000048	.056853
Total	.432498	.204350	.072035	.036910	.002594	.000143	

FREQUENCY CALM OR MISSING WINDS .251470

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2R DAYTIME

YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.057198	.025999	.003923	.002737	.000046	.000000	.089901
NNE	.037356	.014505	.000593	.000046	.000000	.000000	.052500
NE	.021210	.004607	.000502	.000091	.000000	.000000	.026409
ENE	.014277	.003375	.001733	.000319	.000000	.000000	.019704
E	.014322	.003330	.003238	.002600	.000365	.000000	.023855
ESE	.017926	.005473	.004333	.004789	.000639	.000137	.033297
SE	.030378	.007617	.003147	.001733	.000137	.000000	.043012
SSE	.048075	.029192	.001916	.000319	.000000	.000000	.079502
S	.056970	.062990	.015599	.004561	.000000	.000000	.140120
SSW	.034802	.023490	.005702	.001323	.000000	.000000	.065317
SW	.019157	.008393	.002509	.000867	.000000	.000000	.030925
WSW	.013091	.009533	.006066	.001870	.000000	.000000	.030560
W	.012270	.013866	.014733	.008301	.000502	.000000	.049672
WNW	.014049	.011905	.008529	.006431	.000821	.000046	.041781
NW	.017652	.012863	.009168	.004926	.000365	.000000	.044974
NNW	.031062	.013638	.008529	.004424	.000274	.000091	.058019
Total	.439792	.250775	.090221	.045338	.003147	.000274	

FREQUENCY CALM OR MISSING WINDS .170452

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2R NIGHTTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.050903	.022541	.003185	.002339	.000000	.000000	.078967
NNE	.028611	.009355	.000846	.000100	.000050	.000000	.038961
NE	.016470	.004628	.000100	.000000	.000000	.000000	.021197
ENE	.009902	.004478	.001592	.000498	.000000	.000000	.016470
E	.010201	.006319	.005573	.006270	.000697	.000000	.029059
ESE	.015574	.007762	.008359	.009156	.000846	.000000	.041698
SE	.023287	.004628	.003483	.000896	.000149	.000000	.032443
SSE	.037170	.005971	.001144	.000448	.000000	.000000	.044733
S	.055133	.018560	.004727	.000945	.000000	.000000	.079365
SSW	.036871	.008708	.001144	.000249	.000000	.000000	.046972
SW	.022043	.005125	.001493	.000100	.000000	.000000	.028761
WSW	.016221	.007663	.002737	.000547	.000000	.000000	.027168
W	.019406	.011992	.004976	.001742	.000000	.000000	.038115
WNW	.020849	.012340	.005772	.002587	.000199	.000000	.041748
NW	.025427	.009603	.003284	.000597	.000000	.000000	.038911
NNW	.036473	.014032	.003782	.001244	.000050	.000000	.055580
Total	.424541	.153705	.052197	.027716	.001990	.000000	

FREQUENCY CALM OR MISSING WINDS .339852

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZF PERIOD
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

	SPEED (KNOTS)						
	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.041336	.086409	.018086	.007853	.000762	.000190	.154637
NNE	.015349	.020561	.004855	.000333	.000071	.000000	.041170
NE	.018015	.033388	.004284	.000095	.000071	.000119	.055972
ENE	.015135	.020204	.002356	.000500	.000262	.000190	.038647
E	.013350	.033221	.016254	.007234	.003950	.002570	.076581
ESE	.010304	.034388	.022060	.004307	.001166	.000214	.072440
SE	.008924	.020466	.013874	.004902	.000214	.000000	.048381
SSE	.010090	.023131	.012470	.004355	.001499	.000119	.051665
S	.012303	.026939	.009329	.003808	.000547	.000000	.052926
SSW	.014612	.018538	.005283	.002451	.000333	.000024	.041241
SW	.015016	.011970	.005307	.005664	.001452	.000119	.039528
WSW	.012684	.009376	.004117	.004498	.002404	.000500	.033578
W	.014207	.011756	.004641	.004331	.001214	.000238	.036387
WNW	.013160	.020823	.008305	.010328	.002761	.000381	.055758
NW	.011804	.027986	.021061	.011732	.001571	.000309	.074463
NNW	.010185	.031817	.033531	.008305	.000238	.000024	.084101
Total	.236477	.430975	.185812	.080698	.018515	.004998	

FREQUENCY CALM OR MISSING WINDS .042526

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZF DAYTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

	SPEED (KNOTS)						
	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.035669	.076902	.013228	.005656	.000593	.000228	.132275
NNE	.008529	.006386	.000730	.000228	.000000	.000000	.015873
NE	.011312	.011768	.000639	.000091	.000091	.000228	.024129
ENE	.008529	.007207	.000684	.000411	.000182	.000046	.017059
E	.009852	.013501	.004926	.004014	.002235	.001733	.036262
ESE	.008393	.021620	.009077	.003375	.000958	.000228	.043651
SE	.009670	.022989	.013410	.003923	.000137	.000000	.050128
SSE	.013228	.037128	.019294	.005473	.002189	.000182	.077495
S	.019659	.047300	.015326	.005975	.000958	.000000	.089217
SSW	.025360	.031518	.007572	.004014	.000639	.000000	.069102
SW	.026637	.019340	.007435	.008758	.002554	.000228	.064952
WSW	.022350	.015052	.005382	.005382	.003831	.000867	.052864
W	.024494	.019203	.006203	.006203	.001733	.000411	.058247
WNW	.020662	.034984	.012817	.016557	.004698	.000639	.090358
NW	.014185	.034665	.023125	.013957	.002053	.000547	.088533
NNW	.007298	.017561	.016740	.005200	.000182	.000046	.047026
Total	.265827	.417123	.156586	.089217	.023034	.005382	

FREQUENCY CALM OR MISSING WINDS .042830

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZF NIGHTTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

	SPEED (KNOTS)						
	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.047520	.096781	.023387	.010250	.000945	.000149	.179032
NNE	.022789	.036025	.009355	.000448	.000149	.000000	.068766
NE	.025327	.056974	.008260	.000100	.000050	.000000	.090710
ENE	.022342	.034383	.004180	.000597	.000348	.000348	.062198
E	.017167	.054735	.028611	.010748	.005822	.003483	.120565
ESE	.012390	.048316	.036224	.005324	.001393	.000199	.103846
SE	.008111	.017714	.014380	.005971	.000299	.000000	.046475
SSE	.006668	.007862	.005026	.003135	.000746	.000050	.023486
S	.004279	.004727	.002786	.001443	.000100	.000000	.013335
SSW	.002886	.004379	.002786	.000746	.000000	.000050	.010847
SW	.002339	.003931	.002986	.002289	.000249	.000000	.011793
WSW	.002140	.003185	.002737	.003533	.000846	.000100	.012539
W	.002986	.003632	.002936	.002289	.000647	.000050	.012539
WNW	.004976	.005374	.003384	.003533	.000647	.000100	.018013
NW	.009205	.020700	.018809	.009305	.001045	.000050	.059113
NNW	.013335	.047370	.051849	.011693	.000299	.000000	.124546
Total	.204458	.446086	.217694	.071404	.013584	.004578	

FREQUENCY CALM OR MISSING WINDS .042195

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 22K PERIOD
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION							
SPEED (KNOTS)							
	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.036149	.017015	.003260	.000476	.000000	.000000	.056900
NNE	.016420	.003879	.000595	.000048	.000000	.000000	.020942
NE	.010780	.001809	.000309	.000119	.000000	.000000	.013017
ENE	.010257	.002094	.000690	.000095	.000000	.000000	.013136
E	.021727	.006354	.006806	.003950	.000071	.000000	.038909
ESE	.036053	.013707	.009233	.003617	.000024	.000000	.062635
SE	.039456	.015064	.003498	.000643	.000000	.000000	.058661
SSE	.033198	.020371	.005116	.002856	.000119	.000000	.061660
S	.038243	.027415	.007615	.003117	.000071	.000000	.076462
SSW	.032293	.019324	.005331	.001666	.000000	.000000	.058614
SW	.021680	.013279	.006140	.001452	.000071	.000000	.042622
WSW	.015016	.010281	.004974	.001499	.000000	.000000	.031770
W	.015921	.007591	.002784	.000952	.000000	.000000	.027248
WNW	.023940	.009233	.003808	.000238	.000000	.000000	.037219
NW	.048976	.019395	.006568	.001047	.000024	.000000	.076010
NNW	.050213	.026273	.007401	.001023	.000000	.000000	.084910
Total	.450322	.213084	.074130	.022798	.000381	.000000	

FREQUENCY CALM OR MISSING WINDS .239285

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZK DAYTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.030332	.015554	.003238	.000365	.000000	.000000	.049489
NNE	.010035	.002782	.000639	.000000	.000000	.000000	.013456
NE	.005565	.001460	.000137	.000137	.000000	.000000	.007298
ENE	.004789	.001824	.000411	.000046	.000000	.000000	.007070
E	.007800	.003284	.004196	.002737	.000046	.000000	.018062
ESE	.014140	.007845	.006842	.003193	.000000	.000000	.032020
SE	.025634	.009168	.003056	.000547	.000000	.000000	.038405
SSE	.038862	.023536	.004744	.003740	.000182	.000000	.071064
S	.058703	.039272	.009898	.004333	.000137	.000000	.112343
SSW	.051314	.028280	.007161	.002372	.000000	.000000	.089126
SW	.032293	.016968	.008575	.002509	.000137	.000000	.060482
WSW	.018838	.012543	.006614	.002691	.000000	.000000	.040686
W	.019750	.008986	.003877	.001368	.000000	.000000	.033981
WNW	.030150	.012498	.006796	.000411	.000000	.000000	.049854
NW	.058064	.023399	.010628	.001505	.000046	.000000	.093642
NNW	.052864	.027687	.008529	.001505	.000000	.000000	.090586
Total	.459132	.235085	.085340	.027458	.000547	.000000	

FREQUENCY CALM OR MISSING WINDS .192438

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZK NIGHTTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION							
SPEED (KNOTS)							
	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.042494	.018610	.003284	.000597	.000000	.000000	.064985
NNE	.023387	.005075	.000547	.000100	.000000	.000000	.029109
NE	.016470	.002189	.000498	.000100	.000000	.000000	.019257
ENE	.016221	.002388	.000995	.000149	.000000	.000000	.019754
E	.036921	.009703	.009653	.005274	.000100	.000000	.061651
ESE	.059959	.020103	.011843	.004080	.000050	.000000	.096034
SE	.054536	.021496	.003981	.000746	.000000	.000000	.080758
SSE	.027019	.016918	.005523	.001891	.000050	.000000	.051401
S	.015923	.014480	.005125	.001791	.000000	.000000	.037319
SSW	.011544	.009554	.003334	.000896	.000000	.000000	.025327
SW	.010101	.009255	.003483	.000299	.000000	.000000	.023138
WSW	.010847	.007812	.003185	.000199	.000000	.000000	.022043
W	.011743	.006071	.001592	.000498	.000000	.000000	.019903
WNW	.017167	.005672	.000547	.000050	.000000	.000000	.023436
NW	.039061	.015027	.002140	.000547	.000000	.000000	.056775
NNW	.047320	.024730	.006170	.000498	.000000	.000000	.078718
Total	.440713	.189083	.061900	.017714	.000199	.000000	

FREQUENCY CALM OR MISSING WINDS .290392

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZL PERIOD

YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.052545	.021489	.009019	.007163	.000785	.000024	.091026
NNE	.033150	.014255	.008305	.004712	.000214	.000000	.060636
NE	.025321	.012779	.003665	.000785	.000000	.000000	.042550
ENE	.022132	.017539	.003784	.000619	.000000	.000000	.044073
E	.021394	.017182	.003593	.000619	.000000	.000000	.042788
ESE	.017491	.008710	.001166	.000190	.000000	.000000	.027558
SE	.015016	.004807	.001356	.000309	.000000	.000000	.021489
SSE	.021370	.008472	.001499	.000405	.000000	.000000	.031746
S	.027105	.016182	.004307	.002142	.000095	.000000	.049832
SSW	.027272	.016563	.003355	.001523	.000000	.000000	.048714
SW	.028843	.035458	.005331	.001118	.000071	.000000	.070822
WSW	.023702	.036482	.011637	.004307	.000333	.000000	.076462
W	.026749	.020442	.005664	.002713	.000476	.000071	.056115
WNW	.038124	.016206	.005140	.004379	.000500	.000024	.064373
NW	.029247	.019252	.008853	.008258	.001618	.000333	.067561
NNW	.041313	.047786	.008448	.005307	.000952	.000095	.103900
Total	.450775	.313605	.085124	.044549	.005045	.000547	

FREQUENCY CALM OR MISSING WINDS .100355

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZL DAYTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

	SPEED (KNOTS)						
	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.032704	.013547	.010856	.010400	.001368	.000046	.068920
NNE	.026957	.013364	.010035	.006933	.000274	.000000	.057562
NE	.023490	.009852	.003786	.001049	.000000	.000000	.038177
ENE	.021073	.018017	.003558	.000593	.000000	.000000	.043240
E	.024038	.021438	.003877	.000639	.000000	.000000	.049991
ESE	.023171	.013592	.001323	.000182	.000000	.000000	.038269
SE	.022806	.006249	.001596	.000456	.000000	.000000	.031107
SSE	.033160	.010993	.001642	.000639	.000000	.000000	.046433
S	.039591	.022441	.005109	.002874	.000182	.000000	.070197
SSW	.037037	.021803	.003603	.002281	.000000	.000000	.064724
SW	.037949	.054735	.007572	.001733	.000137	.000000	.102126
WSW	.023445	.050447	.016648	.006294	.000593	.000000	.097427
W	.018610	.019340	.006477	.003330	.000821	.000137	.048714
WNW	.019887	.010901	.006614	.006933	.000912	.000046	.045293
NW	.014870	.015964	.010673	.011449	.002326	.000593	.055875
NNW	.018975	.017424	.008940	.007207	.001460	.000182	.054187
Total	.417761	.320106	.102308	.062990	.008073	.001003	

FREQUENCY CALM OR MISSING WINDS .087758

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZL NIGHTTIME

YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.074190	.030154	.007016	.003632	.000149	.000000	.115142
NNE	.039906	.015226	.006419	.002289	.000149	.000000	.063990
NE	.027318	.015973	.003533	.000498	.000000	.000000	.047320
ENE	.023287	.017017	.004030	.000647	.000000	.000000	.044982
E	.018510	.012539	.003284	.000597	.000000	.000000	.034931
ESE	.011295	.003384	.000995	.000199	.000000	.000000	.015873
SE	.006518	.003234	.001095	.000149	.000000	.000000	.010997
SSE	.008509	.005722	.001343	.000149	.000000	.000000	.015724
S	.013485	.009355	.003433	.001343	.000000	.000000	.027616
SSW	.016619	.010847	.003085	.000697	.000000	.000000	.031248
SW	.018908	.014430	.002886	.000448	.000000	.000000	.036672
WSW	.023984	.021247	.006170	.002140	.000050	.000000	.053590
W	.035627	.021645	.004777	.002040	.000100	.000000	.064189
WNW	.058019	.021993	.003533	.001592	.000050	.000000	.085187
NW	.044932	.022839	.006867	.004777	.000846	.000050	.080310
NNW	.065681	.080908	.007912	.003234	.000398	.000000	.158133
Total	.486789	.306513	.066378	.024432	.001742	.000050	

FREQUENCY CALM OR MISSING WINDS .114097

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZN PERIOD
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.029200	.011423	.003213	.002546	.000000	.000000	.046382
NNE	.018800	.010495	.008853	.005878	.000286	.000000	.044311
NE	.019276	.013731	.011018	.005021	.000214	.000000	.049261
ENE	.016016	.008448	.004474	.001190	.000000	.000000	.030128
E	.015802	.007496	.004783	.003498	.000286	.000000	.031865
ESE	.015516	.004236	.001856	.000595	.000000	.000000	.022203
SE	.022060	.005164	.000881	.000071	.000000	.000000	.028176
SSE	.022251	.009900	.001523	.000357	.000071	.000000	.034102
S	.019847	.010852	.002570	.001000	.000071	.000000	.034340
SSW	.020157	.011542	.002118	.000904	.000024	.000000	.034745
SW	.025844	.014469	.002975	.001404	.000095	.000000	.044787
WSW	.038457	.017801	.008662	.002999	.000071	.000000	.067990
W	.056567	.031770	.010471	.003022	.000167	.000000	.101997
WNW	.049142	.027700	.005854	.000976	.000000	.000000	.083672
NW	.043907	.015635	.003379	.000738	.000000	.000000	.063659
NNW	.035197	.012303	.002761	.000476	.000000	.000000	.050737
Total	.448038	.212965	.075391	.030675	.001285	.000000	

FREQUENCY CALM OR MISSING WINDS .231646

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZN DAYTIME

YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.030743	.010308	.003193	.002646	.000000	.000000	.046889
NNE	.015873	.009715	.007070	.003603	.000365	.000000	.036627
NE	.010445	.009259	.008712	.003147	.000228	.000000	.031792
ENE	.006659	.006294	.003512	.001140	.000000	.000000	.017606
E	.006796	.005109	.003467	.002053	.000000	.000000	.017424
ESE	.007526	.002417	.001003	.000821	.000000	.000000	.011768
SE	.011129	.002691	.000411	.000091	.000000	.000000	.014322
SSE	.015554	.006203	.001323	.000547	.000091	.000000	.023718
S	.018655	.009579	.002737	.001414	.000091	.000000	.032476
SSW	.022304	.011357	.001870	.001277	.000046	.000000	.036855
SW	.034255	.016055	.003421	.001642	.000182	.000000	.055556
WSW	.046935	.021255	.011722	.004926	.000137	.000000	.084975
W	.068464	.035304	.013456	.004424	.000274	.000000	.121921
WNW	.063675	.028918	.006568	.001323	.000000	.000000	.100483
NW	.058338	.017834	.004561	.001003	.000000	.000000	.081737
NNW	.042693	.014003	.003147	.000730	.000000	.000000	.060573
Total	.460044	.206304	.076172	.030788	.001414	.000000	

FREQUENCY CALM OR MISSING WINDS .225278

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE 2ZN NIGHTTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.027517	.012639	.003234	.002438	.000000	.000000	.045828
NNE	.021993	.011345	.010798	.008359	.000199	.000000	.052694
NE	.028910	.018610	.013534	.007066	.000199	.000000	.068319
ENE	.026223	.010798	.005523	.001244	.000000	.000000	.043788
E	.025626	.010101	.006220	.005075	.000597	.000000	.047619
ESE	.024232	.006220	.002786	.000348	.000000	.000000	.033587
SE	.033985	.007862	.001393	.000050	.000000	.000000	.043290
SSE	.029557	.013932	.001742	.000149	.000050	.000000	.045430
S	.021147	.012241	.002388	.000547	.000050	.000000	.036374
SSW	.017814	.011743	.002388	.000498	.000000	.000000	.032443
SW	.016669	.012738	.002488	.001144	.000000	.000000	.033040
WSW	.029208	.014032	.005324	.000896	.000000	.000000	.049460
W	.043589	.027915	.007215	.001493	.000050	.000000	.080261
WNW	.033289	.026372	.005075	.000597	.000000	.000000	.065333
NW	.028163	.013236	.002090	.000448	.000000	.000000	.043937
NNW	.027019	.010449	.002339	.000199	.000000	.000000	.040006
Total	.434941	.220232	.074538	.030552	.001144	.000000	

FREQUENCY CALM OR MISSING WINDS .238593

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE NWS-ALQ PERIOD
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.012338	.051815	.027458	.008872	.001140	.000137	.101761
NNE	.008142	.027687	.012908	.002805	.000137	.000023	.051701
NE	.006979	.017675	.005473	.001391	.000114	.000068	.031700
ENE	.006751	.013113	.004789	.003900	.001505	.000775	.030834
E	.009601	.021848	.011973	.014733	.007480	.004037	.069673
ESE	.012999	.033479	.012543	.006796	.002577	.001300	.069695
SE	.014596	.039956	.010764	.002600	.000593	.000205	.068715
SSE	.009715	.026181	.008005	.001756	.000661	.000274	.046593
S	.009807	.031404	.014208	.005291	.001117	.000593	.062420
SSW	.006500	.024425	.014117	.007822	.001733	.000251	.054849
SW	.007777	.030902	.017698	.007982	.001117	.000411	.065887
WSW	.006728	.027344	.012156	.006910	.002053	.000730	.055920
W	.008940	.025109	.012885	.009077	.003170	.001961	.061143
WNW	.007435	.024197	.009579	.006203	.002053	.001117	.050584
NW	.008666	.027937	.011859	.007275	.001665	.000616	.058019
NNW	.008233	.033297	.016717	.007389	.001414	.000411	.067460
Total	.145206	.456372	.203134	.100803	.028530	.012908	

FREQUENCY CALM OR MISSING WINDS .053047

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE NWS-ALQ DAYTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.010400	.040640	.023262	.008986	.001596	.000182	.085067
NNE	.006112	.021985	.009533	.002737	.000182	.000000	.040549
NE	.005154	.013729	.003877	.000867	.000137	.000091	.023855
ENE	.003786	.008165	.003375	.002554	.000775	.000775	.019431
E	.004652	.010810	.006933	.008484	.004652	.003056	.038588
ESE	.007389	.014596	.006933	.005565	.001916	.000912	.037311
SE	.008666	.022396	.007070	.003330	.000730	.000274	.042465
SSE	.007663	.021620	.007435	.001961	.000867	.000411	.039956
S	.009579	.036353	.016648	.007708	.001733	.001095	.073116
SSW	.008301	.033206	.020754	.012133	.003147	.000502	.078042
SW	.010126	.045612	.026820	.011540	.001596	.000821	.096515
WSW	.007663	.039044	.017059	.010536	.003375	.001368	.079046
W	.011403	.034437	.017333	.013182	.005610	.003512	.085477
WNW	.009487	.032020	.013456	.009442	.003330	.002053	.069787
NW	.010035	.035714	.016238	.011038	.002646	.001049	.076720
NNW	.008666	.032521	.017105	.008256	.002007	.000502	.069057
Total	.129082	.442848	.213830	.118318	.034300	.016603	

FREQUENCY CALM OR MISSING WINDS .045019

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE NWS-ALQ NIGHTTIME
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.014277	.062990	.031655	.008758	.000684	.000091	.118455
NNE	.010172	.033388	.016284	.002874	.000091	.000046	.062853
NE	.008803	.021620	.007070	.001916	.000091	.000046	.039546
ENE	.009715	.018062	.006203	.005245	.002235	.000775	.042237
E	.014550	.032886	.017013	.020982	.010308	.005017	.100757
ESE	.018610	.052363	.018154	.008028	.003238	.001688	.102080
SE	.020525	.057517	.014459	.001870	.000456	.000137	.094964
SSE	.011768	.030743	.008575	.001551	.000456	.000137	.053229
S	.010035	.026455	.011768	.002874	.000502	.000091	.051724
SSW	.004698	.015645	.007480	.003512	.000319	.000000	.031655
SW	.005428	.016192	.008575	.004424	.000639	.000000	.035258
WSW	.005793	.015645	.007252	.003284	.000730	.000091	.032795
W	.006477	.015782	.008438	.004972	.000730	.000411	.036809
WNW	.005382	.016375	.005702	.002965	.000775	.000182	.031381
NW	.007298	.020161	.007480	.003512	.000684	.000182	.039318
NNW	.007800	.034072	.016329	.006523	.000821	.000319	.065864
Total	.161330	.469896	.192438	.083288	.022760	.009214	

FREQUENCY CALM OR MISSING WINDS .061075

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE BERNALILLO
YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

	SPEED (KNOTS)						Total
	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	
N	.027442	.013049	.007820	.005661	.000192	.000000	.054164
NNE	.046560	.047352	.032048	.008084	.000336	.000024	.134403
NE	.044257	.056587	.034878	.005685	.000264	.000000	.141671
ENE	.027322	.028521	.015160	.005133	.000792	.000072	.077001
E	.020222	.017799	.010842	.003358	.000408	.000000	.052629
ESE	.007604	.009907	.011562	.002807	.000072	.000000	.031952
SE	.008732	.008899	.009955	.002471	.000120	.000000	.030177
SSE	.009475	.005685	.002423	.000480	.000000	.000000	.018063
S	.024396	.016096	.005301	.000480	.000000	.000000	.046272
SSW	.061768	.059370	.022213	.003190	.000048	.000000	.146589
SW	.053685	.034206	.011298	.002759	.000144	.000000	.102092
WSW	.029145	.010027	.003718	.001559	.000096	.000000	.044545
W	.015040	.003622	.002039	.000888	.000072	.000000	.021661
WNW	.011706	.002663	.001727	.000408	.000024	.000000	.016528
NW	.011658	.002279	.001631	.000312	.000024	.000000	.015904
NNW	.014465	.003190	.001199	.000456	.000000	.000000	.019310
Total	.413476	.319253	.173815	.043730	.002591	.000096	

FREQUENCY CALM OR MISSING WINDS .047040

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE LOS LUNAS

YEARS: 1992 1993 1994 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.024292	.008242	.003470	.000251	.000000	.000000	.036255
NNE	.029223	.010023	.003288	.000365	.000000	.000000	.042899
NE	.026392	.004452	.000913	.000137	.000000	.000000	.031894
ENE	.015068	.002237	.000434	.000023	.000000	.000000	.017762
E	.016027	.003767	.001119	.000091	.000000	.000000	.021004
ESE	.025890	.007488	.001142	.000091	.000000	.000000	.034611
SE	.028766	.004520	.000525	.000023	.000000	.000000	.033835
SSE	.027739	.003516	.000388	.000023	.000000	.000000	.031666
S	.033470	.006233	.001758	.000023	.000000	.000000	.041483
SSW	.024634	.003927	.000822	.000000	.000000	.000000	.029383
SW	.025730	.006256	.002854	.000662	.000000	.000000	.035501
WSW	.027945	.006986	.003447	.000457	.000000	.000000	.038835
W	.025753	.009977	.004566	.000936	.000000	.000000	.041232
WNW	.020958	.007100	.002169	.000274	.000000	.000000	.030502
NW	.017077	.003082	.000822	.000023	.000000	.000000	.021004
NNW	.016826	.004201	.002192	.000320	.000000	.000000	.023538
Total	.385790	.092007	.029908	.003699	.000000	.000000	

FREQUENCY CALM OR MISSING WINDS .488596

ATTACHMENT 4-1 - METEOROLOGICAL DATA TO SUPPORT WINDROSES IN THE ALBUQUERQUE BASIN (Continued)

RUN ID: SITE SOCORRO
YEARS: 1995 1996

FREQUENCY DISTRIBUTION

SPEED (KNOTS)

	1 - 3	4 - 6	7 - 10	11 - 16	17 - 21	> 21	Total
N	.127104	.051984	.007732	.002201	.000000	.000000	.189020
NNE	.037649	.022661	.004282	.000714	.000000	.000000	.065307
NE	.018914	.006899	.000119	.000000	.000000	.000000	.025932
ENE	.014334	.001725	.000119	.000000	.000000	.000000	.016178
E	.014215	.001844	.000059	.000000	.000000	.000000	.016118
ESE	.006543	.001130	.000059	.000000	.000000	.000000	.007732
SE	.011360	.001249	.000000	.000000	.000000	.000000	.012609
SSE	.046452	.022661	.001427	.000119	.000000	.000000	.070660
S	.052400	.033189	.009279	.003331	.000000	.000000	.098198
SSW	.031523	.018319	.010468	.004401	.000357	.000000	.065069
SW	.015226	.008684	.003688	.003509	.000238	.000000	.031345
WSW	.009041	.004996	.002439	.000535	.000000	.000000	.017011
W	.003212	.005056	.003271	.000535	.000000	.000000	.012074
WNW	.004580	.006959	.004520	.002260	.000000	.000000	.018319
NW	.013739	.017189	.007078	.002320	.000000	.000000	.040326
NNW	.028490	.021174	.008148	.002439	.000000	.000000	.060251
Total	.434783	.225718	.062690	.022364	.000595	.000000	

FREQUENCY CALM OR MISSING WINDS .253851

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
Temperature													
Daily Maximum	8.68	13.91	15.05	18.81	25.57	30.32	31.70	30.45	25.30	19.77	13.81	9.61	20.25
Daily Minimum	-0.76	2.72	2.91	6.55	13.16	17.78	19.49	18.84	14.07	8.26	3.13	-0.13	8.83
Monthly	3.43	7.93	9.10	12.70	19.56	24.08	25.38	24.30	19.38	13.54	7.91	4.13	14.29
Extremes													
Record High	16.05	20.38	24.26	28.04	32.40	37.52	37.21	34.65	33.29	27.39	21.47	19.36	37.52
Record Low	-8.33	-9.39	-5.87	-1.42	4.3	9.87	13.56	13.79	2.72	-4.05	-6.33	-12.84	-12.84
Relative Humidity						N/A							
Precipitation													
Monthly													
Maximum						N/A							
Minimum													
24 Hour Max													
Wind													
Monthly	2.46	3.03	3.32	3.46	3.35	3.18	2.96	2.86	2.62	2.78	2.40	2.10	2.88
24 Hour Max	5.03	8.24	10.27	8.77	9.15	6.45	5.82	5.40	9.27	10.42	6.02	6.28	10.42
Maximum Gust	26.05	27.65	30.85	27.65	25.25	32.45	30.85	26.05	30.05	30.05	24.45	30.05	32.45
Barometric Pressure						N/A							

ATTACHMENT 4-2 - CLIMATOLOGICAL DATA FOR SNL/NM (Continued)

Tower A21

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
Temperature													
Daily Maximum	9.40	13.29	15.95	19.79	26.11	31.42	32.92	31.36	26.07	20.47	14.39	10.13	20.94
Daily Minimum	-2.24	0.43	2.22	5.91	11.98	17.09	19.12	18.51	13.47	6.90	1.89	-1.23	7.84
Monthly	3.49	6.87	9.07	12.98	19.36	24.36	25.74	24.40	19.56	13.76	8.20	4.40	14.35
Extremes													
Record High	19.47	20.99	24.68	29.76	33.89	39.06	38.42	35.94	34.08	28.17	22.37	19.39	39.06
Record Low	-9.81	-12.49	-5.8	-2.56	4.47	8.23	11.35	14.12	3.27	-3.93	-6.84	-12.3	-12.49
Relative Humidity													
Monthly	42.90	40.34	37.10	28.25	26.19	25.84	33.24	44.78	45.52	39.28	45.87	47.01	38.03
Precipitation													
Monthly	0.64	0.91	0.72	0.47	2.53	1.88	1.53	6.81	3.27	2.85	2.02	0.76	24.39
Maximum	1.27	1.85	1.80	1.19	7.42	5.21	2.54	10.69	4.37	4.75	3.78	1.96	10.69
Minimum	0.03	0.28	0.03	0.00	0.03	0.18	0.38	4.04	2.54	0.00	0.18	0.00	0.00
24 Hour Max	0.97	1.50	0.48	0.53	2.34	1.75	1.22	4.01	1.83	2.67	1.83	0.99	4.01
Wind													
Monthly	3.30	3.67	4.05	4.39	4.47	4.11	3.77	3.49	3.29	3.55	3.22	2.74	3.67
24 Hour Max	9.22	9.24	12.27	9.92	10.12	8.18	7.44	6.37	10.30	11.71	6.98	7.13	12.27
Maximum Gust	26.85	22.05	26.85	23.65	24.45	32.45	28.45	25.25	26.85	26.05	22.85	26.05	32.45
Barometric Pressure													
Monthly	835.44	835.24	833.80	832.41	832.21	834.99	836.98	837.34	836.76	835.28	836.11	836.12	835.22

ATTACHMENT 4-2 - CLIMATOLOGICAL DATA FOR SNL/NM (Continued)

Tower A36

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
Temperature													
Daily Maximum	9.5	13.5	16.1	20.0	27.8	31.6	32.9	31.5	26.2	20.6	14.3	10.3	21.2
Daily Minimum	-2.4	0.5	2.2	5.5	11.3	16.7	18.5	18.2	13.1	6.8	1.1	-1.3	7.5
Average	3.7	7.2	9.3	13.0	19.6	24.3	25.5	24.4	19.8	14.7	8.6	4.8	14.6
Extremes													
Record High	19.8	20.8	25.0	29.8	34.4	39.3	38.4	36.0	34.1	28.3	22.5	19.5	39.3
Record Low	-10.1	-11.2	-6.1	-2.6	3.1	7.8	11.5	14.8	3.5	-4.5	-7.6	-13.6	-13.6
Relative Humidity													
	46.1	43.4	39.6	30.1	27.9	28.7	35.8	47.6	48.4	42.2	48.9	50.6	40.8
Precipitation													
Average	0.7	0.9	0.7	0.4	2.5	1.6	2.1	7.3	3.3	4.0	1.9	0.8	26.3
Maximum	1.3	1.5	1.5	1.2	7.2	3.7	2.5	11.6	4.4	7.6	3.8	2.1	11.6
Minimum	0.0	0.5	0.1	0.0	0.0	0.1	1.5	3.0	2.0	0.0	0.2	0.0	0.0
24 Hour Max	1.0	1.1	0.4	0.6	1.7	1.6	2.4	3.5	1.7	2.8	1.9	1.1	3.5
Wind													
Monthly	3.3	3.6	4.1	4.4	4.5	4.1	3.9	3.5	3.3	3.6	3.3	2.9	3.7
24 Hour Max	8.5	8.1	11.2	9.7	10.6	9.1	6.6	6.4	9.1	11.6	7.5	7.1	11.6
Maximum Gust	25.3	22.1	25.3	23.7	25.3	26.9	26.9	27.7	19.7	25.3	23.7	26.9	27.7
Barometric Pressure													
	838.2	836.9	834.8	832.4	830.7	832.2	833.7	834.5	835.4	835.2	837.0	837.6	834.9

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
Temperature													
Daily Maximum	9.53	13.50	16.14	19.97	27.80	31.63	32.93	31.46	26.17	20.57	14.29	10.32	21.19
Daily Minimum	-2.84	-0.11	1.83	5.30	11.53	16.56	18.84	18.39	13.36	6.58	1.44	-1.73	7.43
Monthly	3.28	6.75	9.00	12.93	19.25	24.25	25.39	24.33	19.50	13.64	7.99	4.21	14.21
Extremes													
Record High	19.58	20.61	25.43	29.85	33.59	38.92	38.18	35.72	34.29	28.55	22.50	19.47	38.92
Record Low	-9.8	-11.68	-5.79	-4.18	4.89	8.9	11.41	14.46	3.61	-4.2	-7.97	-12.2	-12.21
Relative Humidity													
Monthly	44.23	41.51	38.02	29.12	26.96	28.12	36.32	47.27	47.80	41.27	47.29	47.85	39.65
Precipitation													
Monthly	N/A												
Maximum													
Minimum													
24 Hour Max													
Monthly													
Wind													
Monthly	3.30	3.65	3.90	4.32	4.46	3.99	3.69	3.40	3.17	3.42	3.22	2.80	3.61
24 Hour Max	8.12	8.96	11.83	9.89	9.76	9.80	6.30	6.35	9.63	10.02	7.17	6.62	11.83
Maximum Gust	26.85	22.05	25.25	23.65	27.65	24.45	26.85	22.05	22.05	24.45	22.05	28.45	28.45
Barometric Pressure													
Monthly	N/A												

ATTACHMENT 4-2 - CLIMATOLOGICAL DATA FOR SNL/NM (Continued)

Tower CW1

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
Temperature													
Daily Maximum	9.51	13.39	16.07	19.85	26.34	31.62	32.71	31.40	26.12	20.61	14.51	10.31	21.04
Daily Minimum	-2.68	0.05	1.66	5.09	11.20	16.51	18.17	17.80	13.02	6.43	1.23	-2.04	7.20
Monthly	3.45	6.85	9.01	12.85	19.19	24.32	25.30	24.19	19.40	13.73	8.05	4.32	14.22
Extremes													
Record High	19.80	20.54	25.91	29.99	34.01	39.33	38.26	35.73	33.81	28.37	22.55	19.48	39.33
Record Low	-10.5	-11.3	-5.2	-4.01	3.8	7.28	9.25	14.6	3.74	-4.35	-7.89	-14.5	-14.48
Relative Humidity													
Monthly	47.01	44.09	40.22	30.29	27.99	28.99	36.42	47.64	49.40	42.67	49.96	51.96	41.39
Precipitation													
Monthly							N/A						
Maximum													
Minimum													
24 Hour Max													
Wind													
Monthly	3.70	4.07	4.46	4.83	4.96	4.40	4.10	3.80	3.65	4.03	3.69	3.20	4.07
24 Hour Max	8.80	7.86	11.58	9.98	10.43	9.35	6.97	6.82	8.89	10.54	7.44	6.82	11.58
Maximum Gust	26.85	22.85	26.05	23.65	30.05	24.45	26.05	24.45	28.45	27.65	25.25	26.85	30.05
Barometric Pressure							N/A						

[illegible]

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Totals
Temperature													
Daily Maximum	8.53	12.32	14.99	18.83	25.20	30.46	31.74	30.34	25.14	19.66	13.49	9.30	20.00
Daily Minimum	-2.40	0.05	1.52	5.09	10.93	16.18	18.07	17.54	12.80	6.64	1.70	-1.37	7.23
Monthly	3.16	6.38	8.36	12.23	18.57	23.61	24.77	23.59	18.91	13.34	7.83	4.14	13.74
Extremes													
Record High	18.97	19.95	24.47	28.86	32.82	38.43	38.00	34.87	32.95	32.30	21.64	18.42	38.43
Record Low	-11.1	-10.8	-6.39	-3.5	4.18	6.67	9.93	14.2	2.22	-5.11	-7.11	-14	-13.97
Relative Humidity													
	45.66	43.67	40.60	30.73	28.35	28.97	36.36	48.01	48.58	42.13	48.82	50.54	41.03
Precipitation													
Monthly	0.80	1.01	0.86	0.88	3.00	2.29	2.35	7.48	3.69	3.23	2.10	0.92	28.59
Maximum	1.37	1.75	1.78	2.18	8.33	6.27	4.42	10.06	4.83	5.61	4.06	2.46	10.06
Minimum	0.08	0.53	0.08	0.00	0.00	0.03	0.97	4.80	2.44	0.00	0.36	0.00	0.00
24 Hour Max	0.99	1.09	0.61	0.86	2.39	2.31	1.93	3.25	2.59	2.84	1.93	1.17	3.25
Wind													
Monthly	3.45	3.86	4.24	4.70	4.87	4.35	4.15	3.78	3.45	3.80	3.49	2.94	3.92
24 Hour Max	9.50	8.28	10.85	9.66	11.61	9.18	7.38	7.37	8.11	13.26	7.85	7.46	13.26
Maximum Gust	26.05	23.65	28.45	26.05	26.85	25.25	26.05	26.05	29.25	30.05	27.65	29.25	30.05
Barometric Pressure													
	N/A												

ATTACHMENT 4-3 – METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES

A21	WINTER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00208	0.02531	0.03796	0.01200	0.00232	0.00000	0.00000	0.07967
NNE	0.00162	0.02118	0.00976	0.00073	0.00008	0.00000	0.00000	0.03337
NE	0.00270	0.02847	0.01497	0.00177	0.00027	0.00000	0.00000	0.04819
ENE	0.00382	0.05991	0.01698	0.01404	0.01119	0.00359	0.00012	0.10967
E	0.00359	0.03696	0.00579	0.00799	0.01316	0.01477	0.00085	0.08310
ESE	0.00328	0.03253	0.00239	0.00204	0.00143	0.00031	0.00000	0.04197
SE	0.00297	0.03592	0.00266	0.00096	0.00066	0.00004	0.00000	0.04321
SSE	0.00286	0.03758	0.01551	0.00069	0.00008	0.00000	0.00000	0.05671
S	0.00232	0.03140	0.01852	0.00455	0.00332	0.00042	0.00000	0.06053
SSW	0.00174	0.02952	0.01964	0.00884	0.00552	0.00116	0.00000	0.06640
SW	0.00170	0.02569	0.01246	0.00756	0.00463	0.00228	0.00012	0.05443
WSW	0.00174	0.02639	0.01458	0.00972	0.00610	0.00251	0.00004	0.06107
W	0.00204	0.02138	0.01312	0.00826	0.00802	0.00494	0.00008	0.05783
WNW	0.00181	0.02249	0.01050	0.00548	0.00517	0.00150	0.00000	0.04695
NW	0.00220	0.02940	0.01543	0.01119	0.00648	0.00174	0.00000	0.06643
NNW	0.00197	0.03148	0.03334	0.01670	0.00629	0.00069	0.00000	0.09047
Totals	0.03842	0.49561	0.24360	0.11254	0.07469	0.03395	0.00120	1.00001

A21	SPRING							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00099	0.02267	0.02328	0.00718	0.00111	0.00011	0.00000	0.05535
NNE	0.00050	0.01962	0.00851	0.00095	0.00031	0.00000	0.00000	0.02989
NE	0.00099	0.02386	0.01427	0.00305	0.00023	0.00000	0.00000	0.04241
ENE	0.00198	0.03901	0.02355	0.01527	0.01183	0.00267	0.00000	0.09429
E	0.00179	0.02786	0.01095	0.01324	0.02366	0.01275	0.00000	0.09027
ESE	0.00134	0.02435	0.00450	0.00454	0.00733	0.00145	0.00000	0.04352
SE	0.00092	0.03000	0.00752	0.00328	0.00462	0.00050	0.00000	0.04684
SSE	0.00099	0.02878	0.02237	0.00416	0.00160	0.00011	0.00000	0.05802
S	0.00076	0.02405	0.01840	0.00809	0.01202	0.00553	0.00000	0.06886
SSW	0.00088	0.02321	0.02401	0.01573	0.01225	0.00340	0.00000	0.07946
SW	0.00053	0.02053	0.02378	0.01095	0.00622	0.00107	0.00000	0.06309
WSW	0.00069	0.01851	0.02084	0.01306	0.00920	0.00294	0.00000	0.06523
W	0.00080	0.01737	0.01756	0.01542	0.01496	0.00870	0.00008	0.07489
WNW	0.00080	0.02091	0.02107	0.01206	0.00851	0.00111	0.00000	0.06447
NW	0.00099	0.02424	0.01859	0.00958	0.00447	0.00103	0.00000	0.05890
NNW	0.00076	0.02305	0.02306	0.01122	0.00550	0.00092	0.00000	0.06451
Totals	0.01573	0.38803	0.28225	0.14779	0.12382	0.04229	0.00008	0.99998

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

A21	SUMMER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00152	0.02662	0.01780	0.00587	0.00218	0.00004	0.00000	0.05401
NNE	0.00163	0.02596	0.00909	0.00175	0.00047	0.00012	0.00000	0.03901
NE	0.00229	0.03408	0.01612	0.00249	0.00054	0.00008	0.00000	0.05560
ENE	0.00280	0.05685	0.03668	0.01582	0.01006	0.00202	0.00000	0.12422
E	0.00260	0.03489	0.02180	0.02366	0.02949	0.01216	0.00012	0.12472
ESE	0.00206	0.02797	0.00991	0.00952	0.00742	0.00132	0.00000	0.05821
SE	0.00183	0.03054	0.01173	0.00525	0.00187	0.00019	0.00000	0.05141
SSE	0.00175	0.03116	0.01931	0.00253	0.00051	0.00000	0.00000	0.05525
S	0.00109	0.02914	0.01818	0.00299	0.00066	0.00004	0.00000	0.05211
SSW	0.00136	0.02790	0.02712	0.00486	0.00179	0.00054	0.00000	0.06357
SW	0.00120	0.02910	0.02176	0.00493	0.00093	0.00019	0.00000	0.05813
WSW	0.00152	0.02949	0.01601	0.00385	0.00190	0.00019	0.00000	0.05296
W	0.00144	0.02755	0.01321	0.00443	0.00307	0.00039	0.00000	0.05009
WNW	0.00128	0.03015	0.01368	0.00237	0.00132	0.00019	0.00004	0.04903
NW	0.00152	0.03147	0.01582	0.00330	0.00105	0.00000	0.00000	0.05316
NNW	0.00148	0.03015	0.01958	0.00517	0.00202	0.00012	0.00000	0.05852
Totals	0.02736	0.50303	0.28781	0.09877	0.06528	0.01760	0.00016	1.00000

A21	FALL							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00298	0.03358	0.03365	0.01009	0.00174	0.00049	0.00000	0.08252
NNE	0.00317	0.02908	0.00744	0.00091	0.00004	0.00000	0.00000	0.04064
NE	0.00381	0.04298	0.02138	0.00227	0.00030	0.00000	0.00000	0.07074
ENE	0.00521	0.07882	0.01632	0.00842	0.00854	0.00140	0.00000	0.11870
E	0.00491	0.04150	0.00446	0.00612	0.00956	0.00763	0.00011	0.07429
ESE	0.00468	0.03512	0.00246	0.00317	0.00208	0.00306	0.00000	0.05057
SE	0.00453	0.03418	0.00321	0.00045	0.00038	0.00023	0.00000	0.04298
SSE	0.00351	0.03565	0.01209	0.00057	0.00011	0.00000	0.00000	0.05193
S	0.00321	0.03335	0.01344	0.00412	0.00434	0.00110	0.00000	0.05956
SSW	0.00306	0.03293	0.02028	0.00502	0.00438	0.00155	0.00000	0.06723
SW	0.00257	0.02840	0.01250	0.00329	0.00140	0.00068	0.00000	0.04884
WSW	0.00321	0.02840	0.00793	0.00381	0.00257	0.00087	0.00000	0.04680
W	0.00276	0.02338	0.00816	0.00412	0.00374	0.00261	0.00015	0.04490
WNW	0.00329	0.02836	0.00661	0.00257	0.00344	0.00064	0.00000	0.04490
NW	0.00268	0.03324	0.01647	0.00767	0.00276	0.00038	0.00004	0.06322
NNW	0.00287	0.03577	0.03233	0.01522	0.00480	0.00121	0.00000	0.09219
Totals	0.05646	0.57474	0.21871	0.07780	0.05016	0.02183	0.00030	1.00000

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

A15	WINTER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00747	0.04352	0.01025	0.00017	0.00000	0.00000	0.00000	0.06140
NNE	0.00949	0.01777	0.00041	0.00000	0.00000	0.00000	0.00000	0.02766
NE	0.01221	0.02691	0.00197	0.00041	0.00017	0.00000	0.00000	0.04167
ENE	0.01001	0.06401	0.01030	0.00654	0.00538	0.00052	0.00000	0.09675
E	0.00828	0.04682	0.01198	0.01742	0.02084	0.01192	0.00000	0.11720
ESE	0.00475	0.03079	0.00313	0.00075	0.00006	0.00000	0.00000	0.03947
SE	0.00475	0.02691	0.00191	0.00029	0.00006	0.00000	0.00000	0.03392
SSE	0.00255	0.04010	0.00949	0.00046	0.00000	0.00000	0.00000	0.05261
S	0.00179	0.04178	0.01597	0.00579	0.00133	0.00000	0.00000	0.06667
SSW	0.00208	0.03374	0.01430	0.00602	0.00179	0.00000	0.00000	0.05793
SW	0.00145	0.02483	0.01349	0.00550	0.00179	0.00029	0.00000	0.04734
WSW	0.00220	0.02807	0.02141	0.01065	0.00295	0.00000	0.00000	0.06528
W	0.00278	0.02697	0.01817	0.01279	0.00787	0.00029	0.00000	0.06887
WNW	0.00422	0.03530	0.01354	0.00637	0.00197	0.00000	0.00000	0.06140
NW	0.00492	0.04034	0.02304	0.00613	0.00145	0.00000	0.00000	0.07587
NNW	0.00671	0.05290	0.02332	0.00295	0.00006	0.00000	0.00000	0.08594
Totals	0.08565	0.58071	0.19265	0.08223	0.04572	0.01302	0.00000	0.99995

A15	SPRING							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00613	0.02966	0.00378	0.00017	0.00000	0.00000	0.00000	0.03973
NNE	0.00928	0.02027	0.00046	0.00000	0.00000	0.00000	0.00000	0.03000
NE	0.00773	0.03184	0.00315	0.00034	0.00000	0.00000	0.00000	0.04306
ENE	0.00727	0.04495	0.01569	0.00945	0.00252	0.00023	0.00000	0.08010
E	0.00464	0.02891	0.01769	0.02508	0.03830	0.00641	0.00000	0.12104
ESE	0.00332	0.01930	0.00481	0.00532	0.00212	0.00006	0.00000	0.03493
SE	0.00189	0.02399	0.00618	0.00298	0.00120	0.00000	0.00000	0.03624
SSE	0.00149	0.03132	0.01048	0.00275	0.00120	0.00011	0.00000	0.04735
S	0.00069	0.02622	0.01638	0.01139	0.01013	0.00006	0.00000	0.06487
SSW	0.00080	0.02680	0.02388	0.00968	0.00326	0.00006	0.00000	0.06448
SW	0.00109	0.02634	0.02388	0.00744	0.00143	0.00000	0.00000	0.06017
WSW	0.00092	0.02725	0.03550	0.01924	0.00533	0.00011	0.00000	0.08834
W	0.00218	0.03246	0.03069	0.02113	0.01214	0.00143	0.00000	0.10004
WNW	0.00235	0.03791	0.01781	0.00744	0.00155	0.00000	0.00000	0.06705
NW	0.00378	0.04008	0.01827	0.00555	0.00057	0.00000	0.00000	0.06825
NNW	0.00401	0.03475	0.01380	0.00166	0.00011	0.00000	0.00000	0.05434
Totals	0.05754	0.48204	0.24243	0.12963	0.07987	0.00847	0.00000	1.00001

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

A15	SUMMER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00790	0.03417	0.00442	0.00023	0.00000	0.00000	0.00000	0.04673
NNE	0.01047	0.02835	0.00129	0.00004	0.00000	0.00000	0.00000	0.04015
NE	0.01180	0.04518	0.00416	0.00049	0.00004	0.00000	0.00000	0.06166
ENE	0.01024	0.06574	0.01883	0.00684	0.00302	0.00030	0.00000	0.10500
E	0.00510	0.03591	0.04363	0.04196	0.03183	0.00571	0.00000	0.16413
ESE	0.00231	0.02533	0.01319	0.00771	0.00178	0.00011	0.00000	0.05043
SE	0.00151	0.03123	0.00881	0.00208	0.00030	0.00000	0.00000	0.04393
SSE	0.00064	0.03368	0.00911	0.00117	0.00008	0.00000	0.00000	0.04469
S	0.00045	0.03406	0.01209	0.00129	0.00015	0.00000	0.00000	0.04805
SSW	0.00083	0.03606	0.01618	0.00155	0.00049	0.00000	0.00000	0.05512
SW	0.00079	0.03437	0.01270	0.00106	0.00019	0.00000	0.00000	0.04911
WSW	0.00106	0.03369	0.01228	0.00249	0.00026	0.00000	0.00000	0.04979
W	0.00170	0.04060	0.01293	0.00416	0.00087	0.00000	0.00000	0.06026
WNW	0.00321	0.04884	0.00813	0.00110	0.00011	0.00004	0.00000	0.06143
NW	0.00454	0.05005	0.00866	0.00076	0.00000	0.00000	0.00000	0.06400
NNW	0.00673	0.04113	0.00715	0.00053	0.00000	0.00000	0.00000	0.05554
Totals	0.06930	0.61840	0.19355	0.07345	0.03913	0.00616	0.00000	1.00000

A15	FALL							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.01201	0.04049	0.00665	0.00057	0.00004	0.00000	0.00000	0.05975
NNE	0.01654	0.02447	0.00053	0.00000	0.00000	0.00000	0.00000	0.04154
NE	0.01941	0.04411	0.00287	0.00030	0.00000	0.00000	0.00000	0.06670
ENE	0.01726	0.09148	0.00846	0.00487	0.00234	0.00034	0.00000	0.12476
E	0.01073	0.04857	0.01092	0.01356	0.01269	0.00374	0.00000	0.10021
ESE	0.00699	0.03048	0.00249	0.00162	0.00196	0.00121	0.00000	0.04476
SE	0.00423	0.02428	0.00174	0.00030	0.00015	0.00000	0.00000	0.03070
SSE	0.00268	0.03161	0.00434	0.00049	0.00004	0.00000	0.00000	0.03917
S	0.00193	0.04026	0.01243	0.00567	0.00264	0.00004	0.00000	0.06296
SSW	0.00272	0.04158	0.01288	0.00374	0.00121	0.00000	0.00000	0.06213
SW	0.00193	0.02866	0.00774	0.00132	0.00295	0.00136	0.00000	0.04396
WSW	0.00249	0.02882	0.00839	0.00272	0.00083	0.00019	0.00000	0.04343
W	0.00310	0.03410	0.00880	0.00472	0.00374	0.00064	0.00000	0.05510
WNW	0.00612	0.03917	0.00820	0.00317	0.00091	0.00008	0.00000	0.05763
NW	0.00797	0.04725	0.01839	0.00336	0.00023	0.00000	0.00000	0.07719
NNW	0.00876	0.05654	0.02138	0.00332	0.00004	0.00000	0.00000	0.09004
Totals	0.12486	0.65188	0.13620	0.04974	0.02976	0.00759	0.00000	1.00003

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

CL1	WINTER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00373	0.05097	0.06081	0.02256	0.00430	0.00000	0.00000	0.14238
NNE	0.00361	0.02598	0.01411	0.00250	0.00023	0.00000	0.00000	0.04643
NE	0.00304	0.01715	0.00527	0.00142	0.00046	0.00004	0.00000	0.02737
ENE	0.00357	0.01399	0.00515	0.00584	0.00446	0.00173	0.00004	0.03479
E	0.00350	0.02129	0.00680	0.00911	0.01138	0.01092	0.00058	0.06358
ESE	0.00377	0.04297	0.00930	0.00338	0.00527	0.00104	0.00000	0.06573
SE	0.00415	0.04820	0.00823	0.00123	0.00069	0.00004	0.00000	0.06254
SSE	0.00365	0.03705	0.00750	0.00119	0.00046	0.00000	0.00000	0.04985
S	0.00331	0.03556	0.01841	0.00573	0.00369	0.00161	0.00000	0.06831
SSW	0.00427	0.03037	0.01972	0.00969	0.00600	0.00223	0.00000	0.07227
SW	0.00311	0.02445	0.01557	0.00819	0.00315	0.00215	0.00004	0.05666
WSW	0.00261	0.02179	0.01438	0.01153	0.00761	0.00292	0.00004	0.06088
W	0.00181	0.02233	0.01369	0.00869	0.00715	0.00246	0.00000	0.05612
WNW	0.00200	0.02006	0.00899	0.00519	0.00492	0.00142	0.00000	0.04259
NW	0.00227	0.02791	0.01268	0.00926	0.00384	0.00081	0.00000	0.05677
NNW	0.00238	0.03805	0.02813	0.01707	0.00742	0.00069	0.00000	0.09375
Totals	0.05078	0.47813	0.24873	0.12258	0.07103	0.02806	0.00069	1.00001

CL1	SPRING							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00126	0.03385	0.03947	0.01237	0.00252	0.00023	0.00000	0.08969
NNE	0.00176	0.02340	0.01515	0.00221	0.00069	0.00000	0.00000	0.04321
NE	0.00156	0.01599	0.00679	0.00137	0.00031	0.00000	0.00000	0.02603
ENE	0.00176	0.01103	0.00756	0.00595	0.00313	0.00034	0.00000	0.02977
E	0.00195	0.01500	0.01034	0.01214	0.02157	0.01019	0.00000	0.07119
ESE	0.00179	0.03283	0.01477	0.00439	0.00767	0.00157	0.00004	0.06305
SE	0.00275	0.03836	0.01179	0.00359	0.00511	0.00145	0.00000	0.06306
SSE	0.00252	0.02855	0.01015	0.00439	0.00324	0.00069	0.00004	0.04958
S	0.00252	0.02565	0.01584	0.00824	0.01099	0.01092	0.00004	0.07420
SSW	0.00198	0.02542	0.02508	0.01668	0.01340	0.00573	0.00004	0.08832
SW	0.00145	0.02294	0.02550	0.01206	0.00584	0.00168	0.00000	0.06947
WSW	0.00126	0.02008	0.02099	0.01695	0.01351	0.00286	0.00000	0.07565
W	0.00111	0.02141	0.02134	0.01565	0.01260	0.00485	0.00000	0.07695
WNW	0.00126	0.01909	0.01603	0.00886	0.00786	0.00099	0.00000	0.05409
NW	0.00092	0.02348	0.01366	0.00905	0.00313	0.00038	0.00000	0.05061
NNW	0.00118	0.02924	0.02313	0.01347	0.00638	0.00168	0.00004	0.07511
Totals	0.02702	0.38631	0.27761	0.14737	0.11794	0.04355	0.00019	0.99999

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

CL1	SUMMER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00181	0.04944	0.03703	0.00778	0.00396	0.00102	0.00000	0.10105
NNE	0.00177	0.03042	0.01306	0.00264	0.00109	0.00011	0.00000	0.04910
NE	0.00193	0.02238	0.00974	0.00208	0.00042	0.00000	0.00000	0.03654
ENE	0.00219	0.01861	0.01295	0.00680	0.00294	0.00060	0.00000	0.04408
E	0.00226	0.02612	0.01782	0.02269	0.02189	0.00785	0.00004	0.09868
ESE	0.00264	0.03978	0.01951	0.01196	0.01061	0.00234	0.00000	0.08685
SE	0.00362	0.04235	0.01351	0.00623	0.00393	0.00049	0.00000	0.07013
SSE	0.00313	0.03325	0.01038	0.00464	0.00147	0.00004	0.00000	0.05292
S	0.00336	0.03031	0.01698	0.00513	0.00245	0.00060	0.00000	0.05884
SSW	0.00264	0.03367	0.02548	0.00789	0.00219	0.00057	0.00000	0.07243
SW	0.00230	0.03046	0.02416	0.00555	0.00140	0.00045	0.00000	0.06432
WSW	0.00155	0.02952	0.02027	0.00411	0.00151	0.00019	0.00000	0.05715
W	0.00113	0.02861	0.01404	0.00457	0.00279	0.00008	0.00000	0.05122
WNW	0.00102	0.02600	0.00759	0.00245	0.00121	0.00015	0.00000	0.03842
NW	0.00159	0.03106	0.01049	0.00332	0.00079	0.00011	0.00000	0.04737
NNW	0.00140	0.04065	0.02076	0.00540	0.00249	0.00023	0.00000	0.07092
Totals	0.03435	0.51263	0.27377	0.10323	0.06115	0.01483	0.00004	1.00002

CL1	FALL							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00472	0.06440	0.06452	0.01815	0.00483	0.00103	0.00000	0.15765
NNE	0.00426	0.04054	0.01793	0.00221	0.00027	0.00004	0.00000	0.06524
NE	0.00426	0.02451	0.00442	0.00126	0.00030	0.00000	0.00000	0.03475
ENE	0.00396	0.01861	0.00400	0.00365	0.00343	0.00103	0.00000	0.03468
E	0.00442	0.02642	0.00476	0.00639	0.00891	0.00415	0.00000	0.05504
ESE	0.00495	0.04632	0.00856	0.00289	0.00228	0.00240	0.00015	0.06756
SE	0.00586	0.04925	0.00803	0.00129	0.00099	0.00103	0.00000	0.06646
SSE	0.00533	0.03810	0.00552	0.00080	0.00034	0.00000	0.00000	0.05009
S	0.00521	0.03624	0.01496	0.00430	0.00457	0.00251	0.00000	0.06779
SSW	0.00442	0.03475	0.01918	0.00499	0.00518	0.00221	0.00000	0.07072
SW	0.00415	0.02798	0.01203	0.00453	0.00171	0.00065	0.00000	0.05104
WSW	0.00320	0.02272	0.00818	0.00407	0.00339	0.00088	0.00000	0.04244
W	0.00247	0.02017	0.00708	0.00430	0.00316	0.00160	0.00000	0.03879
WNW	0.00350	0.02341	0.00548	0.00263	0.00304	0.00072	0.00000	0.03879
NW	0.00282	0.03304	0.01024	0.00445	0.00137	0.00015	0.00000	0.05207
NNW	0.00354	0.04625	0.03079	0.01736	0.00719	0.00175	0.00000	0.10686
Totals	0.06707	0.55273	0.22567	0.08328	0.05097	0.02014	0.00015	0.99998

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

CW1	WINTER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00185	0.02129	0.01849	0.00750	0.00273	0.00000	0.00000	0.05185
NNE	0.00188	0.02014	0.01879	0.00227	0.00023	0.00000	0.00000	0.04332
NE	0.00138	0.02410	0.01280	0.00165	0.00050	0.00000	0.00000	0.04044
ENE	0.00181	0.02179	0.05012	0.01806	0.01080	0.00423	0.00035	0.10716
E	0.00219	0.02237	0.04297	0.01219	0.00919	0.00707	0.00035	0.09631
ESE	0.00108	0.02806	0.03782	0.00442	0.00580	0.00188	0.00012	0.07918
SE	0.00127	0.02371	0.03348	0.00284	0.00181	0.00012	0.00000	0.06323
SSE	0.00123	0.02122	0.02337	0.00123	0.00012	0.00008	0.00000	0.04724
S	0.00096	0.02014	0.02083	0.00700	0.00354	0.00138	0.00000	0.05385
SSW	0.00108	0.02745	0.02491	0.01076	0.00665	0.00169	0.00000	0.07253
SW	0.00127	0.02971	0.02099	0.00926	0.00546	0.00308	0.00015	0.06992
WSW	0.00135	0.02407	0.01480	0.00892	0.00607	0.00288	0.00008	0.05815
W	0.00119	0.01657	0.01484	0.01030	0.00957	0.00649	0.00015	0.05912
WNW	0.00127	0.01795	0.01161	0.00565	0.00457	0.00223	0.00008	0.04336
NW	0.00138	0.01922	0.01441	0.00772	0.00646	0.00227	0.00015	0.05162
NNW	0.00161	0.02072	0.02222	0.00995	0.00723	0.00092	0.00004	0.06269
Totals	0.02279	0.35851	0.38244	0.11973	0.08072	0.03432	0.00146	0.99998

CW1	SPRING							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00069	0.01440	0.01267	0.00626	0.00188	0.00019	0.00000	0.03610
NNE	0.00061	0.01398	0.01394	0.00165	0.00019	0.00000	0.00000	0.03038
NE	0.00061	0.01321	0.01344	0.00227	0.00031	0.00004	0.00000	0.02988
ENE	0.00061	0.01455	0.03387	0.02531	0.01893	0.00445	0.00000	0.09774
E	0.00065	0.01701	0.03506	0.01529	0.01398	0.00465	0.00000	0.08664
ESE	0.00088	0.01962	0.03130	0.00802	0.01110	0.00442	0.00000	0.07534
SE	0.00104	0.01809	0.03341	0.00799	0.00568	0.00207	0.00000	0.06828
SSE	0.00058	0.01632	0.02120	0.00492	0.00234	0.00100	0.00000	0.04635
S	0.00088	0.01774	0.01847	0.00945	0.01140	0.00849	0.00000	0.06644
SSW	0.00050	0.02055	0.02945	0.01475	0.01237	0.00603	0.00000	0.08364
SW	0.00042	0.02143	0.03383	0.01417	0.00722	0.00146	0.00004	0.07857
WSW	0.00065	0.01801	0.02492	0.01444	0.00910	0.00280	0.00000	0.06993
W	0.00058	0.01506	0.02312	0.01513	0.01782	0.01025	0.00023	0.08219
WNW	0.00065	0.01467	0.01843	0.00891	0.00803	0.00142	0.00008	0.05219
NW	0.00069	0.01436	0.01682	0.00807	0.00568	0.00157	0.00004	0.04724
NNW	0.00069	0.01425	0.01724	0.00910	0.00618	0.00165	0.00000	0.04912
Totals	0.01075	0.26325	0.37720	0.16571	0.13222	0.05050	0.00038	1.00002

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

CW1	SUMMER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00095	0.02008	0.01233	0.00515	0.00168	0.00011	0.00000	0.04030
NNE	0.00137	0.01893	0.00969	0.00206	0.00069	0.00023	0.00000	0.03297
NE	0.00122	0.02011	0.01328	0.00286	0.00107	0.00057	0.00000	0.03912
ENE	0.00107	0.02557	0.05252	0.02576	0.01614	0.00450	0.00000	0.12555
E	0.00126	0.02546	0.05259	0.02179	0.01492	0.00492	0.00000	0.12093
ESE	0.00118	0.02736	0.03160	0.01427	0.01317	0.00309	0.00004	0.09072
SE	0.00114	0.02404	0.03160	0.00970	0.00370	0.00076	0.00000	0.07095
SSE	0.00107	0.02069	0.01977	0.00420	0.00103	0.00008	0.00000	0.04683
S	0.00118	0.02450	0.02156	0.00550	0.00195	0.00027	0.00000	0.05496
SSW	0.00053	0.03038	0.03393	0.00676	0.00134	0.00023	0.00000	0.07316
SW	0.00080	0.03073	0.03511	0.00630	0.00115	0.00027	0.00000	0.07435
WSW	0.00130	0.02511	0.02332	0.00420	0.00225	0.00027	0.00004	0.05649
W	0.00084	0.02095	0.01561	0.00443	0.00363	0.00050	0.00000	0.04595
WNW	0.00099	0.01996	0.01336	0.00298	0.00118	0.00027	0.00000	0.03874
NW	0.00122	0.02065	0.01439	0.00336	0.00164	0.00015	0.00004	0.04145
NNW	0.00134	0.02091	0.01641	0.00542	0.00286	0.00053	0.00000	0.04748
Totals	0.01748	0.37545	0.39708	0.12473	0.06839	0.01676	0.00011	0.99996

CW1	FALL							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00230	0.02484	0.01933	0.00819	0.00344	0.00060	0.00000	0.05871
NNE	0.00234	0.02409	0.01699	0.00177	0.00015	0.00000	0.00000	0.04534
NE	0.00208	0.03020	0.01099	0.00128	0.00015	0.00000	0.00000	0.04470
ENE	0.00215	0.03375	0.05731	0.01299	0.00868	0.00249	0.00000	0.11739
E	0.00200	0.03062	0.06113	0.01046	0.00717	0.00193	0.00000	0.11328
ESE	0.00177	0.03375	0.03851	0.00449	0.00264	0.00366	0.00072	0.08555
SE	0.00185	0.02620	0.03167	0.00215	0.00155	0.00083	0.00000	0.06426
SSE	0.00219	0.02461	0.01710	0.00075	0.00026	0.00000	0.00000	0.04493
S	0.00181	0.02182	0.01431	0.00366	0.00211	0.00166	0.00000	0.04538
SSW	0.00166	0.03205	0.02443	0.00747	0.00612	0.00344	0.00004	0.07520
SW	0.00162	0.03337	0.01744	0.00529	0.00215	0.00057	0.00000	0.06044
WSW	0.00211	0.02386	0.00997	0.00389	0.00306	0.00170	0.00019	0.04478
W	0.00227	0.02001	0.00929	0.00491	0.00461	0.00264	0.00004	0.04375
WNW	0.00211	0.01910	0.00948	0.00366	0.00325	0.00113	0.00011	0.03885
NW	0.00185	0.02228	0.01507	0.00536	0.00340	0.00076	0.00008	0.04878
NNW	0.00193	0.02692	0.01979	0.01219	0.00589	0.00193	0.00004	0.06867
Totals	0.03205	0.42748	0.37278	0.08853	0.05463	0.02333	0.00121	1.00000

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

KU1	WINTER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00415	0.02890	0.02264	0.01069	0.00365	0.00000	0.00000	0.07003
NNE	0.00457	0.02745	0.00869	0.00115	0.00015	0.00000	0.00000	0.04201
NE	0.00457	0.03083	0.00750	0.00184	0.00046	0.00000	0.00000	0.04521
ENE	0.00438	0.02929	0.01061	0.00850	0.00519	0.00138	0.00046	0.05981
E	0.00415	0.02437	0.00700	0.00711	0.01011	0.00711	0.00019	0.06004
ESE	0.00411	0.02164	0.00723	0.00404	0.00265	0.00077	0.00000	0.04043
SE	0.00346	0.03321	0.03740	0.00219	0.00073	0.00008	0.00000	0.07707
SSE	0.00411	0.03563	0.04351	0.00334	0.00027	0.00008	0.00000	0.08695
S	0.00315	0.02883	0.02541	0.00684	0.00342	0.00161	0.00000	0.06926
SSW	0.00384	0.03210	0.02494	0.01019	0.00750	0.00292	0.00000	0.08149
SW	0.00346	0.03082	0.01599	0.00872	0.00530	0.00258	0.00046	0.06735
WSW	0.00300	0.02372	0.01399	0.01069	0.00699	0.00384	0.00012	0.06235
W	0.00307	0.01918	0.01395	0.00900	0.00876	0.00546	0.00015	0.05958
WNW	0.00234	0.02010	0.01146	0.00492	0.00538	0.00204	0.00000	0.04624
NW	0.00208	0.02330	0.01472	0.00838	0.00669	0.00204	0.00012	0.05731
NNW	0.00254	0.02498	0.02502	0.01399	0.00730	0.00104	0.00000	0.07488
Totals	0.05700	0.43434	0.29005	0.11159	0.07457	0.03094	0.00150	1.00000

KU1	SPRING							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00195	0.01947	0.01794	0.00790	0.00275	0.00038	0.00000	0.05039
NNE	0.00229	0.02073	0.00866	0.00149	0.00015	0.00000	0.00000	0.03333
NE	0.00305	0.02458	0.00775	0.00199	0.00057	0.00000	0.00000	0.03794
ENE	0.00218	0.02096	0.01225	0.00958	0.00714	0.00233	0.00004	0.05447
E	0.00202	0.01722	0.01134	0.01054	0.01332	0.00534	0.00000	0.05978
ESE	0.00214	0.01760	0.01191	0.00794	0.00882	0.00199	0.00000	0.05039
SE	0.00198	0.02309	0.03596	0.00683	0.00565	0.00149	0.00000	0.07501
SSE	0.00195	0.02604	0.03711	0.00756	0.00248	0.00042	0.00000	0.07555
S	0.00187	0.02168	0.02519	0.00901	0.01000	0.00992	0.00011	0.07780
SSW	0.00187	0.02248	0.03210	0.01554	0.01439	0.00756	0.00000	0.09395
SW	0.00157	0.02222	0.02730	0.01455	0.00794	0.00198	0.00000	0.07555
WSW	0.00122	0.01905	0.02325	0.01431	0.01088	0.00332	0.00011	0.07215
W	0.00107	0.01584	0.02256	0.01325	0.01637	0.00924	0.00023	0.07855
WNW	0.00134	0.01615	0.01847	0.00855	0.00966	0.00187	0.00000	0.05604
NW	0.00099	0.01832	0.01710	0.00786	0.00603	0.00130	0.00004	0.05165
NNW	0.00130	0.01733	0.02069	0.00996	0.00615	0.00202	0.00000	0.05745
Totals	0.02878	0.32275	0.32959	0.14685	0.12231	0.04917	0.00053	0.99999

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

KU1	SUMMER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00230	0.02714	0.01688	0.00566	0.00238	0.00038	0.00000	0.05473
NNE	0.00257	0.02763	0.00876	0.00219	0.00072	0.00004	0.00000	0.04190
NE	0.00366	0.02824	0.01102	0.00287	0.00079	0.00030	0.00000	0.04688
ENE	0.00347	0.02873	0.01638	0.01000	0.00679	0.00321	0.00004	0.06863
E	0.00325	0.02646	0.02193	0.01635	0.01680	0.00385	0.00004	0.08867
ESE	0.00268	0.02707	0.02348	0.01653	0.00925	0.00117	0.00004	0.08021
SE	0.00234	0.03156	0.03707	0.00687	0.00415	0.00019	0.00000	0.08217
SSE	0.00242	0.02903	0.03333	0.00464	0.00117	0.00000	0.00000	0.07059
S	0.00215	0.02725	0.02416	0.00536	0.00230	0.00038	0.00000	0.06160
SSW	0.00253	0.03337	0.03582	0.00763	0.00223	0.00075	0.00000	0.08233
SW	0.00234	0.02974	0.02669	0.00645	0.00136	0.00045	0.00000	0.06704
WSW	0.00223	0.02567	0.01895	0.00328	0.00253	0.00045	0.00000	0.05311
W	0.00279	0.02442	0.01348	0.00453	0.00340	0.00064	0.00000	0.04926
WNW	0.00234	0.02469	0.01389	0.00283	0.00109	0.00023	0.00000	0.04507
NW	0.00272	0.02578	0.01752	0.00332	0.00155	0.00011	0.00008	0.05107
NNW	0.00193	0.02609	0.02065	0.00506	0.00276	0.00026	0.00000	0.05673
Totals	0.04171	0.44286	0.33999	0.10358	0.05926	0.01242	0.00019	1.00000

KU1	FALL							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00442	0.03164	0.02107	0.01053	0.00294	0.00117	0.00000	0.07177
NNE	0.00532	0.03447	0.00940	0.00125	0.00008	0.00000	0.00000	0.05052
NE	0.00668	0.03821	0.00672	0.00091	0.00015	0.00000	0.00000	0.05267
ENE	0.00646	0.03745	0.00698	0.00699	0.00306	0.00143	0.00000	0.06237
E	0.00525	0.02979	0.00438	0.00563	0.00510	0.00423	0.00000	0.05436
ESE	0.00525	0.03039	0.00766	0.00415	0.00257	0.00238	0.00004	0.05244
SE	0.00464	0.03602	0.03741	0.00109	0.00094	0.00019	0.00000	0.08030
SSE	0.00498	0.03847	0.03579	0.00219	0.00019	0.00000	0.00000	0.08162
S	0.00476	0.03446	0.02118	0.00657	0.00325	0.00283	0.00000	0.07305
SSW	0.00517	0.03640	0.02624	0.00725	0.00683	0.00313	0.00000	0.08502
SW	0.00468	0.03009	0.01348	0.00464	0.00223	0.00075	0.00004	0.05591
WSW	0.00366	0.02488	0.00808	0.00423	0.00332	0.00117	0.00008	0.04542
W	0.00404	0.02235	0.00857	0.00362	0.00389	0.00310	0.00015	0.04572
WNW	0.00400	0.02869	0.00910	0.00238	0.00310	0.00102	0.00000	0.04829
NW	0.00328	0.02945	0.01450	0.00529	0.00332	0.00053	0.00008	0.05644
NNW	0.00381	0.02994	0.02586	0.01506	0.00774	0.00170	0.00000	0.08411
Totals	0.07641	0.51268	0.25642	0.08177	0.04870	0.02363	0.00038	1.00000

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

SC1	WINTER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00286	0.02118	0.01732	0.01100	0.00278	0.00000	0.00000	0.05513
NNE	0.00590	0.05640	0.01076	0.00066	0.00000	0.00000	0.00000	0.07373
NE	0.00702	0.06621	0.00945	0.00563	0.00405	0.00212	0.00000	0.09450
ENE	0.00559	0.04055	0.01173	0.01601	0.02118	0.00826	0.00012	0.10345
E	0.00374	0.02207	0.00359	0.00386	0.00386	0.00459	0.00019	0.04190
ESE	0.00208	0.02053	0.00386	0.00394	0.00340	0.00096	0.00008	0.03484
SE	0.00204	0.02790	0.00949	0.00100	0.00066	0.00000	0.00000	0.04109
SSE	0.00185	0.02704	0.02079	0.00328	0.00008	0.00000	0.00000	0.05305
S	0.00185	0.02110	0.01879	0.00976	0.00378	0.00112	0.00000	0.05641
SSW	0.00131	0.02215	0.02064	0.01076	0.00737	0.00297	0.00000	0.06520
SW	0.00108	0.02855	0.02562	0.01018	0.00733	0.00339	0.00046	0.07662
WSW	0.00127	0.02496	0.01771	0.01038	0.00679	0.00332	0.00012	0.06455
W	0.00143	0.02269	0.01663	0.00876	0.00918	0.00448	0.00000	0.06316
WNW	0.00089	0.01640	0.02257	0.01019	0.00721	0.00224	0.00000	0.05949
NW	0.00096	0.01184	0.02215	0.00992	0.00459	0.00096	0.00000	0.05043
NNW	0.00154	0.01196	0.02566	0.01906	0.00756	0.00069	0.00000	0.06648
Totals	0.04144	0.44153	0.25676	0.13438	0.08982	0.03511	0.00096	1.00002

SC1	SPRING							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00179	0.01592	0.01202	0.00557	0.00107	0.00004	0.00000	0.03641
NNE	0.00260	0.04195	0.01603	0.00061	0.00034	0.00000	0.00000	0.06153
NE	0.00263	0.03710	0.01481	0.01076	0.00637	0.00397	0.00000	0.07565
ENE	0.00221	0.02404	0.01611	0.02710	0.02989	0.00630	0.00008	0.10574
E	0.00145	0.01595	0.00519	0.00618	0.00615	0.00332	0.00011	0.03836
ESE	0.00160	0.01607	0.00752	0.00867	0.01222	0.00428	0.00000	0.05035
SE	0.00099	0.01951	0.01710	0.00428	0.00511	0.00118	0.00000	0.04817
SSE	0.00118	0.01813	0.02435	0.00798	0.00160	0.00034	0.00000	0.05359
S	0.00095	0.01538	0.01836	0.00897	0.00920	0.00622	0.00000	0.05909
SSW	0.00069	0.01771	0.02546	0.01386	0.01729	0.00943	0.00004	0.08447
SW	0.00073	0.02107	0.03191	0.01683	0.00901	0.00176	0.00000	0.08130
WSW	0.00050	0.01771	0.02584	0.01615	0.01031	0.00263	0.00000	0.07313
W	0.00069	0.01801	0.02473	0.01336	0.01687	0.00737	0.00000	0.08105
WNW	0.00061	0.01290	0.02389	0.01324	0.00996	0.00095	0.00000	0.06157
NW	0.00065	0.00928	0.02054	0.00893	0.00431	0.00061	0.00000	0.04431
NNW	0.00111	0.00817	0.01550	0.01290	0.00679	0.00084	0.00000	0.04531
Totals	0.02038	0.30891	0.29936	0.17539	0.14650	0.04924	0.00023	1.00003

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

SC1	SUMMER							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00266	0.02207	0.01060	0.00300	0.00163	0.00015	0.00000	0.04012
NNE	0.00460	0.05299	0.01136	0.00156	0.00049	0.00004	0.00000	0.07104
NE	0.00547	0.05163	0.02435	0.01276	0.00684	0.00209	0.00000	0.10314
ENE	0.00418	0.03347	0.02933	0.03704	0.02739	0.00745	0.00000	0.13883
E	0.00258	0.01861	0.01299	0.00798	0.00843	0.00376	0.00011	0.05448
ESE	0.00194	0.01751	0.01580	0.01543	0.01710	0.00422	0.00034	0.07233
SE	0.00144	0.02033	0.01599	0.00612	0.00342	0.00027	0.00000	0.04756
SSE	0.00122	0.01956	0.02086	0.00376	0.00068	0.00000	0.00000	0.04608
S	0.00095	0.01956	0.01744	0.00448	0.00137	0.00023	0.00000	0.04403
SSW	0.00099	0.02408	0.02781	0.00707	0.00152	0.00038	0.00000	0.06185
SW	0.00103	0.02982	0.03977	0.00638	0.00171	0.00019	0.00000	0.07890
WSW	0.00141	0.02648	0.02355	0.00517	0.00217	0.00011	0.00004	0.05892
W	0.00103	0.02541	0.02037	0.00448	0.00315	0.00011	0.00000	0.05455
WNW	0.00110	0.02371	0.02070	0.00353	0.00167	0.00008	0.00000	0.05079
NW	0.00125	0.01508	0.01763	0.00357	0.00125	0.00019	0.00000	0.03898
NNW	0.00236	0.01197	0.01387	0.00669	0.00323	0.00027	0.00000	0.03837
Totals	0.03419	0.41229	0.32241	0.12901	0.08206	0.01953	0.00049	0.99997

SC1	FALL							Totals
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	
N	0.00384	0.02427	0.01358	0.00863	0.00293	0.00042	0.00000	0.05367
NNE	0.00711	0.07120	0.00924	0.00061	0.00000	0.00000	0.00000	0.08815
NE	0.00867	0.08398	0.01031	0.00510	0.00418	0.00361	0.00057	0.11643
ENE	0.00555	0.05249	0.01415	0.01270	0.01411	0.00456	0.00000	0.10357
E	0.00403	0.02773	0.00274	0.00236	0.00171	0.00251	0.00049	0.04157
ESE	0.00293	0.02305	0.00380	0.00358	0.00300	0.00304	0.00053	0.03994
SE	0.00262	0.02731	0.01088	0.00099	0.00053	0.00008	0.00000	0.04241
SSE	0.00266	0.02731	0.01609	0.00156	0.00008	0.00000	0.00000	0.04770
S	0.00194	0.02187	0.01354	0.00582	0.00262	0.00164	0.00000	0.04743
SSW	0.00194	0.02560	0.02122	0.00799	0.00757	0.00441	0.00000	0.06873
SW	0.00202	0.03324	0.02457	0.00749	0.00339	0.00068	0.00004	0.07143
WSW	0.00186	0.02746	0.01267	0.00533	0.00327	0.00167	0.00011	0.05237
W	0.00171	0.02799	0.01316	0.00472	0.00377	0.00217	0.00015	0.05367
WNW	0.00160	0.02138	0.02046	0.00506	0.00441	0.00065	0.00000	0.05356
NW	0.00171	0.01430	0.02065	0.00829	0.00255	0.00046	0.00004	0.04800
NNW	0.00175	0.01305	0.02624	0.01928	0.00932	0.00164	0.00008	0.07135
Totals	0.05196	0.52223	0.23331	0.09950	0.06344	0.02754	0.00202	0.99998

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

A36	WINTER							
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	Totals
N	0.003626	0.029630	0.017980	0.006520	0.002238	0.000000	0.000000	0.059993
NNE	0.003819	0.031753	0.007330	0.000193	0.000039	0.000000	0.000000	0.043133
NE	0.002624	0.026003	0.006983	0.000386	0.000039	0.000000	0.000000	0.036033
ENE	0.003240	0.022647	0.005710	0.002238	0.001312	0.001428	0.000424	0.037000
E	0.004128	0.018597	0.011729	0.012692	0.014773	0.010186	0.000232	0.072340
ESE	0.003241	0.032910	0.036727	0.008063	0.004938	0.000965	0.000039	0.086880
SE	0.002546	0.037500	0.054977	0.002238	0.000887	0.000039	0.000000	0.098200
SSE	0.003241	0.029703	0.025697	0.001582	0.000039	0.000039	0.000000	0.060297
S	0.002045	0.025193	0.019520	0.005401	0.002662	0.000926	0.000000	0.055747
SSW	0.002508	0.030017	0.024073	0.010415	0.006946	0.001350	0.000000	0.075310
SW	0.002431	0.028627	0.017207	0.007910	0.005054	0.002276	0.000000	0.063503
WSW	0.002894	0.027160	0.014853	0.008641	0.004012	0.002585	0.000000	0.060147
W	0.002276	0.022223	0.014160	0.009879	0.010186	0.003472	0.000077	0.062270
WNW	0.003048	0.023997	0.012847	0.006019	0.005440	0.002739	0.000039	0.054127
NW	0.002546	0.027277	0.017133	0.009413	0.007252	0.002006	0.000039	0.065663
NNW	0.002315	0.026503	0.023073	0.011191	0.005633	0.000656	0.000000	0.069363
Totals	0.046528	0.439740	0.309998	0.102779	0.071449	0.028666	0.000849	1.000007

A36	SPRING							
	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	Totals
N	0.00231	0.01927	0.01263	0.00549	0.00118	0.00027	0.00000	0.04116
NNE	0.00306	0.02252	0.00561	0.00051	0.00008	0.00000	0.00000	0.03179
NE	0.00224	0.02068	0.00624	0.00082	0.00031	0.00004	0.00000	0.03033
ENE	0.00149	0.01483	0.00616	0.00373	0.00365	0.00302	0.00008	0.03296
E	0.00216	0.01511	0.01491	0.01593	0.02280	0.00608	0.00004	0.07703
ESE	0.00165	0.02127	0.03492	0.01468	0.01087	0.00326	0.00000	0.08664
SE	0.00145	0.02676	0.05042	0.00781	0.00451	0.00133	0.00000	0.09229
SSE	0.00204	0.02245	0.02178	0.00420	0.00173	0.00008	0.00000	0.05226
S	0.00173	0.02079	0.01727	0.00722	0.01048	0.00698	0.00000	0.06447
SSW	0.00165	0.02417	0.03068	0.01514	0.01409	0.00573	0.00000	0.09146
SW	0.00157	0.02319	0.02912	0.01142	0.00530	0.00051	0.00000	0.07110
WSW	0.00118	0.02194	0.02567	0.01436	0.00702	0.00133	0.00000	0.07149
W	0.00137	0.01954	0.02291	0.01554	0.01723	0.00722	0.00004	0.08385
WNW	0.00165	0.01825	0.02009	0.01142	0.00946	0.00145	0.00000	0.06231
NW	0.00137	0.01989	0.02017	0.00863	0.00545	0.00133	0.00000	0.05685
NNW	0.00173	0.01809	0.01911	0.00867	0.00518	0.00126	0.00000	0.05403
Totals	0.02864	0.32874	0.33768	0.14557	0.11933	0.03990	0.00016	1.00002

ATTACHMENT 4-3 - METEOROLOGICAL DATA TO SUPPORT SNL/NM WINDROSES (Continued)

A36 **SUMMER**

	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	Totals
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N
NNE
NE
ENE
E
ESE
SE
SSE
S
SSW
SW
WSW
W
WNW
NW
NNW

NO DATA

Totals

A36 **FALL**

	< 1m/s	1-3 m/s	3-5 m/s	5-7 m/s	7-10 m/s	10-15 m/s	> 15 m/s	Totals
N	0.00518	0.03445	0.01675	0.00651	0.00194	0.00072	0.00000	0.06555
NNE	0.00560	0.03829	0.00674	0.00004	0.00000	0.00000	0.00000	0.05067
NE	0.00434	0.03346	0.00541	0.00011	0.00000	0.00000	0.00000	0.04331
ENE	0.00457	0.02649	0.00442	0.00209	0.00126	0.00247	0.00004	0.04134
E	0.00430	0.02813	0.00883	0.00856	0.01051	0.00426	0.00008	0.06468
ESE	0.00491	0.04263	0.04160	0.00632	0.00228	0.00305	0.00049	0.10130
SE	0.00445	0.04050	0.05345	0.00183	0.00084	0.00023	0.00000	0.10131
SSE	0.00388	0.03045	0.02048	0.00091	0.00011	0.00000	0.00000	0.05584
S	0.00362	0.02893	0.01637	0.00426	0.00305	0.00190	0.00000	0.05813
SSW	0.00312	0.03365	0.02512	0.00796	0.00666	0.00232	0.00000	0.07884
SW	0.00354	0.03018	0.01412	0.00445	0.00164	0.00030	0.00000	0.05424
WSW	0.00384	0.02821	0.00902	0.00384	0.00270	0.00080	0.00004	0.04846
W	0.00335	0.02440	0.00837	0.00377	0.00442	0.00259	0.00011	0.04701
WNW	0.00343	0.02619	0.00910	0.00274	0.00350	0.00099	0.00000	0.04595
NW	0.00411	0.03384	0.01599	0.00636	0.00377	0.00038	0.00008	0.06452
NNW	0.00483	0.03011	0.02326	0.01370	0.00575	0.00122	0.00000	0.07887
Totals	0.06707	0.50993	0.27902	0.07347	0.04842	0.02124	0.00084	1.00002

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS

1996 Annual Building Purchases of HAPs

Building	Org.	CAS Number	Chemical	Pounds
*	09512	107211	Ethylene glycol	9.31
*	09761	7439965	Manganese	0.00937
*	09761	7440020	Nickel	0.00875
*	09761	7440473	Chromium (II) compounds, as Cr	0.00875
Total Pounds of HAPs Used at Bldg:				9.34
6542	07584	67561	Methanol	3.49
Total Pounds of HAPs Used at Building 6542:				3.49
6560	09761	80626	Methyl methacrylate	1.86
6560	09761	107211	Ethylene glycol	512
Total Pounds of HAPs Used at Building 6560:				514
6597	06423	67561	Methanol	8.28
6597	06423	78933	Methyl ethyl ketone (2-Butanone)	0.444
6597	06423	79016	Trichloroethylene	16.9
Total Pounds of HAPs Used at Building 6597:				25.6
6922	06422	80626	Methyl methacrylate	3.71
Total Pounds of HAPs Used at Building 6922:				3.71
807	02643	80626	Methyl methacrylate	8.17
807	02643	1330207	Xylene	1.68
807	02652	67561	Methanol	22.7
807	02652	68122	N,N-Dimethylformamide	0.630
807	02652	71556	1,1,1-Trichloroethane (Methyl chloroform)	0.158
807	02652	78933	Methyl ethyl ketone (2-Butanone)	0.177
Total Pounds of HAPs Used at Building 807:				33.5
823	06116	78933	Methyl ethyl ketone (2-Butanone)	1.31
823	06116	7439921	Lead	0.0220
823	06210	108883	Toluene	86.7
823	06213	75092	Dichloromethane (Methylene chloride)	0.0313
823	06621	67561	Methanol	13.4
Total Pounds of HAPs Used at Building 823:				101

*Applies to general usage at the laboratory.

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of HAPs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
826	09417	67561	Methanol	0.00300
826	09418	108883	Toluene	0.0441
826	09418	1330207	Xylene	0.0992
Total Pounds of HAPs Used at Building 826:				0.146
830	12620	71556	1,1,1-Trichloroethane (Methyl chloroform)	0.851
830	12620	75092	Dichloromethane (Methylene chloride)	0.650
830	12620	123911	1,4-Dioxane	0.0155
Total Pounds of HAPs Used at Building 830:				1.52
840	01412	108883	Toluene	0.0235
840	01412	1330207	Xylene	0.0235
840	01412	7439921	Lead	0.370
840	02481-1	67561	Methanol	0.441
840	02481-2	67561	Methanol	0.617
840	1481-1	67561	Methanol	1.83
840	1481-1	108101	Methyl isobutyl ketone (Hexone)	0.0331
840	1481-1	108883	Toluene	0.0139
840	1481-2	67561	Methanol	0.529
840	1481-4	67561	Methanol	0.353
Total Pounds of HAPs Used at Building 840:				4.23
841	1481-2	67561	Methanol	0.926
841	1481-2	108101	Methyl isobutyl ketone (Hexone)	0.0125
Total Pounds of HAPs Used at Building 841:				0.938
858	01323	67561	Methanol	185
858	01323	110543	n-Hexane	3.09
Total Pounds of HAPs Used at Building 858:				188
860	09742	123319	Hydroquinone	1.31
Total Pounds of HAPs Used at Building 860:				1.31
865	09112	75092	Dichloromethane (Methylene chloride)	2.93
Total Pounds of HAPs Used at Building 865:				2.93

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of HAPs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
878	01411	50000	Formaldehyde	0.836
878	01411	67561	Methanol	5.24
878	01411	79016	Trichloroethylene	1,363
878	01411	106898	Epichlorohydrin	0.309
878	01411	107211	Ethylene glycol	4.23
878	01411	7440473	Chromium (II) compounds, as Cr	0.0313
Total Pounds of HAPs Used at Building 878:				1,374
881	07578	67561	Methanol	0.882
Total Pounds of HAPs Used at Building 881:				0.882
887	07814-4	50000	Formaldehyde	0.000400
887	07814-4	67561	Methanol	2.57
887	07814-4	78933	Methyl ethyl ketone (2-Butanone)	115
887	07814-4	79016	Trichloroethylene	56.5
887	07814-4	98828	Cumene	5.95
887	07814-4	100414	Ethylbenzene	59.4
887	07814-4	107211	Ethylene glycol	0.459
887	07814-4	108883	Toluene	111
887	07814-4	1330207	Xylene	233
887	07814-4	7439921	Lead	17.5
887	07814-4	7439965	Manganese	104
887	07814-4	7440020	Nickel	252
887	07814-4	7440360	Antimony	0.158
887	07814-4	7440473	Chromium (II) compounds, as Cr	9.62
887	07814-4	7440484	Cobalt	50.5
887	07814-4	7723140	Phosphorus	15.5
Total Pounds of HAPs Used at Building 887:				1,034
891	02334	80626	Methyl methacrylate	0.850
Total Pounds of HAPs Used at Building 891:				0.850
893	01322	67561	Methanol	251
893	01322	107062	1,2-Dichloroethane (Ethylene dichloride)	1.38
893	01322	107211	Ethylene glycol	108
893	01322	108883	Toluene	21.6
Total Pounds of HAPs Used at Building 893:				382

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of HAPs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
894	01521	67561	Methanol	86.4
894	01523	67561	Methanol	3.49
894	01523	75058	Acetonitrile	0.882
894	01523	7440020	Nickel	1.10
894	02223	78933	Methyl ethyl ketone (2-Butanone)	0.887
894	09116	75092	Dichloromethane (Methylene chloride)	1.41
894	09116	110543	n-Hexane	0.562
Total Pounds of HAPs Used at Building 894:				94.7
907	02654	67561	Methanol	1.74
Total Pounds of HAPs Used at Building 907:				1.74
922	02654	107211	Ethylene glycol	6.17
Total Pounds of HAPs Used at Building 922:				6.17
940	02652	67561	Methanol	0.0872
Total Pounds of HAPs Used at Building 940:				0.0872
952	05716	71432	Benzene	7.73
Total Pounds of HAPs Used at Building 952:				7.73
959	07577	110543	n-Hexane	2.92
Total Pounds of HAPs Used at Building 959:				2.92
960	09512	75150	Carbon disulfide	1.43
Total Pounds of HAPs Used at Building 960:				1.43
9981	06215	127184	Tetrachloroethylene	1.79
Total Pounds of HAPs Used at Building 9981:				1.79
BURNSI	09735	91203	Naphthalene	1,001
Total Pounds of HAPs Used at Building BURNSITE:				1,001
MO-178	12620	123319	Hydroquinone	16.4
Total Pounds of HAPs Used at Building MO-178:				16.4

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of HAPs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
None	02223	67561	Methanol	1.98
None	02223	71432	Benzene	0.0360
None	02223	71556	1,1,1-Trichloroethane (Methyl chloroform)	0.413
None	02223	75070	Acetaldehyde	0.360
None	02223	75092	Dichloromethane (Methylene chloride)	0.491
None	02223	108101	Methyl isobutyl ketone (Hexone)	0.0720
None	02223	108883	Toluene	0.0713
None	02223	127184	Tetrachloroethylene	0.0883
None	02223	131113	Dimethyl phthalate	0.496
None	02223	7440020	Nickel	1.76
None	02223	7440360	Antimony	1.10
Total Pounds of HAPs Used at Building None Specified:				6.87
Total Pounds				4,823

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of VOCs				
Building	Org.	CAS Number	Chemical	Pounds
	09512	107211	Ethylene glycol	9.31
	09761	67630	Isopropyl alcohol	6.75
	09761	111762	Butyl cellosolve (R)	0.0316
	09761	8008206	Kerosene	0.635
Total Pounds of VOCs Used at Bldg:				16.7
6542	07584	67561	Methanol	3.49
Total Pounds of VOCs Used at Building 6542:				3.49
6560	09761	80626	Methyl methacrylate	1.86
6560	09761	107211	Ethylene glycol	512
Total Pounds of VOCs Used at Building 6560:				514
6597	06423	67561	Methanol	8.28
6597	06423	78933	Methyl ethyl ketone (2-Butanone)	0.444
6597	06423	79016	Trichloroethylene	16.9
Total Pounds of VOCs Used at Building 6597:				25.6
6922	06422	80626	Methyl methacrylate	3.71
Total Pounds of VOCs Used at Building 6922:				3.71
807	02643	80626	Methyl methacrylate	8.17
807	02643	1330207	Xylene	1.68
807	02652	64197	Acetic acid	0.0434
807	02652	67561	Methanol	22.7
807	02652	68122	N,N-Dimethylformamide	0.630
807	02652	78933	Methyl ethyl ketone (2-Butanone)	0.177
807	02652	84662	Diethyl phthalate	0.00220
807	02652	108941	Cyclohexanone	2.40
807	02652	141786	Ethyl acetate	198
807	02671	67630	Isopropyl alcohol	3.26
807	02674	67630	Isopropyl alcohol	6.59
Total Pounds of VOCs Used at Building 807:				244

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of VOCs (cont.)

Building	Org.	CAS Number	Chemical	Pounds
823	06116	78933	Methyl ethyl ketone (2-Butanone)	1.31
823	06116	108941	Cyclohexanone	0.0789
823	06116	109999	Tetrahydrofuran	0.266
823	06210	108883	Toluene	86.7
823	06210	109999	Tetrahydrofuran	73.7
823	06212	67630	Isopropyl alcohol	3.46
823	06612	67630	Isopropyl alcohol	0.0177
823	06612	71363	n-Butyl alcohol	0.0893
823	06621	67561	Methanol	13.4

Total Pounds of VOCs Used at Building 823: 179

826	09417	64175	Alcohol	0.438
826	09417	67561	Methanol	0.00300
826	09417	74986	Propane	0.0398
826	09417	75285	Isobutane	0.0530
826	09418	74986	Propane	0.0441
826	09418	75285	Isobutane	0.0992
826	09418	108883	Toluene	0.0441
826	09418	142825	n-Heptane	0.0992
826	09418	1330207	Xylene	0.0992

Total Pounds of VOCs Used at Building 826: 0.919

830	12620	74986	Propane	0.0851
830	12620	75285	Isobutane	0.387
830	12620	106978	n-Butane	0.0851
830	12620	123911	1,4-Dioxane	0.0155
830	12620	8052413	Stoddard solvent	0.187
830	12620	64742898	Aliphatic petroleum distillates	4.00

Total Pounds of VOCs Used at Building 830: 4.76

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of VOCs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
840	01412	67630	Isopropyl alcohol	0.196
840	01412	108883	Toluene	0.0235
840	01412	110827	Cyclohexane	0.0235
840	01412	1330207	Xylene	0.0235
840	01412	8052413	Stoddard solvent	0.0235
840	01412	64742898	Aliphatic petroleum distillates	0.430
840	02481-1	64175	Alcohol	7.94
840	02481-1	67561	Methanol	0.441
840	02481-1	67630	Isopropyl alcohol	0.441
840	02481-2	64175	Alcohol	11.1
840	02481-2	67561	Methanol	0.617
840	02481-2	67630	Isopropyl alcohol	0.617
840	1481-1	64175	Alcohol	33.4
840	1481-1	67561	Methanol	1.83
840	1481-1	67630	Isopropyl alcohol	1.76
840	1481-1	85687	Butyl benzyl phthalate	0.125
840	1481-1	108101	Methyl isobutyl ketone (Hexone)	0.0331
840	1481-1	108883	Toluene	0.0139
840	1481-1	141786	Ethyl acetate	0.0226
840	1481-2	64175	Alcohol	9.52
840	1481-2	67561	Methanol	0.529
840	1481-2	67630	Isopropyl alcohol	0.529
840	1481-4	64175	Alcohol	6.35
840	1481-4	67561	Methanol	0.353
840	1481-4	67630	Isopropyl alcohol	0.353
Total Pounds of VOCs Used at Building 840:				76.7
841	1481-2	64175	Alcohol	15.9
841	1481-2	67561	Methanol	0.926
841	1481-2	67630	Isopropyl alcohol	0.882
841	1481-2	108101	Methyl isobutyl ketone (Hexone)	0.0125
841	1481-4	67630	Isopropyl alcohol	5.19
Total Pounds of VOCs Used at Building 841:				22.9

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of VOCs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
858	01323	64197	Acetic acid	70.0
858	01323	67561	Methanol	185
858	01323	107835	Isohexanes	3.09
858	01323	108656	Methoxy acetate	131
858	01323	110543	n-Hexane	3.09
Total Pounds of VOCs Used at Building 858:				392
860	09742	64197	Acetic acid	42.4
860	09742	111308	Glutaraldehyde	24.2
Total Pounds of VOCs Used at Building 860:				66.6
865E	09112	141786	Ethyl acetate	0.397
Total Pounds of VOCs Used at Building 865E:				0.397
878	01411	50000	Formaldehyde	0.836
878	01411	57556	Propylene glycol	0.532
878	01411	64175	Alcohol	157
878	01411	67561	Methanol	5.24
878	01411	67630	Isopropyl alcohol	4.94
878	01411	79016	Trichloroethylene	1,363
878	01411	90722	2,4,6-Tri(dimethylaminomethyl) phenol	2.93
878	01411	106898	Epichlorohydrin	0.309
878	01411	107211	Ethylene glycol	4.23
878	01411	112345	2-Butyl oxyethanol dipropylene glycol	0.417
Total Pounds of VOCs Used at Building 878:				1,539
881	07578	67561	Methanol	0.882
Total Pounds of VOCs Used at Building 881:				0.882
883	06642	67630	Isopropyl alcohol	0.431
Total Pounds of VOCs Used at Building 883:				0.431

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of VOCs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
887	07814-4	50000	Formaldehyde	0.000400
887	07814-4	67561	Methanol	2.57
887	07814-4	74986	Propane	23.8
887	07814-4	78933	Methyl ethyl ketone (2-Butanone)	115
887	07814-4	79016	Trichloroethylene	56.5
887	07814-4	98828	Cumene	5.95
887	07814-4	100414	Ethylbenzene	59.4
887	07814-4	106978	n-Butane	0.313
887	07814-4	107211	Ethylene glycol	0.459
887	07814-4	107982	Propylene glycol monomethyl ether	6.35
887	07814-4	108883	Toluene	111
887	07814-4	111762	Butyl cellosolve (R)	2.09
887	07814-4	115071	Propylene	0.625
887	07814-4	1330207	Xylene	233
887	07814-4	8001589	Creosote	9.70
887	07814-4	8052413	Stoddard solvent	236
887	07814-4	8052424	Asphalt(petroleum)fumes	1,592
887	07814-4	64742898	Aliphatic petroleum distillates	18.8
887	07814-4	65996932	Coal tar (PAH)	30.4
Total Pounds of VOCs Used at Building 887:				2,504
891	02334	67630	Isopropyl alcohol	24.2
891	02334	80626	Methyl methacrylate	0.850
Total Pounds of VOCs Used at Building 891:				25.1
893	01322	64175	Alcohol	8.64
893	01322	67561	Methanol	251
893	01322	67630	Isopropyl alcohol	390
893	01322	67685	Dimethylsulfoxide	2.43
893	01322	107062	1,2-Dichloroethane (Ethylene dichloride)	1.38
893	01322	107211	Ethylene glycol	108
893	01322	108656	Methoxy acetate	18.1
893	01322	108883	Toluene	21.6
893	01322	872504	N-Methyl-2-pyrrolidone	18.1
893	01322	8032324	VM & P Naphtha	5.29
Total Pounds of VOCs Used at Building 893:				825

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of VOCs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
894	01521	67561	Methanol	86.4
894	01523	67561	Methanol	3.49
894	01523	75058	Acetonitrile	0.882
894	01523	142825	n-Heptane	1.43
894	02223	67630	Isopropyl alcohol	6.92
894	02223	78933	Methyl ethyl ketone (2-Butanone)	0.887
894	09116	74986	Propane	0.562
894	09116	110543	n-Hexane	0.562
Total Pounds of VOCs Used at Building 894:				101
907	02654	67561	Methanol	1.74
907	02654	67630	Isopropyl alcohol	0.408
Total Pounds of VOCs Used at Building 907:				2.15
915	02653	67630	Isopropyl alcohol	0.622
Total Pounds of VOCs Used at Building 915:				0.622
922	02654	107211	Ethylene glycol	6.17
Total Pounds of VOCs Used at Building 922:				6.17
940	02652	67561	Methanol	0.0872
940	02652	67630	Isopropyl alcohol	0.0862
940	02653	123864	n-Butyl acetate	487
Total Pounds of VOCs Used at Building 940:				487
952	05716	71432	Benzene	7.73
Total Pounds of VOCs Used at Building 952:				7.73
959	07577	107835	Isohexanes	2.92
959	07577	110543	n-Hexane	2.92
Total Pounds of VOCs Used at Building 959:				5.84
9981	06215	67630	Isopropyl alcohol	0.250
9981	06215	127184	Tetrachloroethylene	1.79
9981	06216	67630	Isopropyl alcohol	34.6
Total Pounds of VOCs Used at Building 9981:				36.7

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

1996 Annual Building Purchases of VOCs (cont.)				
Building	Org.	CAS Number	Chemical	Pounds
BURNSI	09735	67630	Isopropyl alcohol	17.3
BURNSI	09735	91203	Naphthalene	1,001
Total Pounds of VOCs Used at Building BURNSITE :				1,019
MO-178	12620	64197	Acetic acid	7.89
Total Pounds of VOCs Used at Building MO-178 :				7.89
None	02223	64175	Alcohol	3.43
None	02223	64197	Acetic acid	6.94
None	02223	67561	Methanol	1.98
None	02223	67630	Isopropyl alcohol	7.43
None	02223	71432	Benzene	0.0360
None	02223	74986	Propane	0.275
None	02223	75070	Acetaldehyde	0.360
None	02223	75785	Dimethyldichlorosilane	1.38
None	02223	108101	Methyl isobutyl ketone (Hexone)	0.0720
None	02223	108883	Toluene	0.0713
None	02223	127184	Tetrachloroethylene	0.0883
None	02223	141786	Ethyl acetate	0.0360
None	02223	64742898	Aliphatic petroleum distillates	0.124
Total Pounds of VOCs Used at Building None Specified :				22.2
Total Pounds				8,142

ATTACHMENT 4-4 - CHEMICAL USER DATA FOR VOLATILE ORGANIC COMPOUNDS (VOC) AND HAZARDOUS AIR POLLUTANT (HAP) EMISSIONS (Continued)

Building No.	CENTROID (Meters) Coordinates on NAD 83 UTM Zone 0013		Building Heights	
	X	Y	Highest	Lowest
6560	359353.9877	3873063.4	24'-0"	9'-10"
6580	359902.9911	3873986.249	15'-4"	14'-10"
6587	359501.9529	3874015.774	16'-3"	
6640	359617.7998	3871827.038	15'-2"	
6922	359708.7439	3871241.179	10'-8"	
805	358790.3901	3879843.015	31'-0"	20'-0"
807	358790.7484	3879893.986	48'-8"	
823	359228.2617	3879412.649	81'-6"	64'-0"
840	359007.9428	3880044.312	?	?
858	359728.8099	3879550.549	46'-0"	30'-0"
860	359141.8825	3880044.288	23'-0"	10'-0"
865	359084.9356	3879894.911	36'-0"	13'-3"
869	359097.8295	3879504.558	16'-2"	
870	359491.3201	3879527.995	47'-6"	35'-1"
878	359339.4221	3879886.128		
882	359342.5916	3879517.578	18'-6"	
883	359370.0376	3879517.447	16'-8"	
887	359459.0199	3879866.341	18'-2"	10'-0"
888	359508.689	3879636.095	36'-0"	14'-6"
890	359244.3883	3879796.21	86'-0"	
891	359112.0406	3879811.143	86'-0"	
893	358998.6021	3879800.958	18'-9.5"	
894	358996.7117	3879617.743	21'-4"	19'-6"
897	359729.7435	3879405.399	64'-0"	
905	359959.196	3878923.684	18'-0"	14'-0"
940	359423.4263	3878475.171	13'-0"	
957	359258.6552	3879059.059	20'-10"	
959	359214.148	3878927.704	12'-4"	
960	359206.9132	3878050.908	50'-8"	17'-0"
963	359344.029	3878226.577	41'-6"	32'-0"
970	359462.1518	3878001.917	43'-0"	22'-0"
981	359174.2727	3877885.276	16'-8"	
983	359295.031	3877888.286	39'-2"	16'-8"
MO-178	358774.6112	3880201.595		
T20	No data	No data	No data	No data
Burn Site	No data	No data	No data	No data

ATTACHMENT 4-5 – STEAM PLANT OPERATIONS DATA

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
January 1996	1	1		929,305		2,060,000			44.4%		66.0%	
January 1996	1	2	504,631	1,010,000		2,130,000		24.1%	48.2%		68.2%	
January 1996	1	3	612,577	861,440		2,040,000		29.3%	41.1%		65.3%	
January 1996	1	4	297,474	561,889		951,177	1,280,000	14.2%	26.8%		30.5%	22.4%
January 1996	1	5		400,024			2,630,000		19.1%			46.0%
January 1996	1	6					2,990,000					52.4%
January 1996	1	7					2,970,000					52.0%
January 1996	1	8		605,424			2,560,000		28.9%			44.8%
January 1996	1	9		617,266			2,310,000		29.5%			40.4%
January 1996	1	10		591,949			2,290,000		28.3%			40.1%
January 1996	1	11		555,803			2,440,000		26.5%			42.7%
January 1996	1	12		528,536			2,450,000		25.2%			42.9%
January 1996	1	13		430,817			2,310,000		20.6%			40.4%
January 1996	1	14		463,319		354,169	1,800,000		22.1%		11.3%	31.5%
January 1996	1	15		806,817		2,080,000			38.5%		66.6%	
January 1996	1	16		752,324		1,940,000			35.9%		62.1%	
January 1996	1	17		931,648		2,040,000			44.5%		65.3%	
January 1996	1	18	387,475	1,069,347		2,150,000		18.5%	51.1%		68.9%	
January 1996	1	19	407,949	891,583		2,040,000		19.5%	42.6%		65.3%	
January 1996	1	20	422,599	733,591		1,910,000		20.2%	35.0%		61.2%	
January 1996	1	21	278,960	773,280		2,030,000		13.3%	36.9%		65.0%	
January 1996	1	22		999,021		2,090,000			47.7%		66.9%	
January 1996	1	23		1,157,502		2,260,000			55.3%		72.4%	
January 1996	1	24	84,020	1,041,769		2,170,000	26,109	4.0%	49.7%		69.5%	0.5%
January 1996	1	25		601,637		1,130,000	1,408,750		28.7%		36.2%	24.7%
January 1996	1	26		812,173			2,864,121		38.8%			50.1%
January 1996	1	27		612,918			2,854,234		29.3%			50.0%
January 1996	1	28		391,149			2,520,255		18.7%			44.1%
January 1996	1	29		532,270			2,566,073		25.4%			44.9%
January 1996	1	30		227,013	229,546		2,355,201		10.8%	11.0%		41.2%
January 1996	1	31			487,618		2,112,416			23.3%		37.0%

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
February 1996	2	1			572,859		2,323,347			27.4%		40.7%
February 1996	2	2			964,422		2,778,116			46.1%		48.6%
February 1996	2	3			799,816		2,471,430			38.2%		43.3%
February 1996	2	4			775,114		2,454,191			37.0%		43.0%
February 1996	2	5			614,738		2,275,866			29.4%		39.8%
February 1996	2	6			262,830		2,303,643			12.6%		40.3%
February 1996	2	7					2,556,494					44.8%
February 1996	2	8			8,376		2,463,954			0.4%		43.1%
February 1996	2	9					2,442,795					42.8%
February 1996	2	10					2,311,353					40.5%
February 1996	2	11					2,656,135					46.5%
February 1996	2	12					2,703,148					47.3%
February 1996	2	13					2,596,472					45.5%
February 1996	2	14					2,430,803					42.6%
February 1996	2	15					2,298,356					40.2%
February 1996	2	16					2,476,797					43.4%
February 1996	2	17					2,119,747					37.1%
February 1996	2	18					2,032,161					35.6%
February 1996	2	19					2,268,532					39.7%
February 1996	2	20				7,408	2,124,796				0.2%	37.2%
February 1996	2	21				784,839	1,282,171				25.1%	22.4%
February 1996	2	22				241,788	2,185,201				7.7%	38.3%
February 1996	2	23					3,064,364					53.7%
February 1996	2	24					2,773,010					48.6%
February 1996	2	25					2,540,550					44.5%
February 1996	2	26			350,578		2,864,711			16.7%		50.2%
February 1996	2	27			630,748		2,678,647			30.1%		46.9%
February 1996	2	28			807,121		2,898,082			38.5%		50.7%
February 1996	2	29			781,840		2,823,788			37.3%		49.4%

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
March 1996	3	1			675,369		2,654,031			32.3%		46.5%
March 1996	3	2			232,386		2,756,160			11.1%		48.3%
March 1996	3	3					2,846,596					49.8%
March 1996	3	4			144,327		2,737,021			6.9%		47.9%
March 1996	3	5			125,502		2,558,345			6.0%		44.8%
March 1996	3	6			270,514		3,020,599			12.9%		52.9%
March 1996	3	7			651,409		2,569,775			31.1%		45.0%
March 1996	3	8	177,573		414,796		2,436,719	8.5%		19.8%		42.7%
March 1996	3	9	188,415				2,495,566	9.0%				43.7%
March 1996	3	10					2,416,345					42.3%
March 1996	3	11					2,409,669					42.2%
March 1996	3	12					2,355,255					41.2%
March 1996	3	13					2,494,665					43.7%
March 1996	3	14	120,802				2,621,832	5.8%				45.9%
March 1996	3	15			150,776		2,629,607			7.2%		46.0%
March 1996	3	16					2,498,412					43.7%
March 1996	3	17					2,528,533					44.3%
March 1996	3	18					2,933,714					51.4%
March 1996	3	19					2,911,321					51.0%
March 1996	3	20					2,695,758					47.2%
March 1996	3	21					2,465,189					43.2%
March 1996	3	22					2,378,590					41.6%
March 1996	3	23					2,371,214					41.5%
March 1996	3	24					2,682,503					47.0%
March 1996	3	25					2,957,160					51.8%
March 1996	3	26			494,383		3,010,559			23.6%		52.7%
March 1996	3	27					2,860,049					50.1%
March 1996	3	28					2,506,472					43.9%
March 1996	3	29					2,747,821					48.1%
March 1996	3	30					2,443,908					42.8%
March 1996	3	31					2,009,790					35.2%

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
April 1996	4	1					2,107,981					36.9%
April 1996	4	2					2,125,491					37.2%
April 1996	4	3					2,200,654					38.5%
April 1996	4	4					2,726,134					47.7%
April 1996	4	5					3,114,834					54.5%
April 1996	4	6					2,620,294					45.9%
April 1996	4	7					2,208,575					38.7%
April 1996	4	8					2,141,434					37.5%
April 1996	4	9					2,113,191					37.0%
April 1996	4	10					2,176,143					38.1%
April 1996	4	11	144,577			1,088,462	1,050,412	6.9%			34.9%	18.4%
April 1996	4	12				2,013,194					64.5%	
April 1996	4	13				2,086,719					66.8%	
April 1996	4	14				2,216,986					71.0%	
April 1996	4	15	160,338			2,179,525		7.7%			69.8%	
April 1996	4	16				2,022,620					64.8%	
April 1996	4	17				1,919,124					61.5%	
April 1996	4	18				1,945,763					62.3%	
April 1996	4	19				2,269,114					72.7%	
April 1996	4	20				2,021,265					64.7%	
April 1996	4	21				1,946,103					62.3%	
April 1996	4	22				2,033,962					65.1%	
April 1996	4	23				1,940,547					62.2%	
April 1996	4	24				1,795,096					57.5%	
April 1996	4	25	450,804	580,690		903,512		21.5%	27.7%		28.9%	
April 1996	4	26	856,726	1,165,612				40.9%	55.7%			
April 1996	4	27	831,852	1,040,858				39.7%	49.7%			
April 1996	4	28	1,019,598	1,081,214				48.7%	51.6%			
April 1996	4	29	1,060,313	1,344,833				50.6%	64.2%			
April 1996	4	30	943,485	1,182,730				45.1%	56.5%			

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
May 1996	5	1	936,468	1,110,000				44.7%	53.0%			
May 1996	5	2	888,152	1,100,000				42.4%	52.5%			
May 1996	5	3	864,692	1,060,000				41.3%	50.6%			
May 1996	5	4	856,141	1,050,000				40.9%	50.1%			
May 1996	5	5	855,500	1,050,000				40.9%	50.1%			
May 1996	5	6	828,306	996,067				39.6%	47.6%			
May 1996	5	7	791,733	933,720				37.8%	44.6%			
May 1996	5	8	618,884	1,120,000				29.6%	53.5%			
May 1996	5	9	756,403	930,035				36.1%	44.4%			
May 1996	5	10	711,464	877,231				34.0%	41.9%			
May 1996	5	11	684,852	752,703				32.7%	35.9%			
May 1996	5	12	829,328	669,463				39.6%	32.0%			
May 1996	5	13	741,949	816,480				35.4%	39.0%			
May 1996	5	14	724,397	834,854				34.6%	39.9%			
May 1996	5	15	730,033	857,152				34.9%	40.9%			
May 1996	5	16	718,380	830,144				34.3%	39.6%			
May 1996	5	17	981,011	184,771	355,129			46.8%	8.8%	17.0%		
May 1996	5	18	60,465		46,805			2.9%		2.2%		
May 1996	5	19	482,586		955,792			23.0%		45.6%		
May 1996	5	20	401,663	144,479	944,077			19.2%	6.9%	45.1%		
May 1996	5	21		980,198	570,595				46.8%	27.2%		
May 1996	5	22		1,016,630	548,889				48.5%	26.2%		
May 1996	5	23		911,836	647,551				43.5%	30.9%		
May 1996	5	24		962,320	646,103				46.0%	30.9%		
May 1996	5	25		979,399	650,035				46.8%	31.0%		
May 1996	5	26		1,038,212	754,066				49.6%	36.0%		
May 1996	5	27		827,636	920,675				39.5%	44.0%		
May 1996	5	28		819,839	795,685				39.1%	38.0%		
May 1996	5	29		620,634	918,515				29.6%	43.9%		
May 1996	5	30		709,039	803,171				33.9%	38.4%		
May 1996	5	31		929,740	643,367				44.4%	30.7%		

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
June 1996	6	1		876,620	642,510				41.9%	30.7%		
June 1996	6	2		834,412	625,762				39.8%	29.9%		
June 1996	6	3		1,164,775	342,871				55.6%	16.4%		
June 1996	6	4	979,077	531,175				46.8%	25.4%			
June 1996	6	5	1,299,804	171,684				62.1%	8.2%			
June 1996	6	6	1,028,963	448,330				49.1%	21.4%			
June 1996	6	7	1,007,983	514,125				48.1%	24.6%			
June 1996	6	8	909,075	535,103				43.4%	25.6%			
June 1996	6	9	904,704	536,251				43.2%	25.6%			
June 1996	6	10	873,892	597,427				41.7%	28.5%			
June 1996	6	11	951,355	488,901				45.4%	23.3%			
June 1996	6	12	997,958	427,754				47.7%	20.4%			
June 1996	6	13	1,041,371	427,572				49.7%	20.4%			
June 1996	6	14	1,029,602	544,664				49.2%	26.0%			
June 1996	6	15	973,916	543,628				46.5%	26.0%			
June 1996	6	16	998,007	472,191				47.7%	22.5%			
June 1996	6	17	954,031	519,473				45.6%	24.8%			
June 1996	6	18	926,968	519,926				44.3%	24.8%			
June 1996	6	19	903,054	536,023				43.1%	25.6%			
June 1996	6	20	877,463	535,497				41.9%	25.6%			
June 1996	6	21	815,297	572,953				38.9%	27.4%			
June 1996	6	22	941,692	427,567				45.0%	20.4%			
June 1996	6	23	926,586	470,989				44.2%	22.5%			
June 1996	6	24	901,040	535,833				43.0%	25.6%			
June 1996	6	25	771,082	659,834				36.8%	31.5%			
June 1996	6	26	853,466	668,896				40.8%	31.9%			
June 1996	6	27	844,962	683,014				40.3%	32.6%			
June 1996	6	28	848,472	675,328				40.5%	32.2%			
June 1996	6	29	725,596	750,257				34.6%	35.8%			
June 1996	6	30	783,434	678,923				37.4%	32.4%			

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
July 1996	7	1	828,357	641,924				39.6%	30.7%			
July 1996	7	2	809,190	642,480				38.6%	30.7%			
July 1996	7	3	844,290	591,935				40.3%	28.3%			
July 1996	7	4	868,940	535,212				41.5%	25.6%			
July 1996	7	5	847,160	534,951				40.5%	25.5%			
July 1996	7	6	845,646	533,849				40.4%	25.5%			
July 1996	7	7	830,793	544,209				39.7%	26.0%			
July 1996	7	8	755,827	674,370				36.1%	32.2%			
July 1996	7	9	835,952	613,785				39.9%	29.3%			
July 1996	7	10	900,601	552,071				43.0%	26.4%			
July 1996	7	11	859,243	534,617				41.0%	25.5%			
July 1996	7	12	770,304	533,828				36.8%	25.5%			
July 1996	7	13	848,255	324,602				40.5%	15.5%			
July 1996	7	14	1,278,585					61.1%				
July 1996	7	15	1,386,886					66.2%				
July 1996	7	16	1,228,730	192,494				58.7%	9.2%			
July 1996	7	17	862,769	535,015				41.2%	25.5%			
July 1996	7	18	996,997	429,576				47.6%	20.5%			
July 1996	7	19	829,149	536,929				39.6%	25.6%			
July 1996	7	20	781,782	561,710				37.3%	26.8%			
July 1996	7	21	827,105	533,857				39.5%	25.5%			
July 1996	7	22	835,751	534,518				39.9%	25.5%			
July 1996	7	23	894,821	401,049				42.7%	19.2%			
July 1996	7	24	1,370,615					65.4%				
July 1996	7	25	1,254,658					59.9%				
July 1996	7	26	1,201,869					57.4%				
July 1996	7	27	1,191,964					56.9%				
July 1996	7	28	1,184,803					56.6%				
July 1996	7	29	1,200,282					57.3%				
July 1996	7	30	1,206,070					57.6%				
July 1996	7	31	1,199,634					57.3%				

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)			Load						
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
August 1996	8	1	1,030,000					49.2%				
August 1996	8	2	1,030,000					49.2%				
August 1996	8	3	1,020,000					48.7%				
August 1996	8	4	1,000,000					47.8%				
August 1996	8	5	1,020,000					48.7%				
August 1996	8	6	1,020,000					48.7%				
August 1996	8	7	1,040,000					49.7%				
August 1996	8	8	1,130,000					54.0%				
August 1996	8	9	1,110,000					53.0%				
August 1996	8	10	1,070,000					51.1%				
August 1996	8	11	1,030,000					49.2%				
August 1996	8	12	1,020,000					48.7%				
August 1996	8	13	1,010,000					48.2%				
August 1996	8	14	1,020,000					48.7%				
August 1996	8	15	1,020,000					48.7%				
August 1996	8	16	1,050,000					50.1%				
August 1996	8	17	1,060,000					50.6%				
August 1996	8	18	1,050,000					50.1%				
August 1996	8	19	1,040,000					49.7%				
August 1996	8	20	1,100,000					52.5%				
August 1996	8	21	1,080,000					51.6%				
August 1996	8	22	1,110,000					53.0%				
August 1996	8	23	1,150,000					54.9%				
August 1996	8	24	1,120,000					53.5%				
August 1996	8	25	1,130,000					54.0%				
August 1996	8	26	1,120,000					53.5%				
August 1996	8	27	1,120,000					53.5%				
August 1996	8	28	1,100,000					52.5%				
August 1996	8	29	1,110,000					53.0%				
August 1996	8	30	1,110,000					53.0%				
August 1996	8	31	1,100,000					52.5%				

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
September 1996	9	1	706,605	213,135				33.7%	10.2%			
September 1996	9	2	710,428	211,374				33.9%	10.1%			
September 1996	9	3	691,855	233,787				33.0%	11.2%			
September 1996	9	4	651,880	271,713				31.1%	13.0%			
September 1996	9	5	634,415	285,148				30.3%	13.6%			
September 1996	9	6	358,869	90,989		479,000		17.1%	4.3%		15.3%	
September 1996	9	7				909,000					29.1%	
September 1996	9	8				917,000					29.4%	
September 1996	9	9				922,905					29.6%	
September 1996	9	10				884,166					28.3%	
September 1996	9	11				870,860					27.9%	
September 1996	9	12				975,842					31.3%	
September 1996	9	13				962,467					30.8%	
September 1996	9	14				1,054,008					33.8%	
September 1996	9	15				991,866					31.8%	
September 1996	9	16				912,828					29.2%	
September 1996	9	17				934,289					29.9%	
September 1996	9	18				1,109,890					35.5%	
September 1996	9	19				1,158,298					37.1%	
September 1996	9	20				1,047,524					33.6%	
September 1996	9	21				977,936					31.3%	
September 1996	9	22				939,381					30.1%	
September 1996	9	23				1,021,314					32.7%	
September 1996	9	24				1,080,662					34.6%	
September 1996	9	25				1,142,506					36.6%	
September 1996	9	26				1,192,491					38.2%	
September 1996	9	27				1,279,574					41.0%	
September 1996	9	28				1,193,401					38.2%	
September 1996	9	29				1,099,278					35.2%	
September 1996	9	30				1,105,701					35.4%	

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

	Fuel Usage (scf)					Load				
	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
October 1996	10	1		1,375,365					44.1%	
October 1996	10	2		1,476,380					47.3%	
October 1996	10	3		1,538,299					49.3%	
October 1996	10	4		1,615,403					51.7%	
October 1996	10	5		1,430,517					45.8%	
October 1996	10	6		1,360,000					43.6%	
October 1996	10	7		1,470,000					47.1%	
October 1996	10	8		1,450,000					46.4%	
October 1996	10	9		1,396,868					44.7%	
October 1996	10	10		1,411,576					45.2%	
October 1996	10	11		1,419,216					45.5%	
October 1996	10	12		1,447,009					46.3%	
October 1996	10	13		1,566,731					50.2%	
October 1996	10	14		1,472,055					47.1%	
October 1996	10	15		1,529,126					49.0%	
October 1996	10	16		1,596,206					51.1%	
October 1996	10	17		1,645,353					52.7%	
October 1996	10	18		1,744,133					55.9%	
October 1996	10	19		1,574,974					50.4%	
October 1996	10	20		1,755,410					56.2%	
October 1996	10	21		1,734,516					55.6%	
October 1996	10	22		1,427,409					45.7%	
October 1996	10	23		710,151	1,500,000				22.7%	26.3%
October 1996	10	24			2,300,000					40.3%
October 1996	10	25			2,370,000					41.5%
October 1996	10	26			2,800,000					49.0%
October 1996	10	27			2,830,000					49.6%
October 1996	10	28		63,213	2,750,000				2.0%	48.2%
October 1996	10	29		62,400	2,840,000				2.0%	49.7%
October 1996	10	30			2,610,000					45.7%
October 1996	10	31			2,290,000					40.1%

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
November 1996	11	1					2,550,000					44.6%
November 1996	11	2					2,530,000					44.3%
November 1996	11	3					2,430,000					42.5%
November 1996	11	4					2,610,000					45.7%
November 1996	11	5					2,430,000					42.5%
November 1996	11	6					2,480,000					43.4%
November 1996	11	7		340,075		628,795	1,869,318		16.2%		20.1%	32.7%
November 1996	11	8		655,890		1,915,354			31.3%		61.3%	
November 1996	11	9		179,173		2,055,120			8.6%		65.8%	
November 1996	11	10		48,355		2,134,240			2.3%		68.4%	
November 1996	11	11		255,556		2,092,749			12.2%		67.0%	
November 1996	11	12		385,780	191,079	1,535,041			18.4%	9.1%	49.2%	
November 1996	11	13		343,539	725,366	1,207,350			16.4%	34.6%	38.7%	
November 1996	11	14			534,669	1,560,969				25.5%	50.0%	
November 1996	11	15			535,575	1,628,535				25.6%	52.2%	
November 1996	11	16			616,481	1,819,952				29.4%	58.3%	
November 1996	11	17			623,328	1,794,966				29.8%	57.5%	
November 1996	11	18			679,029	1,653,241				32.4%	53.0%	
November 1996	11	19			544,994	1,589,766				26.0%	50.9%	
November 1996	11	20			473,938	1,573,192				22.6%	50.4%	
November 1996	11	21			269,583	869,855	1,030,169			12.9%	27.9%	18.0%
November 1996	11	22					2,193,261					38.4%
November 1996	11	23					2,385,206					41.8%
November 1996	11	24			124,278		2,420,000			5.9%		42.4%
November 1996	11	25			226,879		2,606,052			10.8%		45.6%
November 1996	11	26			383,553		2,420,198			18.3%		42.4%
November 1996	11	27			549,503		2,400,272			26.2%		42.0%
November 1996	11	28			657,329	262,635	2,015,483			31.4%	8.4%	35.3%
November 1996	11	29			669,675		2,360,346			32.0%		41.3%
November 1996	11	30			740,320		2,364,989			35.4%		41.4%

ATTACHMENT 4-5 - STEAM PLANT OPERATIONS DATA (Continued)

			Fuel Usage (scf)					Load				
			Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6	Boiler 1	Boiler 2	Boiler 3	Boiler 5	Boiler 6
December 1996	12	1			711,114		2,334,473			34.0%		40.9%
December 1996	12	2			725,151		2,614,145			34.6%		45.8%
December 1996	12	3			750,753		2,640,904			35.9%		46.2%
December 1996	12	4			537,376		2,657,894			25.7%		46.5%
December 1996	12	5			564,882		2,517,392			27.0%		44.1%
December 1996	12	6			429,450		2,352,581			20.5%		41.2%
December 1996	12	7			533,877		2,152,669			25.5%		37.7%
December 1996	12	8			490,361		2,185,277			23.4%		38.3%
December 1996	12	9			694,954		1,849,336			33.2%		32.4%
December 1996	12	10			485,771		1,873,859			23.2%		32.8%
December 1996	12	11			550,173		1,787,882			26.3%		31.3%
December 1996	12	12			540,869	19,663	1,996,498			25.8%	0.6%	35.0%
December 1996	12	13			556,298		2,023,590			26.6%		35.4%
December 1996	12	14			555,945		1,983,902			26.5%		34.7%
December 1996	12	15			554,992		2,418,220			26.5%		42.3%
December 1996	12	16			668,147		2,553,365			31.9%		44.7%
December 1996	12	17			750,025	10,398	2,613,889			35.8%	0.3%	45.8%
December 1996	12	18		100,506	887,396	143,375	2,011,472		4.8%	42.4%	4.6%	35.2%
December 1996	12	19		9,093	528,026		1,908,245		0.4%	25.2%		33.4%
December 1996	12	20			591,726	55,220	2,228,146			28.3%	1.8%	39.0%
December 1996	12	21			604,046		2,325,689			28.8%		40.7%
December 1996	12	22			543,110		2,230,011			25.9%		39.0%
December 1996	12	23			706,324		2,506,266			33.7%		43.9%
December 1996	12	24			714,322		2,567,142			34.1%		44.9%
December 1996	12	25			574,867		2,266,703			27.5%		39.7%
December 1996	12	26			496,246		2,097,098			23.7%		36.7%
December 1996	12	27			449,329		2,048,733			21.5%		35.9%
December 1996	12	28			424,236		2,018,157			20.3%		35.3%
December 1996	12	29			507,827		1,953,606			24.2%		34.2%
December 1996	12	30			510,661		1,893,831			24.4%		33.2%
December 1996	12	31			500,842		1,869,493			23.9%		32.7%

ATTACHMENT 4-6 - AIR QUALITY DATA FOR THE ALBUQUERQUE BASIN

Summary of the Albuquerque Basin Ambient Air Quality-Carbon Monoxide (ppm)*

Averaging Period	Site Code	Note	1996 High	1996 2nd High	1995 High	1995 2nd High	1994 High	1994 2nd High	1993 High	1993 2nd High	1992 High	1992 2nd High	Five-Year High	Five-Year 2nd High
1-Hour	2R		8.0	8.0	7.0	6.0	9.0	7.0	7.0	7.0	6.0	6.0	7.4	6.8
	2ZE		9.0	8.0	9.0	9.0	10.0	9.0	10.0	10.0	12.0	11.0	10.0	9.4
	2ZK		12.0	11.0	14.0	11.0	11.0	11.0	12.0	12.0	12.0	11.0	12.2	11.2
	2ZL		8.0	6.0	13.0	10.0	8.0	7.0	5.0	5.0	5.0	4.0	7.8	6.4
	2ZM		10.0	9.0	9.0	8.0	8.0	8.0	10.0	9.0	10.0	9.0	9.4	8.6
	2ZN		10.0	9.0	10.0	9.0	10.0	9.0	9.0	9.3	12.0	9.0	10.2	9.1
	2ZQ				4.7	4.4	4.3	4.1	5.7	4.1	5.5	3.8	5.1	4.1
	2ZR	1	3.5	2.5										
	Average		9.5	8.5	9.5	8.2	8.6	7.9	8.4	8.1	8.9	7.7	9.0	8.1
8-Hour	2R		4.9	4.5	4.5	4.5	5.0	5.0	3.9	3.8	3.6	3.4	4.4	4.2
	2ZE		5.1	4.5	5.1	4.9	5.9	5.5	8.0	7.4	7.9	7.6	6.4	6.0
	2ZK		8.3	7.1	9.1	7.6	7.6	7.6	9.0	8.5	8.9	8.4	8.6	7.8
	2ZL		2.6	2.5	5.6	5.1	2.4	2.4	2.1	2.1	1.9	1.7	2.9	2.8
	2ZM		4.1	4.1	3.9	3.7	5.0	4.5	5.8	5.0	5.8	4.4	4.9	4.3
	2ZN		3.3	3.3	4.1	4.0	4.9	4.6	5.1	3.9	6.9	4.6	4.9	4.1
	2ZQ				2.0	1.9	1.7	1.7	2.0	1.8	2.2	2.0	2.0	1.9
	2ZR	1	1.6	1.4										
	Average		4.7	4.3	4.9	4.5	4.6	4.5	5.1	4.6	5.3	4.6	4.9	4.5

1-Monitoring Started 2/6/96, replacing 2ZQ

*-Based on Data from the NMED Annual Summaries

ATTACHMENT 4-6 - AIR QUALITY DATA FOR THE ALBUQUERQUE BASIN (Continued)

Summary of the Albuquerque Basin Ambient Air Quality-Nitrogen Dioxide (ppm)*

Averaging Period	Site	Note	1996 High	1996 2nd High	1995 High	1995 2nd High	1994 High	1994 2nd High	1993 High	1993 2nd High	1992 High	1992 2nd High	Five-Year High	Five-Year 2nd High
24-Hour	ZM		0.0450	0.0440	0.0590	0.0480	0.0550	0.0520	0.0540	0.0540	0.0410	0.0400	0.0508	0.0476
	ZQ	1			0.0230	0.0210							0.0230	0.0210
	ZR	2	0.0290	0.0240									0.0290	0.0240
	ZC	3					0.0060	0.0040	0.0030	0.0030	0.0040	0.0040	0.0043	0.0037
	Average		0.0370	0.0340	0.0410	0.0345	0.0305	0.0280	0.0285	0.0285	0.0225	0.0220	0.0319	0.0294
Annual	ZM		0.0220		0.0180		0.0230		0.0240		0.0210		0.0216	
	ZQ	1			0.0100								0.0100	
	ZR	2	0.0080										0.0080	
	ZC	3					0.0030		0.0030		0.0030		0.0030	
	Average		0.0150		0.0140		0.0130		0.0135		0.0120		0.0135	

1-Monitoring Started 3/16/95

2-Monitoring Started 2/6/96, replacing ZQ

3-Monitoring shutdown 10/1/94

*-Based on Data from the NMED Annual Summaries

ATTACHMENT 4-6 - AIR QUALITY DATA FOR THE ALBUQUERQUE BASIN (Continued)

Summary of the Albuquerque Basin Ambient Air Quality-Ozone (ppm)*

Averaging Period	Site	Note	1996 High	1996 2nd High	1995 High	1995 2nd High	1994 High	1994 2nd High	1993 High	1993 2nd High	1992 High	1992 2nd High	Five-Year High	Five-Year 2nd High
1-Hour	2R		0.080	0.079	0.068	0.068	0.084	0.080	0.084	0.080	0.094	0.089	0.082	0.079
	2ZE		0.111	0.098	0.077	0.077	0.067	0.069	0.087	0.084	0.094	0.089	0.089	0.083
	2ZF		0.098	0.088	0.107	0.095	0.101	0.101	0.085	0.080	0.085	0.078	0.095	0.088
	2ZH		0.091	0.084	0.097	0.088	0.106	0.087	0.085	0.080	0.093	0.092	0.094	0.086
	2ZJ		0.087	0.078	0.093	0.091	0.120	0.094	0.082	0.080	0.098	0.096	0.096	0.088
	2ZL	1	0.081	0.079	0.086	0.085	0.090	0.086	0.088	0.088	0.084	0.082	0.086	0.084
	2ZM		0.080	0.079	0.051	0.040		0.067	0.078	0.072	0.080	0.080	0.066	0.060
	2ZP		0.080	0.079	0.077	0.076	0.093	0.093	0.090	0.086		0.080	0.077	0.075
	2ZQ	2			0.109	0.100	0.094	0.094					0.098	0.093
	2ZR	3	0.100	0.088										
	3ZC	4	0.090	0.084	0.085	0.080	0.090	0.074	0.077	0.071	0.078	0.076	0.082	0.074
	Average						0.092	0.083	0.084	0.080	0.088	0.085	0.088	0.082

1-Monitoring Started 7/31/95

2-Monitoring Started 10/93

3-Monitoring Started 2/6/96, replacing 2ZQ

4-Monitoring shutdown 10/1/94

*-Based on Data from the NMED Annual Summaries

ATTACHMENT 4-6 - AIR QUALITY DATA FOR THE ALBUQUERQUE BASIN (Continued)

Summary of the Albuquerque Basin Ambient Air Quality-Particulate Matter (ug/m3)*

Averaging Period	Site	Note	1996 High	1996 2nd High	1995 High	1995 2nd High	1994 High	1994 2nd High	1993 High	1993 2nd High	1992 High	1992 2nd High	Five-Year* High	Five-Year* 2nd High
24-Hour	2G		84	46	55	52	53	44	53	38	48	47	59	45
	2R		96	96	106	97	89	84	100	69	71	59	92	81
	2U		39	39	75	51	53	49	82	63	50	49	60	50
	2ZE		53	52	43	41	39	37	52	40	55	52	48	44
	2ZH		96	94	145	112	91	83	96	86	75	67	101	88
	2ZK		37	34	52	49	77	55	74	53	82	48	64	48
	2ZL		80	76	121	81	121	65	78	47	43	39	89	62
	2ZM		36	34	54	46	48	41	65	56	51	37	51	43
	2ZN		35	34	52	40	41	35	103	36	57	35	58	36
	2ZO		67	54	81	65	71	63	82	65	50	49	70	59
	3ZC						29	19	30	16	21	17	27	17
	Average		62.3	55.9	78.4	63.4	64.7	52.3	74.1	51.7	54.8	45.4	66.9	53.7
Annual	2G		23		21		20		21		23		21.6	
	2R		37		33		37		35		31		34.6	
	2U		22		24		26		28		23		24.6	
	2ZE		18		18		16		17		16		17.0	
	2ZH		38		35		27		25		28		30.6	
	2ZK		22		24		24		27		28		25.0	
	2ZL		37		34		27		22		21		28.2	
	2ZM		19		22		20		26		24		22.2	
	2ZN		19		19		18		19		18		18.6	
	2ZO		31		31		29		28		28		29.4	
	3ZC						9		8		8		8.3	
	Average		26.6		26.1		23.0		23.3		22.5		24.3	

*Based on Data from the NMED Annual Summaries

ATTACHMENT 4-7 - SNL/NM CLEAN AIR NETWORK (CAN) PROGRAM DATA

	CO		NO2		SO2		O3	
	1HR MAX	8H MAX	Monthly Avg	24H MAX	Monthly Avg	3H MAX	24H MAX	Monthly Avg
Jan, 1994	9	3.5	2.1	24	36	2	2	1.0
Feb	7.6	4	1.3	19	39	2	2	0.4
Mar	6	3	1.2	16	32	2	2	0.3
Apr	4	2			26	2	2	
May	3.6	2.2	1.4	9	14	1	1	0.1
Jun	3.8	2.2	1.2	13	28	2	2	0.3
Jul	2.8	1.5	0.8	9	16	1	1	0.0
Aug	3.8	2	1.1	7	18	1	1	0.0
Sep	4.5	2.9	1.7	15	34	2	2	0.1
Oct	7.7	3.7	1.8	18	34	1	1	0.1
Nov	7.6	4.5	1.6	19	34	2	2	0.2
Dec	7.4	3.3	1.6	23	41	2	2	0.5
Jan, 1995	6.3	2.9	1.6	16	33	1	1	0.1
Feb	5.9	2.6	1.5	14	27	1	1	0.1
Mar	2.8	1.9	0.8	11	20	1	1	0.0
Apr	3.9	2.1	1	9	17	1	1	0.1
May	1.7	0.9	0.3	7	17	1	1	0.0
Jun	2.3	1	0.4	7	17	0	0	0.0
Jul	3	0.9	0.3	10	23	2	2	0.2
Aug	8.4	1.4	0.4	9	18	0	0	0.0
Sep	4.1	1.4	0.4	10	22	1	1	0.0
Oct	15.3	4.8	1.4	19	33	2	2	0.5
Nov	3.3	1.6	0.6	19	31	2	2	0.5
Dec	7	2.7	0.9	10	29	1	1	0.2
Jan, 1996	8	2.9	0.8	17	35	3	3	0.4
Feb	8.3	2.7	0.8	14	30	2	2	0.3
Mar	3.2	1.3	0.4	10	22	0	0	0.0
Apr	2.9	1.4	0.7	8	19	1	1	0.1
May	2.9	1.7	0.7	9	19	1	1	0.1
Jun	2.8	1.2	0.7	10	16	1	1	0.0
Jul	2.2	1.3	0.8	8	16	0	0	0.0
Aug	2.5	1.3	0.8	9	14	1	1	0.1
Sep	3	2.1	1	12	20	1	1	0.0
Oct	4	2.3	0.9	14	26	1	1	0.2
Nov	4.4	1.8	0.8	18	31	3	3	0.8
Dec	5.7	2.7	1.1	18	31	2	2	0.5

[illegible]

Compound	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Nov-94	Dec-94	Jan-95
Isopentane	0.2	0.8	0.6		0.8	0.4		0.2	0.2	0.1	0.5
m/p-Xylene											
Methanol			1.1								
Methylene Chloride								0.05			
MTBE + Isohexane + c-4-m-2-Pentene	0.2	0.6	0.2		0.2						0.09
n-Butane	0.4	0.9	0.3		0.5	0.3	0.3	0.2	0.2	0.2	
n-Hexane											
n-Pentane		0.2			0.3	0.2					0.2
n-Undecane											
o-Xylene											
Propane	2	2.1	0.6								
Propylene	0.3	0.7	0.2								
Tetrachloroethene	0.1			0.03	0.06			0.09		0.05	
TNMHC	4.3	11.3	4.7	1.5	4.6	10.8	2.6	5.5	1.3	3.8	4.1
Toluene	0.1	0.3	0.3		0.3	0.4		0.2	0.2	0.2	
Trichloroethene											
Trichloroethylene + BDCmethane	0.2	0.3		0.2	0.3			1	0.09	0.1	
Trichlorofluoromethane	0.3	0.1	0.07	0.2	0.4	0.08	0.08	0.3	0.1	0.2	0.9
MWL											
1,1,1-Trichloroethane	0.2	0.6		0.2	0.2			0.06	0.09		
1,4-Dioxane + 2,2,4-TMpentane	0.3										
1-Butene											
2,2,4-Trimethylpentane											
3-Methylpentane		0.2									
Acetone	0.2	0.3	27.2	0.7	0.4	2.8	1	0.6	0.3	27.6	4.9
Acetylene	0.7	0.4	0.7								
Benzene	0.3	0.2	0.3	0.2	0.3	0.4	0.3	0.1	0.2	0.2	0.2
Bromodichloromethane											
Carbon Tetrachloride	0.07			0.08	0.07			0.05	0.06		
Chloromethane	0.4	3	0.4	1	0.4	0.9		0.4	0.3	0.1	
Dichlorodifluoromethane	0.6	0.4	0.1	0.5	1.1	0.5	0.4	0.7	0.6	0.5	0.5
Ethane	4.2	1.8	2.8								
Ethylbenzene											
Ethylene	0.8	0.7	0.9								
Halocarbon 113	0.07	0.05		0.1	0.2	0.04		0.04	0.04		
Isobutene											
Isobutene + 1-Butene						4.6					
Isohexane											
Isopentane	1.5	12.6	0.8	0.6	0.9	0.4	0.6		0.3	0.3	0.8
m/p-Xylene		0.1	0.1								
Methanol	10.3	1	1.9								
Methylene Chloride					0.09						
MTBE + Isohexane + c-4-m-2-Pentene		0.6	0.2		0.3						
n-Butane	0.6	0.4	0.3		0.6	0.3	0.4	0.2	0.4	0.3	0.6
n-Hexane		0.4									
n-Pentane	0.2	1.1	0.2		0.4		0.2		0.2		0.2
n-Undecane											
Propane	3.1	2.1	1.7								
Propylene	0.8	0.7	0.5								
Tetrachloroethene	0.03										
TNMHC	10.3	26.6	19.5	2.4	5.6	8.1	4	2.5	2.5	16.4	6.7
Toluene	0.3	1.2	0.3		0.4	0.3	0.2		0.2	0.2	0.1
Trichloroethylene + BDCmethane				0.2							
Trichlorofluoromethane	0.3	0.1	0.08								

ATTACHMENT 4-7 - SNL/NM CLEAN AIR NETWORK (CAN) PROGRAM DATA (Continued)

Compound	Mar-94	Apr-94	May-94	Jun-94	Jul-94	Aug-94	Sep-94	Oct-94	Nov-94	Dec-94	Jan-95
1,1,1-Trichloroethane	0.5	0.2			0.1	0.1			0.1	0.07	
1,4-Dioxane + 2,2,4-Trimethylpentane	0.2										
1-Butene											
2,2,4-Trimethylpentane											
3-Methylpentane	0.3					0.2					
Acetone	1.7	0.4		0.5			3.5	1		0.1	0.7
Acetylene	2.5	0.7	0.7								
Benzene	0.7	0.3	0.4	0.2	0.5	0.4	0.2	0.3	0.3		0.2
Carbon Tetrachloride	0.09			0.009	0.08				0.06		
Chloromethane	0.3	1.7	0.4	0.9	0.3	0.4	0.4	0.3	0.3		
Dichlorodifluoromethane	0.6	0.3	0.07	0.6	1.2	0.5	0.3	0.9	0.6		1.3
Ethane	6.7	2.8	3.5								
Ethylbenzene											
Ethylene	3.1	1.1	1.1								
Halocarbon 113	0.1			0.09	0.2			0.06	0.05		
Isobutene											
Isobutene + 1-Butene	1.4	0.6		0.4		2.2					
Isohexane											
Isopentane	1.5	16.6	1.4	0.5	1.7	1.1		0.5	0.9		0.2
m/p-Xylene	0.2		0.2								
Methanol	0.9	1									
Methylene Chloride	0.9				0.07						
MTBE + Isohexane + c-4-m-2-Pentene	0.6	0.4	0.3		0.4						
n-Butane	2	0.7	0.6		0.9	0.5	0.3	0.5	0.7		0.5
n-Hexane	0.4	0.2			0.2						
n-Pentane	0.6	1.5	0.4		0.7	0.5			0.2		
n-Undecane											
o-Xylene											
Propane	2.8	1.1	0.9								
Propylene	0.8	0.5	0.4								
Tetrachloroethene	0.05				0.04				0.02		
TNMC	17.8	24.2	6.2	9	7.4	9.3	8.4	3.6	4		3
Toluene	1	0.4	0.6	0.2	0.7	0.4		0.2	0.3		
Trichloroethene											
Trichloroethylene + BDCmethane				0.04							
Trichlorofluoromethane	0.3	0.2	0.05	0.2	0.4	0.09	0.07	0.3	0.2		0.2

**ATTACHMENT 4-7 - SNL/NM CLEAN AIR NETWORK (CAN) PROGRAM
DATA (Continued)**

Compound CPMS	Feb-95	Mar-95	Apr-95	May-95	Jun-95	Jul-95	Aug-95	Sep-95	Oct-95	Nov-95	Dec-95
1,1,1-Trichloroethane	0.05		0.1	0.08	0.2	0.4	0.5	0.08	0.06	0.1	0.1
1,4-Dioxane + 2,2,4-TMpentane	0.1				0.2	0.2		0.4	0.2	0.2	0.5
1-Butene											
2,2,4-Trimethylpentane											
3-Methylpentane	0.3	0.1		0.2	0.2	0.2		0.6	0.3	0.4	0.8
Acetone	0.4	0.3	3.7	0.4	0.8	3.2	2.8	1	0.9	2.6	2.4
Acetylene											
Benzene	0.7	0.4	0.3	0.4	0.4	0.4	0.1	0.9	0.7	0.8	1.3
Carbon Tetrachloride	0.05		0.08	0.09	0.1	0.1	0.1	0.05	0.05	0.06	0.09
Chloromethane	0.2		0.4	0.3	0.6	0.4	0.3	0.4	0.2	0.3	0.3
Dichlorodifluoromethane	0.4	0.4	0.5	0.4	0.8	0.7	2.9	0.5	0.4	0.6	0.9
Ethane											
Ethylbenzene	0.2							0.2		0.2	0.3
Ethylene											
Halocarbon 113	0.08		0.07	0.06	0.1	0.07	0.09	0.05	0.02	0.08	0.08
Isobutene											
Isobutene + 1-Butene								0.2		0.3	0.5
Isohexane											
Isopentane	1.7	1.3	0.4	1.8	1.3	3.9	0.7	3	1.8	2.3	4.2
m/p-Xylene	0.3	0.1			0.2	0.2	0.6	0.3	0.3	0.3	0.8
Melhanol											
Methylene Chloride					0.05	0.1	0.06	0.06		0.2	0.2
MTBE + Isohexane + c-4-m-2-Pentene											
n-Butane	2.2			1.8	0.4	0.9	0.5	1.6	0.7	3.4	5.6
n-Hexane	0.4			0.2	0.2	0.2	0.4	0.4	0.3	0.4	0.7
n-Pentane	0.8	0.2	0.2	0.5	0.4	0.7	0.2	1.4	1.2	1.2	1.8
n-Undecane											
o-Xylene	0.09				0.1	0.1	0.3	0.2	0.2	0.1	0.3
Propane											
Propylene											
Tetrachloroethene								0.02		0.03	0.05
TNMC	15.8	8.6	6.3	7.5	7.4	14.3	7.5	19.1	13.6	20.9	33.8
Toluene	1.1	0.5	0.3	0.5	0.5	0.7	0.2	1.6	1.4	1.4	2.7
Trichloroethene											
Trichloroethylene + BDCmethane	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.2	0.1	0.2	0.4
Trichlorofluoromethane											
CWL											
1,1,1,1-Trichloroethane	0.08	0.1		0.1	0.1	0.1	0.04	0.05	0.03	0.04	0.1
1,4-Dioxane + 2,2,4-TMpentane											
1-Butene											
2,2,4-Trimethylpentane											
3-Methylpentane											
Acetone	7.6	2		1.8	1.1	1.1	1.6	0.9	0.5	3.2	3.2
Acetylene											
Benzene	0.3	0.3		0.1						0.2	0.3
Carbon Tetrachloride	0.03			0.09	0.1	0.1	0.04	0.05	0.03	0.04	0.08
Chloromethane				0.3	0.6	0.4	0.2	0.3	0.2	0.3	0.3
Dichlorodifluoromethane	0.5	1.2		0.6	0.8	0.4	0.3	0.4	0.2	0.5	0.5
Ethane											
Ethylbenzene											
Ethylene											
Halocarbon 113	0.03			0.1	0.1	0.06	0.04	0.05		0.07	0.09
Isobutene											
Isobutene + 1-Butene											
Isohexane											

[illegible]

TA-II

ATTACHMENT 4-7 - SNL/NM CLEAN AIR NETWORK (CAN) PROGRAM DATA (Continued)

Compound	Feb-95	Mar-95	Apr-95	May-95	Jun-95	Jul-95	Aug-95	Sep-95	Oct-95	Nov-95	Dec-95
1,1,1-Trichloroethane											
1,4-Dioxane + 2,2,4-Trimethylpentane		0	0.1		0.1	0.06	0.1	0.07	0.03	0.08	0.07
1-Butene											0.2
2,2,4-Trimethylpentane											
3-Methylpentane	0.4							0.3		0.1	0.3
Acetone	2.5	0.3		0.5	3.6	12.8	1.6	1.7	1	0.9	0.5
Acetylene											
Benzene	0.4	0.3	0.2	0.2				0.4	0.3	0.3	0.7
Carbon Tetrachloride	0.03		0.07	0.06	0.1	0.07	0.1	0.05	0.03	0.06	0.08
Chloromethane		1	0.4	0.2	0.6	0.3		0.4		0.3	0.3
Dichlorodifluoromethane	0.5	0.2	0.4	0.4	0.8	0.3	0.6	0.4	0.3	0.5	1.3
Ethane											
Ethylbenzene											0.1
Ethylene											
Halocarbon 113	0.04		0.07	0.06	0.1	0.06	0.08	0.05		0.08	0.07
Isobutene											
Isobutene + 1-Butene	0.3										
Isohexane											
Isopentane	1.1	0.4	0.3		0.5	0.5		1.7	0.9	4.3	2
m/p-Xylene	0.1							0.3			0.2
Methanol											
Methylene Chloride										0.1	0.07
MTBE + Isohexane + c-4-m-2-Pentene											
n-Butane	1.5			0.6		0.6		1	0.6	2.3	3
n-Hexane	0.2							0.3		0.2	0.3
n-Pentane	0.5			0.2		0.4		1		4	0.9
n-Undecane											
o-Xylene								0.2			0.08
Propane											
Propylene											
Tetrachloroethene			0.04					0.02			0.03
TNPHC	9.3	2.6	2.4	2.7	3.1	44.7	1.3	10.4	5.5	16.5	13.2
Toluene	0.6	0.3	0.2	0.3	0.2	0.2		0.8	0.4	0.8	1
Trichloroethene											
Trichloroethylene + BDCmethane											
Trichlorofluoromethane	0.1	0.1	0.2	0.1	0.3	0.1	0.2	0.2	0.1	0.2	0.2

ATTACHMENT 4-7 - SNL/NM CLEAN AIR NETWORK (CAN) PROGRAM DATA (Continued)

Compound CPMS	Jan-96	Feb-96	Apr-96	May-96	Jun-96	Jul-96	Aug-96	Sep-96	Oct-96	Nov-96	Dec-96
1,1,1-Trichloroethane	0.08	0.07	0.122	2.06	0.486	0.191	0.219	0.1	0.12	0.174	0.142
1,4-Dioxane + 2,2,4-Trimethylpentane	0.5	0.4									
1-Butene			0.104	0.0727	0.159	0.191	0.186	0.12	0.35	0.566	0.222
2,2,4-Trimethylpentane						0.085	0.107	0.07	0.189	0.398	0.111
3-Methylpentane	0.5	0.4	0.167	0.13	0.0953	0.174	0.169	0.07	0.33	0.632	0.133
Acetone	2.4	0.6	2.58	17	30.4	4.86	3.4	4.9	2.04	3.5	1.75
Acetylene											
Benzene	1.1	0.7	0.343	0.24	0.178	0.344	0.359	0.23	0.66	1.3	0.686
Carbon Tetrachloride	0.09	0.07	0.106	0.109	0.115	0.104	0.112	0.1	0.0988	0.104	0.121
Chloromethane	0.4	0.3	0.574	0.613	0.57	0.503	0.406	0.39	0.449	0.458	0.367
Dichlorodifluoromethane	0.6	0.6	0.675	0.509	0.523	1.27	0.516	0.48	0.566	0.548	0.635
Ethane											
Ethylbenzene	0.3	0.2	0.116	0.0404		0.07	0.073	0.06	0.144	0.276	0.0889
Ethylene											
Halocarbon 113	0.1	0.07	0.112	0.0991	0.0933	0.132	0.136	0.08	0.0787	0.0724	0.0801
Isobutene			0.183								
Isobutene + 1-Butene	0.5	0.3									
Isobutane				0.251		0.402	0.419	0.17	0.608	1.14	0.334
Isopentane	3	3.1	0.809			1.28	1.02	0.74	1.84	3.27	1.52
m/p-Xylene	0.6	0.5	0.261	0.0757	0.0339	0.195	0.174	0.19	0.442	0.724	0.0896
Methanol											
Methylene Chloride	0.06	0.06	0.0153	0.043	0.0976	0.095	0.044	0.03	0.0951	0.0796	0.0855
MTBE + Isobutane + c-4-m-2-Pentene											
n-Butane	4.3	4.5	1.04	0.9	0.667	0.739	0.56	0.36	1.55	3.28	2.15
n-Hexane	0.5	0.4	0.174	0.131		0.156	0.15	0.06	0.324	0.721	0.158
n-Pentane	1.3	2	0.551	0.428	0.727	0.485	0.46	0.29	0.841	1.54	0.534
n-Undecane							0.002	0.005	0.0161		
o-Xylene	0.3	0.2	0.137	0.0427		0.077	0.077	0.08	0.174	0.3	0.0575
Propane											
Propylene											
Tetrachloroethene	0.07		0.0229			0.019			0.0277	0.0515	0.0629
TNMC	29.4	22.5	7.98	200	34.2	10.8	10.5	21.6	16.5	49.2	40.3
Toluene	2.1	2.3	0.588	0.371	0.197	0.563	0.607	0.39	1.01	2.22	1.08
Trichloroethene			0.0243			0.023	0.022	0.01	0.0113		
Trichloroethylene + BDCmethane											
Trichlorofluoromethane	0.2	0.2	0.247	0.263	0.53	0.277	0.319	0.25	0.244	0.245	0.274
CWL											
1,1,1-Trichloroethane											
1,4-Dioxane + 2,2,4-Trimethylpentane	0.07	0.06	0.135	0.198	0.398	0.126	0.239	0.11	0.13	0.117	0.119
1-Butene				0.0763	0.133	0.089	0.116	0.03	0.101	0.134	0.103
2,2,4-Trimethylpentane				0.00774				0.005	0.0721	0.0383	
3-Methylpentane				0.0136		0.033	0.01	0.005	0.0526	0.0675	0.0272
Acetone		0.8	6.59	2.36	6.02	3.79		1.8	2.46	4.32	1.22
Acetylene											
Benzene	0.1	0.1	0.0864	0.0678	0.0593	0.081	0.038	0.03	0.115	0.166	0.239
Carbon Tetrachloride	0.07	0.04	0.0933	0.103	0.108	0.103	0.089	0.11	0.0864	0.102	0.102
Chloromethane	0.3	0.1	0.57	0.573	0.512	0.513	0.414	0.37	0.44	0.436	0.366
Dichlorodifluoromethane	0.6	0.4	0.566	0.479	0.473	1.1	0.435	0.46	0.483	0.468	0.542
Ethane											
Ethylbenzene											0.0319
Ethylene											
Halocarbon 113	0.1	0.05	0.11	0.114	0.0955	0.112	0.137	0.08	0.0951	0.0784	0.0947
Isobutene			0.216								
Isobutene + 1-Butene											
Isobutane				0.0317		0.107	0.061		0.0954	0.14	0.0826

**ATTACHMENT 4-7 - SNL/NM CLEAN AIR NETWORK (CAN) PROGRAM
DATA (Continued)**

Compound	Jan-96	Feb-96	Apr-96	May-96	Jun-96	Jul-96	Aug-96	Sep-96	Oct-96	Nov-96	Dec-96
Isopentane	0.4	0.6	0.163	0.126	0.287	0.347	0.046	0.02	0.0542	0.0308	0.0319
m/p-Xylene			0.0272			0.022			0.0415		0.0548
Methanol											
Methylene Chloride				0.0214	0.0459	0.036	0.046				
MTBE + Isohexane + c-4-m-2-Pentene											
n-Butane	0.7	0.9	0.282	0.129	0.258	0.317	0.077	0.1	0.341	0.82	0.664
n-Hexane						0.028			0.0488		0.0396
n-Pentane	0.2	0.3	0.216	0.0586	0.134	0.143	0.057	0.05	0.744	0.318	0.201
n-Undecane			0.0114								
o-Xylene											0.0218
Propane											
Propylene											
Tetrachloroethene			0.0073								
TNMC	3.4	5.9	9.57	4.12	9.95	5.98	30.6	6.8	10.2	16	24.4
Toluene	0.1	0.2	0.127	0.0734	0.0269	0.096	0.082	0.03	0.209	0.162	0.198
Trichloroethene			0.161	0.148		0.06	0.135	0.15	0.155		0.0447
Trichloroethylene + BDCmethane	0.06	0.07									
Trichlorofluoromethane	0.2	0.1	0.258	0.245	0.241	0.267	0.206	0.26	0.244	0.226	0.234
MWL											
1,1,1-Trichloroethane	4.8	8.3	5.19	54.9	167	50.8	174	10.8	4.04	8.52	3.84
1,4-Dioxane + 2,2,4-Tmpentane											
1-Butene				0.115	0.118	0.126	0.09	0.07	0.128	0.147	0.0681
2,2,4-Trimethylpentane			0.0258	0.0196	0.0211	0.029	0.008	0.007	0.0613	0.0767	0.0174
3-Methylpentane			0.0307	0.0208	0.0446	0.061		0.02	0.0565	0.116	0.0238
Acetone	0.8	9.1	3.64	6.47	10.5	6.68	5.08	2.9	4.47	4.35	1.81
Acetylene											
Benzene	0.1	0.0927	0.0768	0.0925	0.126	0.126	0.059	0.03	0.127	0.241	0.231
Bromodichloromethane				0.0319							
Carbon Tetrachloride	0.2		0.104	0.104	0.141	0.102	0.117	0.12	0.0958	0.0979	0.112
Chloromethane	0.2	0.2	0.585	0.53	0.536	0.501	0.415	0.39	0.419	0.433	0.398
Dichlorodifluoromethane	0.6	0.4	0.647	0.43	0.494	1.39	0.494	0.5	0.491	0.498	0.577
Ethane											
Ethylbenzene						0.016				0.0299	0.0302
Ethylene											
Halocarbon 113	0.1	0.07	0.0891	0.0869	0.108	0.1	0.124	0.08	0.0731	0.0739	0.0795
Isobutene			0.184								
Isobutene + 1-Butene											
Isohexane				0.0399			0.056		0.137	0.256	0.0745
Isopentane	0.5	0.7	0.498	0.299	0.449	0.452	0.16	0.11	1.69	0.767	0.427
m/p-Xylene			0.0389			0.035					0.0479
Methanol											
Methylene Chloride					0.0817	0.063	0.042	0.02	0.0507	0.0397	0.0319
MTBE + Isohexane + c-4-m-2-Pentene											
n-Butane	1	2.2	0.363	0.175	0.338	0.423	0.124	0.11	0.425	1.08	0.71

ATTACHMENT 4-7 - SNL/NM CLEAN AIR NETWORK (CAN) PROGRAM DATA (Continued)

Compound	Jan-96	Feb-96	Apr-96	May-96	Jun-96	Jul-96	Aug-96	Sep-96	Oct-96	Nov-96	Dec-96
1,1,1-Trichloroethane	0.06	0.05	0.103	0.185	0.3	0.146	1.77	0.09	0.105	0.168	0.114
1,4-Dioxane + 2,2,4-Tmpentane	0.1	0.2		0.158	0.278	0.171	0.773	0.02	0.139	0.296	0.143
1-Butene			0.0602	0.038		0.051	0.063		0.0702	0.163	0.0572
2,2,4-Trimethylpentane	0.2	0.2	0.092	0.0847	0.156	0.095	0.123	0.01	0.0951	0.257	0.0769
3-Methylpentane	0.5	0.8	3.6	4.52	7.62	26.1	6.41	2.2	3.47	3.81	1.71
Acetone											
AcetMene											
Benzene	0.5	0.4	0.183	0.184	0.124	0.181	0.206	0.05	0.279	0.571	0.499
Carbon Tetrachloride	0.08	0.05	0.104	0.115	0.115	0.107	0.117	0.11	0.0936	0.0969	0.115
Chloromethane	0.3	0.2	0.579	0.718	0.576	0.563	0.436	0.38	0.444	0.446	0.372
Dichlorodifluoromethane	0.6	0.5	0.653	0.56	0.493	1.07	0.496	0.45	0.527	0.522	0.608
Ethane											
Ethylbenzene			0.0396	0.0341		0.031	0.047		0.0419	0.0939	0.0707
Ethylene											
Halocarbon 113	0.1	0.05	0.0805	0.141	0.0878	0.101	0.123	0.08		0.0785	0.0795
Isobutene			0.187								
Isobutene + 1-Butene											
Isohexane	1.2	2.2	0.661	0.504	4.85		0.366		0.195	0.521	0.206
Isopentane								0.2	0.771	1.71	1.01
m/p-Xylene	0.2	0.2	0.0797	0.0635		0.074	0.11	0.03	0.119	0.16	0.156
Methanol											
Methylene Chloride			0.0365	0.0315	0.218	0.081	0.204	0.02	0.0647	0.0639	0.0563
MTBE + Isohexane + c-4-m-2-Pentene											
n-Butane	2.2	2.9	0.744	0.442	0.604	0.507	0.355	0.12	0.733	1.75	1.55
n-Hexane	0.2	0.2	0.0946		0.196	0.092	0.178		0.0981	0.274	0.0998
n-Pentane	0.5	0.5	0.507	0.237	0.757	0.303	0.739	0.08	0.331	0.821	0.332
n-Undecane			0.0367				0.176	0.006			
o-Xylene			0.0388	0.0428		0.031	0.054		0.0428	0.08	0.0687
Propane											
Propylene											
Tetrachloroethene	0.04		0.00964			0.018	0.044			0.0342	0.0268
TNMIHC	11.5	10.9	11.9	7.03	15.6	8.3	18.4	8.9	18.2	22	21.7
Toluene	0.7	0.6	0.371	0.233	0.527	0.268	0.703	0.06	0.341	0.845	0.62
Trichloroethene			0.0453				0.019				
Trichloroethylene + BDCmethane											
Trichlorofluoromethane	0.2	0.2	0.264	0.254	0.264	0.27	0.361	0.24	0.234	0.238	0.301

CHAPTER 5 - ECOLOGY

Contents

EXECUTIVE SUMMARY	5-3
1.0 INTRODUCTION.....	5-5
1.1 Purpose.....	5-5
1.2 Scope.....	5-6
2.0 PHYSICAL, ADMINISTRATIVE, AND REGULATORY SETTING.....	5-6
2.1 Overview	5-6
2.2 Location and Physical Description.....	5-7
2.3 Administrative and Jurisdictional Setting	5-7
2.4 Regulatory Setting.....	5-8
3.0 ABIOTIC ENVIRONMENT.....	5-11
3.1 Overview	5-11
3.2 Physiography	5-12
3.3 Climate.....	5-12
3.4 Geology and Soils	5-13
3.5 Surface Hydrology.....	5-13
4.0 PRINCIPAL HABITATS AND VEGETATION TYPES.....	5-17
4.1 Overview	5-17
4.2 Grassland Habitat.....	5-18
4.3 Woodland Habitat.....	5-23
4.4 Riparian Habitat.....	5-25
4.5 Altered Habitats.....	5-27
5.0 WILDLIFE COMMUNITIES	5-28
5.1 Overview	5-28
5.2 Grassland Wildlife Communities.....	5-28
5.3 Woodland Wildlife Communities.....	5-30
5.4 Riparian Wildlife Communities.....	5-32
5.5 Wildlife Communities of the Altered Habitats.....	5-32
6.0 THREATENED, ENDANGERED, AND SENSITIVE SPECIES.....	5-33
7.0 SENSITIVE HABITATS AND OTHER ISSUES OF CONCERN.....	5-39
7.1 Overview	5-39
7.2 Wetlands and Surface Water	5-40
7.3 Cliffs, Crevices, and Caves	5-41
7.4 Large Trees, Motts, and Snags	5-41
7.5 Prairie Dog Towns.....	5-42
7.6 Corridors	5-42

8.0 REFERENCES.....	5-43
8.1 Regulations, Orders, and Laws	5-43
8.2 General References	5-44

ATTACHMENTS

5-1 - Plant Species Known or Expected to Occur on the KFC.....	5-49
5-2 - Amphibian and Reptile Species Known or Expected to Occur on the KFC	5-61
5-3 - Bird Species Known or Expected to Occur on the KFC.....	5-63
5-4 - Mammal Species Known or Expected to Occur on the KFC	5-69
5-5 - Past Ecological Risk Assessment Studies	5-73
5-6 - Data Gaps	5-77

LIST OF TABLES

5-1. Shrub Species in the Grassland Habitat.....	5-22
5-2. Tree and Shrub Species of the Riparian Woodland	5-26
5-3. Common Raptors and Other Birds in the Grassland Habitat	5-29
5-4. Species Designations Used by Federal and State Agencies with Management Jurisdiction at the KFC	5-34
5-5. Threatened, Endangered, and Sensitive Species Known to Occur at the KFC	5-36

LIST OF FIGURES

5-1. Administrative Boundaries of the Kirtland Federal Complex.....	5-9
5-2. Major Soil Types at the Kirtland Federal Complex.....	5-15
5-3. Major Vegetation Types at the Kirtland Federal Complex.....	5-19

EXECUTIVE SUMMARY

This chapter presents a compilation and summary of the current information concerning the biological and ecological resources of the Kirtland Federal Complex (KFC) based on existing reports and other reference documents. Information regarding the biological and ecological resources at the KFC exists in a wide variety of sources that range from biological survey reports prepared for SNL/NM, the U.S. Air Force (USAF), and resource management agencies to more general publications, such as field guides and reference books on the flora and fauna of New Mexico. Because biological and ecological resources are best understood within the context of the physical and cultural settings at the KFC, which are described in other chapters, this chapter provides brief synopses of key information from other chapters that are relevant to understanding the ecology of the KFC.

This chapter describes the following:

- Physical, administrative, and regulatory setting of the KFC as it pertains to biological and ecological resources
- Abiotic environment of the KFC as it pertains to habitat conditions
- Major habitat and vegetation types on the KFC and wildlife communities that reside in these habitats
- Threatened, endangered, and sensitive species on the KFC
- Sensitive habitats and other issues related to biological and ecological resources on the KFC
- Plants, amphibians, reptiles, birds, and mammals that are known or expected to occur on the KFC

1.0 INTRODUCTION

1.1 Purpose

The purpose of this chapter is to provide a comprehensive summary of existing information regarding the biological resources and ecological setting of the Kirtland Federal Complex (KFC). The specific objectives of this chapter are to:

- Briefly summarize the administrative and regulatory settings as they affect the current ecological conditions and the ecological potential of the KFC.
- Briefly describe the abiotic environment of the KFC as it affects and controls the biological resources of the KFC, including topography, climate, surface hydrology, geology, and soils.
- Describe the KFC's place within the regional ecological landscape.
- Provide concise descriptions of the major habitat types of the KFC, characteristic vegetation, and significant wildlife resources.
- Identify any threatened, endangered, and other sensitive species actually or potentially occurring at the KFC, and any sensitive habitats on the KFC.
- Describe existing resource management practices implemented at SNL/NM that protect and conserve biological and ecological resources at the KFC.
- Provide updated lists of plant and wildlife species actually or potentially occurring at the KFC, identify the source documentation, and indicate whether the species was observed or has the potential to occur on the KFC.
- Identify data gaps in the current information base for KFC biological resources and provide recommendations for filling these gaps.
- Summarize ecological risk assessments conducted to evaluate the potential impact of SNL/NM operations on the health of the KFC ecosystem and the surrounding environment.

1.2 Scope

The chapter provides a single, comprehensive source of information on the biological resources of the five tech areas at SNL/NM and other lands at the KFC and any adjacent offsite SNL/NM facilities used with potential biological and ecological resources. The information resources used to develop this chapter are limited to existing documents through calendar year 1996 (CY1996). The data record contains gaps. No additional field surveys were performed to supplement the source documents.

Biological resources include naturally occurring vascular plants and wildlife populations that live on or otherwise rely on the potentially affected lands for continued existence. Landscape and ornamental plants were not considered biological resources. Ecological resources involve both biotic and abiotic elements of habitat that influence the habitat's quality and its potential for supporting diverse biological resources. These elements include the following:

- Climate
- Topography
- Geology
- Hydrology
- Soils
- Vegetation, which may include landscape and ornamental plants

Because habitat conditions are affected by land use, both on the area of concern and on adjacent areas, this chapter also describes administrative and jurisdictional boundaries in and around the KFC.

2.0 PHYSICAL, ADMINISTRATIVE, AND REGULATORY SETTING

2.1 Overview

To put the biological and ecological resources of the Kirtland Federal Complex (KFC) into geographical context, the following sections describe:

- Physical size and location of the KFC.
- Extent and distribution of development on and adjacent to the KFC.
- Land ownership and administrative boundaries within the KFC (see Chapter 2, "Land Use," for more information).

- Regulatory requirements influencing the management of these resources on the KFC (see Chapter 13, "Regulatory Requirements," for more information).

This information, in condensed form, provides essential background for the descriptions of the biological and ecological resources presented later in this chapter.

2.2 Location and Physical Description

Located in central New Mexico, the Kirtland Federal Complex (KFC) is south of and immediately adjacent to the City of Albuquerque, New Mexico (see Figure 5-1). The KFC boundaries encompass an area of approximately 51,559 acres (82.3 square miles) in Bernalillo County. The KFC is approximately 13 miles from east to west and 6.5 miles from north to south. The majority of development is concentrated in an approximate 5-square-mile area in the northwestern corner, which is continuous with developed areas in the City of Albuquerque. This development includes:

- Main Kirtland Air Force Base (KAFB) area, including base housing and administrative facilities
- Tech Areas I, II, and IV at SNL/NM
- DOE Albuquerque Operations Headquarters
- Airfield facilities for KAFB and the New Mexico Air National Guard, which share runways with the Albuquerque International Sunport
- Several other KFC facilities

Most of the lands south and east of this area are sparsely developed with widely scattered test, research, and training facilities connected by a network of paved and unpaved roads. These facilities include reactor facilities in Tech Area V, the Lovelace Inhalation Research Institute (LIRI), formerly known as the Inhalation and Toxicology Research Institute (ITRI), and the Manzano Area. Chapter 2, "Land Use," describes the KFC and its facilities.

2.3 Administrative and Jurisdictional Setting

Although the Kirtland Federal Complex (KFC) is comprised of federally-owned land, land ownership and administrative responsibilities at KFC and adjacent lands are complex (see Figure 5-1). The western part of the KFC is under the administrative jurisdiction of the U.S. Air

Force (USAF). DOE controls about 7,525 acres of this area either by direct ownership or through agreement with the USAF. Of these lands, SNL/NM uses five main tech areas that are on DOE land, and several facilities on non-DOE-owned lands. In addition, SNL/NM uses portions of the Manzano Area, which comprises about 2,880 acres of USAF lands in the northern portion of the KFC.

The eastern part of the KFC is situated on USAF withdrawn lands. This area lies within the Cibola National Forest, which is administered through the Sandia Ranger District of the U.S. Forest Service (USFS). About 20,810 acres of the Cibola National Forest lands were withdrawn from public use for the sole use by the USAF (16,215 acres) and DOE (4,595 acres) (U.S. Forest Service, Southwestern Region, 1996). However, DOE and SNL/NM use portions of the USAF withdrawn lands through agreement with the USAF (U.S. Department of Agriculture, Forest Service, 1987; 1989). Under the memoranda of agreement (MOA) with these agencies, the USFS retains the management responsibilities for the natural resources of these withdrawn lands (referred to as the Withdrawn Area). See Attachments 2-2 and 2-3 of Chapter 2, "Land Use," for copies of these MOAs.

2.4 Regulatory Setting

Chapter 13, "Regulatory Requirements," describes the statutory and regulatory requirements controlling DOE operations at the Kirtland Federal Complex (KFC). Those that directly address the protection and conservation of biological resources include:

- *Endangered Species Act of 1973*, 16 U.S.C. §1531 *et seq.*
- *Migratory Bird Treaty Act*, 16 U.S.C. §703 *et seq.*
- *Wildlife Coordination Act*, 16 U.S.C. §661 *et seq.*
- *Wildlife Conservation Act*, (New Mexico) §17-2-37 *et seq.*, *NMSA 1978*
- *Endangered Plants*, (New Mexico) §75-6-1 *et seq.*, *NMSA 1978*

LAND USE CLASSIFICATION KEY

- DOE Fee Owned
- DOE Withdrawn from U.S. Forest Service (USFS)
- DOE Leased (State of New Mexico and Bureau of Indian Affairs)
- U.S. Air Force Permitted to DOE
- U.S. Air Force Withdrawn from U.S. Forest Service Permitted to DOE
- U.S. Air Force Fee Various Structures Within This Area Permitted to DOE, SNL, TSD, CTA and Support Agreement Between U.S. Air Force and DOE for Various Facilities (Manzano Area)
- U.S. Air Force Withdrawn from U.S. Forest Service Joint Operating Agreement Between DOE, SNL, and PHILLIPS
- U.S. Air Force FEE Joint Operating Agreement Between DOE, SNL, and PHILLIPS
- U.S. Air Force Permitted to Others
- DOE Outgranted or Permitted to U.S. Air Force
- DOE Outgranted or Permitted to Others
- Private Property
- Bureau of Land Management

LEGEND

- Kirtland Air Force Base Boundary
- U.S. Forest Service Withdrawn Area Boundary
- Paved Roads
- Unpaved Roads and Trails

SCALE 1: 84000

Planimetry compiled by photogrammetric methods from aerial photography dated March 1983, March 1988, September 1991, and July 1992.

Transverse Mercator Projection, New Mexico State Plane Coordinate System, Central Zone, 827 North American Horizontal Datum, 829 North American Vertical Datum

U.S. DEPARTMENT OF ENERGY	
MANAGEMENT SUPPORT DIVISION	
KIRTLAND AIR FORCE BASE EAST	ALBUQUERQUE, NEW MEXICO
Sandia National Laboratories Facilities Development Center	
ALBUQUERQUE, NEW MEXICO; LIVERMORE, CALIFORNIA; TONOPAH, NEVADA	
Facilities Geographic Information System	
Figure 5-1. Administrative Boundaries of the Kirtland Federal Complex (KFC)	
Electrical & Architectural System Engineering Department 7821	
Date: 11/10/98	Map ID #: 970122

Statutory and administrative requirements that can indirectly benefit biological resources through the protection and conservation of key habitats include:

- *National Environmental Policy Act*, 42 U.S.C. §4321 *et seq.*
- *Clean Water Act*, 33 U.S.C. §1251 *et seq.*
- *National Forest Management Act*, 16 U.S.C. §1600 (note)
- Executive Order 11988, *Floodplain Management*
- Executive Order 11990, *Protection of Wetlands*

DOE orders implement these requirements, including 10 CFR 1022, *Compliance with Floodplain/Wetlands Environmental Review Requirements*, and DOE 5400.1, *General Environmental Protection Program*. Department of Defense (DoD) and USAF directives implement these regulatory requirements on U.S. Air Force (USAF) lands. In addition, the U.S. Forest Service (USFS) has developed a series of plans for the management of the natural resources on the KFC, including an integrated natural resources management plan (Kirtland Air Force Base, 1995), the *Kirtland Air Force Base Fish and Wildlife Management Plan* (Daniel B. Stephens and Associates Incorporated, 1996), and a land management plan (Kirtland Air Force Base, 1992). The USFS, Cibola National Forest:

- Implements these regulatory requirements on USFS lands.
- Addresses the management of natural resources on the Withdrawn Area in the *Environmental Analysis: Ecosystem Management Plan for National Forest Lands In and Adjacent to the Military Withdrawal* (U.S. Forest Service, Southwestern Region, 1996).

3.0 ABIOTIC ENVIRONMENT

3.1 Overview

The following sections present brief summaries of the physiography, climate, geology, soils, and surface hydrology of the Kirtland Federal Complex (KFC). These are essential elements of the abiotic environment that control and determine habitat conditions in terrestrial ecosystems. This information provides essential background for the descriptions of the biological and ecological resources.

3.2 Physiography

Chapter 1, "Geology," describes the topography of the western portion of the Kirtland Federal Complex (KFC) as piedmont composed of alluvial fan deposits. The surface rises gradually to the east, where it abuts the Manzanita Mountains, a low range situated between the higher Sandia Mountains to the north and the Manzano Mountains to the south. Most of the Manzanita Mountains and its foothills lie within the Cibola National Forest boundary. However, a small outlier range, known as the "Four Hills," lies outside the Withdrawn Area in the northern part of the KFC, rising about 1,000 feet above the adjoining plain. These mountains are the site of Manzano Area. A line of low, rounded hills extends about two miles southwest of the southern tip of the Four Hills.

The 4-mile-long reach of Tijeras Arroyo, which crosses the northwestern part of the KFC, is the largest surface drainage feature on the site and essentially forms the southern limit of the main area of urban development on the KFC. The wide floodplain of Tijeras Arroyo is about 100 feet below the surrounding surface. It enters the KFC along the northern boundary with a southwesterly flow direction, then turns to the west, exiting the KFC along the western boundary. The only other significant surface drainage on the KFC is Arroyo del Coyote, which flows west from the canyons in the Manzanita Mountains (the Withdrawn Area), past the southern tip of the Manzano Area, where it turns northwest and gradually descends into Tijeras Arroyo.

The elevations of the KFC range from a low point of about 5,200 feet in Tijeras Arroyo to a high point of 7,716 feet at Mount Washington in the Manzanita Mountains. Elevations of the alluvial surface range from about 5,300 feet to about 6,000 feet with an east-to-west slope of approximately 2%. The highest peak in the Four Hills is 6,958 feet.

3.3 Climate

The climate at the Kirtland Federal Complex (KFC) is arid and continental in nature. It is typified by wide seasonal extremes in temperature and highly variable precipitation. The annual precipitation averages about 8.45 inches, with approximately 44% typically received as intense, afternoon and evening thunderstorms in the summer months (July through September). Precipitation is greatest near the mountains, with about 15 to 20 inches of rainfall per year being typical in the higher elevations of the Manzanita Mountains (Tuan et al., 1973). Average monthly high temperatures range from 47.1°F in January to 91.2°F in July. Freezing temperatures can occur between late October and mid April, with precipitation in the form of snow being common in this period. See Chapter 4, "Air Quality and Meteorology," for a more detailed discussion of climate.

3.4 Geology and Soils

Figure 5-2 illustrates the major soil types at the Kirtland Federal Complex (KFC) (U.S. Department of Agriculture, Soil Conservation Service and Forest Service, and U.S. Department of the Interior, Bureau of Indian Affairs and Bureau of Land Management in cooperation with the New Mexico Agricultural Experiment Station, 1977). Rock outcrops along the Manzanita Mountains are primarily Paleozoic limestones. These form ledges and cliff faces along parts of the western slopes and canyon walls. On the more gradual slopes east of the ridge and along drainages at the higher elevations of these mountains, soils of the Seis Series formed from the weathering of the limestone bedrock. These soils are loams and clay loams that vary in coarse material content from cobbly to stony. Along the foothills and alluvial slopes of these mountains, there is a very gravelly loam called the Salas complex. On more gradual slopes below the Salas complex and the canyon floors, the Tesajo-Millet Series, a stony sandy loam, and the Ildefonso Series, a gravelly sandy loam, occur. See Chapter 1, "Geology," for more detailed information on geology and soils.

Proceeding west from the Manzanita Mountains across the alluvial surface, slopes become more gradual and soil textures become finer. These soils range from gravelly fine sandy loams (Embudo and Tijeras Series) to very fine sandy loams (Tome Series). The Four Hills are primarily Precambrian granites, which outcrop along the majority of the upper slopes. The low hills south of the Four Hills are called the Laporte-Rock Outcrop-Escabosa complex, derived from limestone exposures. The Gila fine sandy loam dominates the arroyo floodplains, including Tijeras Arroyo and Arroyo del Coyote. The slopes descending from the surrounding terrace surface to these floodplains are a Bluepoint-Kokan association, which ranges from a loamy fine sand to a gravelly sand.

3.5 Surface Hydrology

For a detailed discussion of surface hydrology, see Chapter 3, "Hydrology and Water Resources." Three types of surface hydrologic features provide special habitat conditions for the biota at the Kirtland Federal Complex (KFC). These include:

- Surface drainages
- Springs (including rock seeps)
- Ponds

Tijeras Arroyo, the largest drainage feature on the KFC, conducts surface-water runoff flows from Tijeras Canyon, which separates the Sandia and Manzanita Mountains northeast of the KFC, to the Rio Grande, about four miles west of the KFC boundary. All other major surface drainages on the KFC originate within the KFC boundary. Arroyo del Coyote discharges into Tijeras Arroyo within the KFC. The smaller arroyos south of Arroyo del Coyote discharge into an internal drainage basin along the western boundary of the KFC. Except for a short reach of Arroyo del Coyote, called G Spring, all the surface drainages are ephemeral, containing surface water only after significant precipitation events. At G Spring, subsurface water reaches the surface of the arroyo bed and flows a few hundred feet before infiltrating back into the sediments (U.S. Army Corps of Engineers, 1995).

In addition to G Spring, eight other springs and rock seeps have been identified on the KFC (U.S. Army Corps of Engineers, 1995). The Sol se Mete and Lurance Springs are named for the canyons in which they occur and were developed with stone tubs (Schwarz, 1994; U.S. Army Corps of Engineers, 1995). Coyote Springs, along the southern bank of Arroyo del Coyote near the mouth of Lurance Canyon, is the largest developed spring on the KFC. Three unnamed springs occur around the Four Hills--two within the Manzano Area boundary and one outside on the northern end of the Four Hills. These springs are small and undeveloped. Two rock seeps also occur on the Four Hills within the Manzano Area boundary.

Ponds on the KFC are limited to manmade impoundments. There are four small ponds associated with the golf course immediately south of Tijeras Arroyo. A two-acre pond, called Christian Lake, was constructed in the southern part of the KFC for testing purposes and to maintain water (U.S. Army Corps of Engineers, 1995).

4.0 PRINCIPAL HABITATS AND VEGETATION TYPES

4.1 Overview

The undeveloped areas of the Kirtland Federal Complex (KFC) contain three major habitat types: grassland, woodland, and riparian (Daniel B. Stephens and Associates Incorporated, 1996). Much of this undeveloped area receives little or no disturbance from operations at the KFC. Pre-1940 disturbances in this area included livestock grazing and some farming, with a few scattered residences and small mining operations. Since the military acquisition of the land and the withdrawal of additional lands from the U.S. Forest Service (USFS), there has been no livestock grazing or other agricultural use within the boundaries of the KFC. The natural vegetation over large areas of the KFC has been allowed to recover from the effects of these land uses through natural succession, although the suppression of wildfires may have removed an important factor in the process of natural succession in these habitats. The areas developed and disturbed as a result of the various operations at the KFC constitute a fourth habitat type designated "altered habitat." This includes areas where the natural vegetation and possibly the soil was removed, replaced, or otherwise altered through various land uses, including pre-1940 land uses where the effects of disturbance are still evident (for example, mines).

The four habitat types are distinct in the form and composition of their vegetation. As the names imply, the grassland and woodland habitats differ in the vegetation formation found on each--the former being dominated by grasses and other low-growing herbaceous plants, and the latter having an open canopy of woody plants, particularly small evergreen trees, such as junipers and piñon pines. The vegetation of the riparian habitat (the habitat associated with surface-water drainages) on the KFC includes both woodland and scrubland (shrub-dominated) formations. Because the KFC is located at the juncture of four major North American biotic provinces, the Great Basin, the Rocky Mountains, the Great Plains, and the Chihuahuan Desert (Brown, Lowe, and Pase, 1982), the floristic composition of these vegetation types exhibit influences from each of these provinces. The vegetative cover of the altered habitat varies from bare ground (no vegetation) to landscaped lawns with ornamental trees.

Figure 5-3 shows an areal extent of the major natural vegetation types on the KFC. The following sections describe each of the major habitat types and their associated vegetation. A list of the plant species currently known or expected to occur on the KFC appears in Attachment 5-1, "Plant Species Known or Expected to Occur on the KFC."

4.2 Grassland Habitat

The grassland habitat occupies the lower alluvial slopes and terrace surfaces of the Rio Grande Valley near the City of Albuquerque. It is the dominant habitat type on the Kirtland Federal Complex (KFC) west of the Withdrawn Area. Soils supporting grassland vegetation are typically fine sandy loams to gravelly sandy loams with slopes of less than 5%. These soils include:

- Latene Series
- Madurez Series
- Embudo Series
- Wink Series
- Tijeras Series
- Tome Series

Steeper slopes in this habitat occur on the low hills in the southern portion of the KFC and along both sides of the Tijeras Arroyo floodplain. The soils in these areas are coarser and include the Laporte-Rock Outcrop-Escabosa complex and the Bluepoint-Kokan association, respectively.

Reference documents use various names to identify the vegetation of the grassland habitat depending on the classification system used. The U.S. Forest Service (USFS) (1996) refers to it broadly as the Desert Grassland vegetation zone, while Dick-Peddie's (1993) classification of the vegetation types of New Mexico places it in the Plains-Mesa Sand Scrub vegetation zone type. The latter name implies that it is more of a scrubland than a grassland, which is misleading for most of the habitat type because it occurs on the KFC. Sullivan and Knight (1994) use the term Mesa and Desert Grassland habitat type, but also recognize the inclusion of true scrubland vegetation in some parts of this habitat. Under the hierarchical classification system and map of the biotic communities (biomes) in the southwestern United States developed by Brown, Lowe, and Pase, the KFC is located at the juncture of the Chihuahuan Semidesert Grassland, a warm-temperate biome, and the Great Basin Scrub Grassland and Plains Grassland, both cold-temperate biomes (Brown, Lowe, and Pase, 1982). All three of these biomes influence the grassland vegetation of the KFC with the expression of each controlled by changes in elevation, slope, exposure, and soil.

The influence of the Chihuahuan Semidesert Grassland is most prevalent at lower elevations and on southern exposures. It is typified by the presence of black grama (*Bouteloua eriopoda*) as a dominant or codominant species, but also includes mesa dropseed (*Sporobolus flexuosus*), purple threeawn (*Aristida purpurea*), and bush muhly (*Muhlenbergia porteri*) which are typical Chihuahuan desert grasses.

The influence of the Great Basin Scrub Grassland occurs in varying degrees throughout the grassland habitat of the KFC, but is most prevalent in areas of more moderate exposure, sandier soils, or higher elevation than those supporting the Chihuahuan desert species. Grass species typical of the Great Basin Scrub Grassland biome include galleta (*Hilaria jamesii*), sand dropseed (*Sporobolus cryptandrus*), and Indian ricegrass (*Oryzopsis hymenoides*).

The influence of the Plains Grassland, which has affinities to the Great Plains biotic province to the east, is strongly associated with higher elevations and coarser soils than either of the previously described biomes. Grass species typical of the Plains Grassland include blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), and little bluestem (*Andropogon scoparius*). Other common grasses in the grassland habitat of the KFC include:

- Spike dropseed (*Sporobolus contractus*)
- Ring muhly (*Muhlenbergia torreyi*)
- Ear muhly (*Muhlenbergia arenacea*)
- New Mexico porcupine grass (*Stipa neomexicana*)
- Burro grass (*Scleropogon brevifolius*)

Few areas of the KFC grassland habitat have been quantitatively surveyed to identify and map vegetation associations (geographical subunits of the vegetation characterized by the dominance of one or two species). At the Coyote Test Field (CTF) in the southwestern corner of the KFC, Sullivan and Knight (1994) identified five grassland associations, all in the Black Grama Series. These are:

- Black grama (monotypic stands)
- Black grama-spike dropseed
- Black grama-threeawn
- Black grama-galleta
- Black grama-burro grass

The black grama-burro grass grassland association occurs on the Tome Series soil in the southwestern quadrant of the KFC. This fine sandy loam occurs where arroyos from the Manzanita Mountains reach the flat internal basins near the McCormick Ranch (located on state-owned land west of the KFC) resulting in sediment deposition along broad fans. These areas are distinct from surrounding grasslands in that the fine-textured soils form large areas of bare ground interspersed with patches of ground stabilized by grasses and shrubs. Another distinctive element of the grassland vegetation on the KFC is New Mexico porcupine grass (*Stipa neomexicana*), which occurs in nearly monotypic stands, especially on alluvial slopes near the base of the mountains (Parmenter and Chavez, 1995). The dominant shrub species and other common shrubs and subshrubs in the grassland habitat at the KFC appear in Table 5-1.

Table 5-1. Shrub Species in the Grassland Habitat

Dominant Shrub Species	Common Shrub and Subshrub Species
Sand sagebrush (<i>Artemisia filifolia</i>)	Broom snakeweed (<i>Gutierrezia sarothrae</i>)
Fourwing saltbush (<i>Atriplex canescens</i>)	Cane cholla (<i>Opuntia imbricata</i>)
Winterfat (<i>Eurotia lanata</i>)	Soapweed yucca (<i>Yucca glauca</i>)
	Mormon tea (<i>Ephedra torreyana</i>)

Near the western boundary fence of the KFC, sand sagebrush dominates the vegetation in a true scrubland. Also of interest is a relict stand of creosote bush (*Larrea divaricata*) on the south-facing slope of a low hill in the North Thunder Range area of the CTF (Sullivan and Knight, 1994). This species is a characteristic shrub of the warm-temperate deserts of North America. Approaching the mountains from west to east, one-seed junipers (*Juniperus monosperma*) increase in size and density in the grasslands.

The grassland vegetation on the KFC is generally in excellent condition and relatively free of shrubs and subshrubs over wide areas. Natural and man-caused fires occur periodically in the grassland areas and may be important in maintaining the dominance of grasses over woody plants (Daniel B. Stephens and Associates Incorporated, 1996). The current condition of the grasslands is also due to the long period of protection from grazing within the KFC boundaries. A possible result of this protection is the presence of the grama grass cactus (*Pediocactus papyracanthus*). This small and cryptic cactus was previously listed as endangered by the State of New Mexico; however, it was delisted in 1995, in part as a result of the numbers found during sensitive species surveys conducted on the KFC and other lands protected from grazing. Although not abundant, this plant is widely distributed in the grassland habitat from the western boundary of the KFC to the edge of the woodlands and from the southern boundary to near Tijeras Arroyo (Sullivan and Knight, 1994; IT Corporation, 1995; New Mexico Natural Heritage Program, 1995). Individual cacti of this species were transplanted from construction sites to prevent their destruction (IT Corporation, 1992). The visnagita cactus (*Neolloydia intertexta*)

and Wright's pincushion cactus (*Mammillaria wrightii*) are two other species of small cacti that appear in the grasslands of the KFC. They were previously listed as endangered by the State of New Mexico, but delisted in 1995 (Sivinski and Lightfoot, 1992). These species are limited in occurrence to the eastern part of the grassland habitat, near the transition with the woodlands (IT Corporation, 1995; New Mexico Natural Heritage Program, 1995).

4.3 Woodland Habitat

The woodland habitat occurs primarily on the upper alluvial slopes and in the mountainous areas of the Withdrawn Area. The soils of the woodlands are coarser than those of the grasslands, ranging from gravelly sandy loams to rock outcrop. These include the Tesajo, Millett, Ildefonso, Salas, and the Seis Series. The tree canopy of the woodlands varies from open, savannah-like stands of widely scattered trees with a grass and shrub understory to a dense, nearly closed canopy with a scant understory (Daniel B. Stephens and Associates Incorporated, 1996).

Dick-Peddie (1993) broadly classified the vegetation in the woodland habitat as Coniferous and Mixed Woodland. The U.S. Forest Service (USFS) (1996), however, recognizes four vegetation zones within this area. These are (in order of increasing elevation):

- Juniper Woodland
- Piñon Pine - Juniper Woodland
- Piñon Pine - Oneseed Juniper - Oak Woodland
- Ponderosa Pine - Piñon Pine - Oak Woodland

Under the biome classification system of Brown, Lowe, and Pase (Brown, Lowe, and Pase, 1982), the woodlands of the Kirtland Federal Complex (KFC) are part of the Great Basin Conifer Woodland, but have some influences of the Rocky Mountain Montane Coniferous Forest biome, particularly at the higher elevations of the Manzanita Mountains.

The two dominant conifer species in the woodland habitat are one-seed juniper and Colorado piñon (*Pinus edulis*), often referred to as piñon pine. Although the juniper extends well into the grassland habitat, commonly attaining only a shrub-like stature in that habitat, the Colorado piñon prefers the cooler, moister sites of the woodland habitat. At higher elevations, the influence of the Rocky Mountain Montane Coniferous Forest biome is evidenced by the

occurrence of ponderosa pine (*Pinus ponderosa*) and Rocky Mountain juniper (*Juniperus scopularum*). Important understory shrubs in the woodlands include:

- Wavy-leaf oak (*Quercus undulata*)
- Gray oak (*Quercus grisea*)
- Gambel oak (*Quercus gambellii*)
- Mountain mahogany (*Cercocarpus montanus*)
- Skunkbush (*Rhus trilobata*)

Also important are shrub-sized plants of the lily family, such as bear grass (*Nolina microcarpa*) and banana yucca (*Yucca baccata*). At the lower elevations, grasses of the grassland habitat, including blue grama, side-oats grama, and galleta, commonly dominate the understory. As the density of woody species increases across the transition from grassland to woodland, that of grasses and other herbaceous understory plants decreases. However, small areas of grass-dominated montane meadow occur along drainages near the ridge of the Manzanita Mountains.

The USFS (1996) recognizes ten “habitat types” in the woodland vegetation. Because these are generally defined on the basis of the dominant overstory and understory plant species, they are approximately equivalent to vegetation associations. These are:

- One-Seed Juniper - Blue Grama Woodland
- One-Seed Juniper - Sideoats Grama Woodland
- One-Seed Juniper - Winterfat Woodland
- Piñon Pine - Mountain Mahogany Woodland
- Piñon Pine - Wavyleaf Oak Woodland
- Piñon Pine - Gambel Oak Woodland
- Transition (between Piñon - Juniper Woodland and Ponderosa Pine Woodland)

- Ponderosa Pine - Wavyleaf Oak Coniferous
- Ponderosa Pine - Gambel Oak - Piñon Pine Coniferous
- Scarp Woodland

Fire suppression in the woodland habitat has allowed an increase in the density of woody plants and an unnaturally high accumulation of dead wood and litter in many parts of this habitat. This condition of high fuel loadings makes wildfire a significant threat in this habitat. An accidental, man-caused fire in 1989 burned approximately 375 acres in Madera Canyon, killing most of the vegetation in its path due to the generation of high temperatures. This site was reseeded the following year and now exhibits a vegetative cover dominated by grasses. The woodland habitat of the KFC provides important habitat to wildlife and contains populations of the visnagita and Wright's pincushion cacti. As mentioned in "4.2, Grassland Habitat," these species were previously listed as endangered by the State of New Mexico, but were delisted in 1995.

4.4 Riparian Habitat

The riparian habitat occurs along the surface drainages of the Kirtland Federal Complex (KFC). The periodic concentration of surface-water runoff along these drainages, often coupled with shallow subsurface flows, allows for the development of a vegetation type along the banks of the drainages that is distinct from the surrounding upland habitats in both structure and species composition. This riparian vegetation is typically denser than the upland vegetation and dominated by deep-rooted, often woody plants (shrubs or trees) with a distinctly greater stature than the adjacent upland plants. Except for G Spring, which is classified as a riparian flow all of the drainages on the KFC are ephemeral and contain flows only after large rainfall events (U.S. Army Corps of Engineers, 1995). The soils along the larger arroyos are the Gila fine sandy loam. The vegetation of the riparian habitat on the KFC varies from scrubland to woodland. Scrubland dominates the riparian vegetation, having closest association with the Great Basin Riparian Scrubland biome of Brown, Lowe, and Pase (Brown, Lowe, and Pase, 1982). The most common shrub species of this vegetation are rabbitbrush, Apache plume (*Fallugia paradoxa*), and fourwing saltbush. One-seed juniper extends well beyond the lower boundary of the woodland habitat as a shrub or small tree along the arroyos. Alkali sacaton (*Sporobolus airoides*) is a characteristic grass of the riparian habitat along the arroyos.

The riparian woodland vegetation on the KFC is primarily limited to the upper reach of Arroyo del Coyote and the canyon drainages that feed into it. Dense stands of trees grow where there is a sufficient supply of subsurface water, such as at G Spring and near Coyote Springs. Large individuals of Fremont cottonwood (*Populus fremontii*) occur in these areas, representing one of

the few native tree species on the KFC that is specific to riparian habitat. Most trees along the arroyos are introduced species that have escaped cultivation. Salt-cedar (*Tamarix pentandra*), an introduced species that is a nuisance in many drainages in the western United States, appears along many of the arroyos on the KFC and forms dense stands on Arroyo del Coyote at G Spring and near Coyote Springs. Two other exotic trees, Siberian elm (*Ulmus pumila*) and tree-of-heaven (*Ailanthus altissima*), have also become established locally, the latter forming dense thickets of root sprouts, called motts.

The riparian vegetation in the canyons of the Manzanita Mountains is a more complex mixture of woody species than that of the arroyos on the alluvial surfaces to the west. Although the scrubland arroyo vegetation extends well into the lower parts of the canyons, particularly Lurance and Madera Canyons, the vegetation becomes more of a true riparian woodland in the upper reaches. A wider diversity of shrubs occurs in the canyons than in the lower arroyos. The tree and shrub species appear in Table 5-2.

Table 5-2. Tree and Shrub Species of the Riparian Woodland

Trees	Shrubs
One-seed juniper (<i>Juniperus monosperma</i>)	Rabbitbrush (<i>Chrysothamnus nauseosus</i>)
Piñon pine (<i>Pinus edulis</i>)	Apache plume (<i>Fallugia paradoxa</i>)
Ponderosa pine (<i>Pinus ponderosa</i>)	Skunkbush (<i>Rhus trilobata</i>)
Gambel oak (<i>Quercus gambellii</i>)	Mountain mahogany (<i>Cercocarpus montanus</i>)
Narrow-leaf hoptree (<i>Ptelea trifoliata</i>)	New Mexico olive (<i>Forestiera neomexicana</i>)
Tree-of-heaven (<i>Ailanthus altissima</i>)	New Mexico locust (<i>Robinia neomexicana</i>)
	Cliff fendlerbush (<i>Fendlera rupicola</i>)
	Mock-orange (<i>Philadelphus microphyllus</i>)

Natural, spring-fed wetlands form a minor component of the riparian habitat on the KFC. These include the two springs along the canyon drainages (Sol se Mete and Lurance), Coyote Springs, and the three unnamed springs along drainages on and around the Manzano Area. Coyote Springs is the largest of these, with a wetland area of approximately 0.9 acres. The wetland areas of the other springs are less than 100 square feet in size (U.S. Army Corps of Engineers, 1995).

Although the wetland habitat type is extremely small in areal extent on the KFC, it contains plant species that are unique to this type, including:

- Wire rush (*Juncus balticus*)
- Three-square (*Scirpus americanus*)
- Torrey rush (*Juncus torreyi*)
- Yerba mansa (*Anemopsis californica*)
- Rabbitfoot grass (*Polypogon monspeliensis*)
- Cattail (*Typha latifolia*)

The spring north of Manzano Area has a Russian olive tree (*Elaeagnus angustifolia*) established nearby, which is another introduced tree species. The two small springs on Manzano Area have salt-cedar and a small Fremont cottonwood marking their locations (U.S. Army Corps of Engineers, 1995).

4.5 Altered Habitats

The altered habitats on the Kirtland Federal Complex (KFC) include a variety of land uses, such as the following:

- Residential areas
- Golf course
- Stables
- Landfill
- Runways and taxiways
- Roadways
- Structures for testing programs, training, and utilities
- Buildings and surrounding landscaping or cleared areas

The highly varied vegetation in this habitat type ranges from no vegetative cover, due to continued use, disturbance, or paving, to manicured landscapes, such as the golf course. Much of this habitat type, however, consists of disturbed ground with early successional (ruderal) vegetation, which is often considered “weedy,” and may contain a high proportion of non-native species along with native species from the adjacent natural habitat types. Common ruderal species that occur on areas of only moderate disturbance include Russian thistle (*Salsola kali*), summer cypress (*Kochia scoparia*), and three-awns (*Aristida spp.*). The KFC includes a wide variety of landscaping plants. The more common trees include:

- Siberian elm (*ulmus pumila*)
- Russian olive (*Elaeagnus angustifolia*)
- Poplars (*Populus spp.*)
- Arizona cypress (*Cupressus arizonica*)
- Pines (*Pinus spp.*)

Kentucky bluegrass (*Poa pratensis*) and fescue (*Festuca spp.*) are the most common types of lawns planted at the KFC. Increasingly, efforts are underway to reseed disturbed areas with native plant species to assist the natural revegetation process and direct it toward a more desirable condition for wildlife (Daniel B. Stephens and Associates Incorporated, 1996).

5.0 WILDLIFE COMMUNITIES

5.1 Overview

Each of the major habitat types of the Kirtland Federal Complex (KFC) supports a distinct assemblage of wildlife species, which include:

- Amphibians
- Birds
- Reptiles
- Mammals

Each wildlife species exhibits specific habitat requirements for food, water, and cover, as well as behaviorally controlled requirements, such as the use of travel corridors, breeding site preferences, sensitivity to human activity, and others. The composition of the wildlife community at any one location depends upon the quality and quantity of available habitat as it meets the needs of individual wildlife species. Just as vegetation varies within the broad habitat types, the composition of the wildlife communities also varies. The limited availability of surface water is probably the most important factor controlling the wildlife communities on the KFC (Daniel B. Stephens and Associates Incorporated, 1996).

Because of their mobility, bird communities are particularly dynamic. Although some bird species at the KFC are resident throughout the year, many are migratory, being present only seasonally, either breeding, wintering, or as transients, moving between their breeding and wintering grounds.

The following sections provide general descriptions of the wildlife communities in each of the habitat types on the KFC. Attachments 5-2 through 5-4 include lists of the wildlife species (amphibians, reptiles, birds, and mammals) that are known or expected to occur on the KFC.

5.2 Grassland Wildlife Communities

A lack of surface water is prevalent in the grassland habitat. No amphibians are documented in the grassland habitat on the Kirtland Federal Complex (KFC). However, some species, such as spadefoots and some toads that are capable of breeding in ephemeral surface water and spending long periods in dormancy underground during dry conditions, are expected to occur in parts of this habitat. The western box turtle (*Terrapene ornata*) has been observed in the grasslands, and lizards are common in this habitat. Common lizards include the following:

- Whiptail lizard (*Cnemidophorus spp.*)
- Lesser earless lizard (*Holbrookia maculata*)
- Great Plains skink (*Eumeces obsoletus*)
- Side-blotched lizard (*Uta stansburiana*)
- Roundtail horned lizard (*Phrynosoma modestum*)

Few snakes are well documented on the KFC, but the species commonly observed in the grassland habitat include the following:

- Bullsnake (*Pituophis melanoleucus*)
- Massasauga (*Sistrurus catenatus*)
- Western diamondback rattlesnake (*Crotalus atrox*)
- Coachwhip (*Masticophis flagellum*)
- Western rattlesnake (*Crotalus viridis*)

Raptors hunt in grassland areas throughout the year, but the lack of nesting sites (for example, trees, cliffs) limits the use of this habitat type for breeding purposes. Manmade structures may occasionally be used by some species for nesting. The more common raptor and other bird species known to occur in the grassland habitat appear in Table 5-3. Turkey vultures (*Cathartes aura*) are common scavengers in this habitat.

Table 5-3. Common Raptors and Other Birds in the Grassland Habitat

Raptors	Other Birds
Northern harrier (<i>Circus cyaneus</i>)	Scaled quail (<i>Callipepla squamata</i>)
Red-tailed hawk (<i>Buteo jamaicensis</i>)	Mourning dove (<i>Zenaida macroura</i>)
Swainson's hawk (<i>Buteo swainsoni</i>)	Greater roadrunner (<i>Geococcyx californianus</i>)
American kestrel (<i>Falco sparverius</i>)	Say's phoebe (<i>Sayornis saya</i>)
Barn owl (<i>Tyto alba</i>)	Horned lark (<i>Eremophila alpestris</i>)
Great horned owl (<i>Bubo virginianus</i>)	Chihuahuan raven (<i>Corvus cryptoleucus</i>)
Burrowing owl (<i>Speotyto cunicularia</i>)	Northern mockingbird (<i>Mimus polyglottos</i>)
	Loggerhead shrike (<i>Lanius ludovicianus</i>)
	Black-throated sparrow (<i>Amphispiza bilineata</i>)
	Eastern and western meadowlark (<i>Sturnella magna</i> and <i>S. neglecta</i>)
	House finch (<i>Carpodacus mexicanus</i>)

Rodents and lagomorphs (rabbits and hares) dominate the mammal community in the grassland habitat. The common rodents known to occur in this habitat include the following:

- Spotted ground squirrel (*Spermophilus spilosoma*)
- Silky pocket mouse (*Perognathus flavus*)
- Banner-tailed kangaroo rat (*Dipodomys spectabilis*)
- Western harvest mouse (*Reithrodontomys megalotis*)
- Northern grasshopper mouse (*Onychomys leucogaster*)
- Gunnison's prairie dog (*Cynomys gunnisoni*)
- Ord's kangaroo rat (*Dipodomys ordii*)
- Merriam's kangaroo rat (*Dipodomys merriami*)
- White-footed mouse (*Peromyscus leucopus*)
- Deer mouse (*Peromyscus maniculatus*)

The two most common species of lagomorph are the desert cottontail (*Sylvilagus auduboni*) and black-tailed jackrabbit (*Lepus californicus*). Mammalian predators in the grassland community include:

- Coyote (*Canis latrans*)
- Badger (*Taxidea taxus*)
- Bobcat (*Lynx rufus*)
- Kit fox (*Vulpes macrotis*)
- Striped skunk (*Mephitis mephitis*)

5.3 Woodland Wildlife Communities

Many of the grassland wildlife species listed in "5.2 Grassland Wildlife Communities" extend into the woodland wildlife community, at least into the open savannahs of the lower elevations. Amphibians are probably rare or absent from the woodland community due to rapid drainage of the coarser soils. Among the reptiles that are more prevalent in the woodlands are the collared lizard (*Crotaphytus collaris*), tree lizard (*Urosaurus ornatus*), and prairie lizard (*Sceloporus undulatus*). Very little is known of the snakes in this habitat, although the night snake (*Hypsiglena torquata*) and the mountain patchnose snake (*Salvadora grahamiae*) are expected to occur.

As the vertical habitat diversity increases in the woodlands, the diversity of bird species using the habitat also increases. Some birds common to the woodland habitat are:

- Cooper's hawk (*Accipiter cooperii*)
- Common poorwill (*Phalaenoptilus nuttallii*)
- Rock wren (*Salpinctes obsoletus*)
- Western bluebird (*Sialia mexicana*)

- Northern flicker (*Colaptes auratus*)
- Ladder-backed woodpecker (*Picoides scalaris*)
- American robin (*Turdus migratorius*)
- Western wood-pewee (*Contopus sordidulus*)
- Scrub jay (*Aphelocoma coerulescens*)
- Common raven (*Corvus corax*)
- Black-headed grosbeak (*Pheucticus melanocephalus*)
- Mountain chickadee (*Parus gambeli*)
- Bushtit (*Psaltiriparus minimus*)
- Townsend's solitaire (*Myadestes townsendi*)
- Ash-throated flycatcher (*Myiarchus cinerascens*)
- Grace's warbler (*Dendroica graciae*)
- Yellow-rumped warbler (*Dendroica coronata*)
- MacGillivray's warbler (*Oporornis tolmiei*)
- Plain titmouse (*Parus inornatus*)
- Rufous-sided towhee (*Pipilo erythrophthalmus*)
- Bewick's wren (*Thryomanes bewickii*)
- Chipping sparrow (*Spizella passerina*)

Mammal communities also change with the transition between grassland and woodland vegetation. Coupled with this transition is an increase in the amount of rock outcrops, which are an essential element in the habitat of some mammal species. Rodents found primarily in the woodlands include:

- Texas antelope squirrel (*Ammospermophilus interpres*)
- Rock squirrel (*Spermophilus variegatus*)
- Brush mouse (*Peromyscus boylii*)
- Abert squirrel (*Sciurus aberti*)
- Rock pocket mouse (*Chaetodipus intermedius*)
- Colorado chipmunk (*Eutamias quadrivittatus*)
- Piñon mouse (*Peromyscus truei*)
- Rock mouse (*Peromyscus difficilis*)
- White-throated woodrat (*Neotoma albigua*)
- Porcupine (*Erethizon dorsatum*)

The mountain cottontail (*Sylvilagus floridanus*) probably replaces the desert cottontail in the woodland habitat, although these two species are extremely difficult to distinguish by field observation (Findley, 1987). Large predators that occur in the woodlands include the black bear (*Ursus americanus*) and mountain lion (*Felis concolor*). The mule deer (*Odocoileus*

hemionus) is common in the woodland habitat and is the only large herbivore known to use the Kirtland Federal Complex (KFC).

5.4 Riparian Wildlife Communities

Drainages provide a focal point for wildlife due to the higher levels of food, water, and cover generally found along their courses. Diversity is, therefore, generally high in the riparian habitat, especially where surface water is available. Although increased diversity is not particularly noticeable in the riparian scrublands on the Kirtland Federal Complex (KFC), it is more evident in the riparian woodlands. In general, the wildlife communities of the arroyos and canyons come from the adjacent grassland and woodland communities.

In addition to those species listed in the previous two sections, amphibian and reptile species in the riparian and wetland habitats include the red-spotted toad (*Bufo punctatus*) and western terrestrial garter snake (*Thamnophis elegans*). Birds that are generally limited to these habitats include the following:

- Western screech owl (*Otus kennicottii*)
- Solitary vireo (*Vireo solitarius*)
- Broad-tailed hummingbird (*Selasphorus platycercus*)
- Acorn woodpecker (*Melanerpes formicivorus*)
- Western tanager (*Piranga ludoviciana*)
- Northern oriole (*Icterus galbula*)
- Empidonax flycatchers (*Empidonax spp.*)
- Lark sparrow (*Chondestes grammacus*)
- Violet-green swallow (*Tachycineta thalassina*)

Most large mammal species of the area use the canyons and arroyos for feeding, water, travel corridors, or shelter. Species with affinities to this habitat are the gray fox (*Urocyon cinereoargenteus*), ringtail (*Bassariscus astutus*), and raccoon (*Procyon lotor*).

5.5 Wildlife Communities of the Altered Habitats

Although many of the wildlife species listed in “5.4 Riparian Wildlife Communities” are less common in habitats that are disturbed, altered, or in close proximity to human activities, others favor such habitats. Whiptail lizards are common on open, disturbed ground. Colonies (or “towns”) of Gunnison's prairie dogs occur around the margins of highly developed portions of the Kirtland Federal Complex (KFC), including roads, runways, housing on Kirtland Air Force Base (KAFB), and the golf course. Burrowing owls commonly appear with these colonies.

House sparrows (*Passer domesticus*), rock doves (*Columba livia*), European starlings (*Sturnus vulgaris*), and great-tailed grackles (*Quiscalus mexicanus*) appear in landscaped grounds and residential areas, but typically not in natural habitats. Birds from surrounding natural habitats that are also common in altered habitats include:

- House finch
- Mourning dove
- Say's phoebe
- Western kingbird (*Tyrannus verticalis*)
- Barn swallow (*Hirundo rustica*)
- American robin

The stables probably attract a variety of wildlife due to the presence of food and water. Rodents, such as deer mice and house mice (*Mus musculus*), are often associated with livestock feeding areas. These, in turn, attract predators, such as bullsnakes, striped skunks, coyotes, and barn owls.

With its green grass, ponds, and variety of trees, the golf course provides a particularly rich haven for wildlife of all kinds, including waterfowl and shorebirds. Special consideration for the mitigation of impacts to wildlife in altered habitats include the "raptor-proofing" of powerlines to reduce the danger of electrocuting large birds that perch on or fly near these lines, and the avoidance of construction activities that may impact raptor nests, especially those of burrowing owls (Daniel B. Stephens and Associates Incorporated, 1996).

6.0 THREATENED, ENDANGERED, AND SENSITIVE SPECIES

Three agencies have authority to list threatened or endangered species in New Mexico. These are the U.S. Fish and Wildlife Service (USFWS), the New Mexico Department of Game and Fish (NMDGF), and the New Mexico Forestry and Resource Conservation Division (NMFRCD) of the Energy, Minerals, and Natural Resources Department. These agencies also have designations included under the definition of sensitive species. In addition, the U.S. Forest Service (USFS) can also designate species as Forest Service Sensitive, thereby affording it special management consideration on USFS lands.

Table 5-4 summarizes the categories used by these agencies to designate and protect threatened, endangered, and sensitive species under their jurisdiction. As conditions change for the species, or as new information about the species is obtained, these agencies can also "delist" the species by removing it from an endangered or threatened status.

Table 5-4. Species Designations Used by Federal and State Agencies with Management Jurisdiction at the KFC

Agency	Category	Comments
U.S. Fish and Wildlife Service	Federally Endangered	Official listing under the <i>Endangered Species Act</i> of species or subspecies in jeopardy of extinction in part or all of its range.
	Federally Threatened	Official listing under the <i>Endangered Species Act</i> of species or subspecies that may become endangered in the foreseeable future.
	Proposed	A species or subspecies for which a Proposed Rule for listing as either threatened or endangered has been published in the <i>Federal Register</i> , but a Final Rule has not yet been made.
	Candidate	Official listing of species or subspecies for which sufficient information exists for a Proposed Rule to list as threatened or endangered, but the Proposed Rule has not yet been issued.
	Migratory, Nongame Bird of Management Concern	<ul style="list-style-type: none"> • A list of migratory nongame birds for which information exists indicating declining populations in one or more USFWS regions. • These species are not protected by the <i>Endangered Species Act</i>, and they are not necessarily candidate species; however, they are typically protected under the <i>Migratory Bird Treaty Act</i>.
	Species of Concern	An unofficial designation of species for which current information indicates potential vulnerability, but insufficient information exists to warrant designation as a candidate.
New Mexico Department of Game and Fish	State Endangered	Equivalent to Federally Endangered, but limited to wildlife species within the State of New Mexico and protected under the <i>New Mexico Wildlife Conservation Act</i> .
	State Threatened	Equivalent to Federally Threatened, but limited to wildlife species within the State of New Mexico and protected under the <i>New Mexico Wildlife Conservation Act</i> .
New Mexico Forestry and Resource Conservation Division	List 1 (Endangered)	Official listing of plant species that are in jeopardy of extinction or extirpation within the State of New Mexico and are protected under the <i>New Mexico Endangered Plant Species Act</i> .
	List 2 (Rare and Sensitive)	Official listing of plant species that are vulnerable to extinction or extirpation within the state of New Mexico due to rarity or restricted distribution, but are not protected under the <i>New Mexico Endangered Plant Species Act</i> .
	List 3 (Rare Plant Review List)	<ul style="list-style-type: none"> • Plant species for which insufficient information exists to either list or reject them. • They are not protected under the <i>New Mexico Endangered Plant Species Act</i>.
	List 4 (Plant Species Considered, But Not Included)	<ul style="list-style-type: none"> • Plant species that have previously been considered for Lists 1, 2, or 3, but have been determined to be too abundant to retain. • These species are not considered sensitive at this time.
U.S. Forest Service	Forest Service Sensitive	<ul style="list-style-type: none"> • Species listed for special management consideration on USFS lands. • Forest Service Sensitive species are commonly included in one or more of the above categories, but may be independently designated for a specific national forest.

Under the authority of the *Endangered Species Act of 1973*, the USFWS can list species of both plants and animals as either threatened or endangered throughout all or part of their range and may designate geographic areas as critical habitat for these species. The USFWS also recognizes proposed and candidate species, which are two levels of designation in the process of listing a species as either threatened or endangered. Proposed species are considered to be sensitive species designations. Species for which some evidence of vulnerability exists, but the information is insufficient to warrant designation as a candidate species, are referred to as "species of concern." However, because this is not an official USFWS designation under the *Endangered Species Act*, species at the Kirtland Federal Complex (KFC) that fall into this category are mentioned here, but are not considered to be sensitive species.

The USFWS also has authority to protect migratory birds listed under the *Migratory Bird Treaty Act* and is directed under the *Wildlife Conservation Act* to "identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the *Endangered Species Act of 1973*." Therefore, the USFWS maintains a list of migratory, nongame birds of management concern for each of its seven regions based on population trends (U.S. Fish and Wildlife Service, 1995). Although these species are not considered as candidates for listing as threatened or endangered, those from Region 2, which includes New Mexico, are considered as sensitive species at the KFC (Daniel B. Stephens and Associates Incorporated, 1996).

The State of New Mexico separates the protection of wildlife and plant species between the NMDGF and the NMFRCD, respectively. The NMDGF recognizes two levels of endangerment for wildlife species within the state. These are endangered and threatened, which are approximately equivalent to the endangered and threatened designations of the USFWS. The NMFRCD recognizes four categories for listing plants, of which only one is considered endangered and protected by state law on state lands (see Attachment 5-1, "Plant Species Known or Expected to Occur on the KFC"). List 2 includes rare and sensitive plants, List 3 includes plants under review, and List 4 includes plants dropped from consideration and are, therefore, not considered as sensitive species on the KFC.

The Pueblo of Isleta recognizes all state and federal designations of endangered, threatened, and sensitive species as applying to those populations occurring on pueblo lands. In addition, the Pueblo of Isleta considers all species occurring on pueblo lands to be of cultural importance and are protected.

Table 5-5 lists threatened, endangered, and sensitive species known to occur on the KFC. Of the federally-listed threatened or endangered species, only the peregrine falcon (also a state-listed endangered species) was observed on the KFC. However, no nesting activity of this species were observed and only a marginal habitat exists for nesting (New Mexico Natural

Heritage Program, 1995). No federally proposed or candidate species are known to occur on the KFC and no critical habitat occurs there. Of the state-listed threatened and endangered wildlife species that are not listed by the USFWS, only the gray vireo (*Vireo vicinior*) is known to breed on the KFC. The gray vireo is also a Forest Service sensitive species and is found in the open woodlands along the foothills of the Manzanita Mountains (New Mexico Natural Heritage Program, 1995; Daniel B. Stephens and Associates Incorporated, 1996). The Bell's vireo (*Vireo bellii*), also a state-listed threatened species, has recently been reported at the KFC (Pope, 1997), but confirmation of this observation has not been made.

Table 5-5. Threatened, Endangered, and Sensitive Species Known to Occur at the KFC

Common Name	Scientific Name	Status
Santa Fe milkvetch	<i>Astragalus feenis</i>	Federal: None State: List 2 KFC: Found on limestone hills in grasslands
Grama grass cactus	<i>Pediocactus papyracanthus</i>	Federal: Forest Service Sensitive State: None KFC: Observed in grasslands and Lurance Canyon
Texas horned lizard	<i>Phrynosoma cornutum</i>	Federal: Species of Concern, Forest Service Sensitive State: None KFC: Observed in grasslands and Lurance Canyon
White-faced ibis	<i>Plegadis chichi</i>	Federal: Species of Management Concern; Forest Service Sensitive State: None KFC: Observed, probably transient
Northern harrier	<i>Circus cyaneus</i>	Federal: Species of Management Concern State: None KFC: Migrant
Peregrine falcon	<i>Falco peregrinus</i>	Federal: Endangered; Forest Service Sensitive State: Threatened KFC: Observed, probably transient
Ferruginous hawk	<i>Buteo regalis</i>	Federal: Species of Management Concern; Species of Concern State: None KFC: Observed, probably transient
Burrowing owl	<i>Speotyto cunicularia</i>	Federal: Species of Management Concern; Species of Concern State: None KFC: Breeding
Gray flycatcher	<i>Empidonax wrightii</i>	Federal: Species of Management Concern State: None KFC: Observed, possible breeding
Curve-billed thrasher	<i>Toxostoma curvirostre</i>	Federal: Species of Management Concern State: None KFC: Observed, possible breeding

**Table 5-5. Threatened, Endangered, and Sensitive Species Known to Occur at the KFC
(Continued)**

Common Name	Scientific Name	Status
Loggerhead shrike	<i>Lanius ludovicianus</i>	Federal: Species of Management Concern; Species of Concern State: None KFC: Breeding
Gray vireo	<i>Vireo vicinior</i>	Federal: Species of Management Concern; Forest Service Sensitive State: Threatened KFC: Breeding
Virginia's warbler	<i>Vermivora virginiae</i>	Federal: Species of Management Concern State: None KFC: Observed, possible breeding
Lark sparrow	<i>Chondestes grammacus</i>	Federal: Species of Management Concern State: None KFC: Breeding
Black-throated sparrow	<i>Amphispiza bilineata</i>	Federal: Species of Management Concern State: None KFC: Breeding
Sage sparrow	<i>Amphispiza belli</i>	Federal: Species of Management Concern State: None KFC: Possible breeding
Cassin's sparrow	<i>Aimophila cassini</i>	Federal: Species of Management Concern State: None KFC: Possible breeding

No plant species currently listed as endangered by the NMFRCD is known to occur on the KFC and only one sensitive (List 2) plant species, the Santa Fe milkvetch (*Astragalus feensis*), has been recorded. A population of this plant species has been found on the low hills in the southwestern part of the KFC (Sullivan and Knight, 1994). As mentioned in "4.1, Overview," the grama grass cactus, visnagita cactus, and Wright's pincushion cactus all occur on the KFC and were previously listed as endangered (List 1) by the NMFRCD. These have since been delisted by this agency (being placed on List 4), but the grama grass cactus is still a Forest Service sensitive species.

The following thirteen migratory, nongame birds of management concern for the USFWS Region 2 have been observed on the KFC:

- White-faced ibis (*Plegadis chihi*)
- Northern harrier (*Circus cyaneus*)
- Ferruginous hawk (*Buteo regalis*)
- Burrowing owl (*Speotyto cunicularia*)
- Gray flycatcher (*Empidonax wrightii*)
- Loggerhead shrike (*Lanius ludovicianus*)

- Cassin's sparrow (*Aimophila cassinii*)
- Gray vireo (*Vireo vicinior*)
- Virginia's warbler (*Vermivora virginiae*)
- Lark sparrow (*Chondestes grammacus*)
- Black-throated sparrow (*Amphispiza bilineata*)
- Sage sparrow (*Amphispiza belli*)
- Curve-billed thrasher (*Toxostoma curvirostre*)

Of these thirteen migratory, nongame birds, the burrowing owl, loggerhead shrike, gray vireo, lark sparrow, and black-throated sparrow are locally common breeding species on the KFC.

Seven USFWS species of concern have been observed on KFC. Four of these (the white-faced ibis, ferruginous hawk, burrowing owl, and loggerhead shrike) are also designated as species of management concern by the USFWS. Two (the small-footed myotis [*Myotis ciliolabrum*] and the Townsend's big-eared bat [*Plecotus townsendii pallescens*]) are species of bats recorded during two bat surveys conducted at the KFC using mist netting and vocalization survey methods (New Mexico Natural Heritage Program, 1995) and by examination of three mine shafts (Altenbach, 1997). The following six bat species are considered to be species of concern by the USFWS and have ranges that potentially include the KFC, but have not been recorded there to date (the spotted bat is also a state-listed threatened species, and both it and the occult little brown bat are Forest Service sensitive species):

- Spotted bat (*Euderma maculatum*)
- Occult little brown bat (*Myotis lucifugus occultus*)
- Fringed myotis (*Myotis thysanodes*)
- Yuma myotis (*Myotis yumanensis*)
- Long-legged myotis (*Myotis volans*)
- Big free-tailed bat (*Nyctinomops macrotis*)

The Texas horned lizard (*Phrynosoma cornutum*) is the final species of concern that has been recorded on the KFC (Sullivan, 1994; Sullivan and Knight, 1994), and is a Forest Service Sensitive species. Degenhardt, Painter, and Price (1996) state that populations of this species in the Albuquerque area may not be natural, but the result of escaped pets or deliberate introductions.

Due to the potential for the occurrence of the federally threatened Mexican spotted owl (*Strix occidentalis lucida*) in Sol se Mete Canyon, the habitat conditions in this canyon were investigated in 1993 by R. W. Skaggs, a qualified expert in this species (Sullivan, 1994). This investigation, which also included parts of the Lurance Canyon Burn Site, identified that the habitat was not conducive to the probable occurrence of the Mexican spotted owl. In 1993, two nights of surveys for this species were conducted in Sol se Mete Canyon as part of the threatened and endangered species surveys conducted by the New Mexico Natural Heritage

Program for Kirtland Air Force Base (KAFB). No evidence of the species was found during this survey (New Mexico Natural Heritage Program, 1995). Marginal habitat exists in the ponderosa pine woodlands of the Manzanita Mountains for the occurrence for the Forest Service Sensitive northern goshawk (*Accipiter gentilis*), which is also a USFWS species of management concern, and habitat conditions conducive to the occurrence of the Forest Service Sensitive flammulated owl (*Otus flammeolus*) have been found in Bonito Canyon. However, neither species has been recorded on the KFC. The mountain plover (*Charadrius montanus*), a species that nests in association with prairie dog towns in short grass prairie habitats, is the only federal candidate species likely to occur in Bernalillo County. Although habitat conditions for this species exist at the KFC, the mountain plover has not been recorded there.

Lists of threatened, endangered, and sensitive species are continuously changing. As data accumulates, species of concern may become candidate species and candidates may be proposed and listed. Others may be dropped from consideration or listed species may be reduced in status or delisted. Therefore, state and federal agencies should be consulted for current lists and concerns before initiating new actions.

7.0 SENSITIVE HABITATS AND OTHER ISSUES OF CONCERN

7.1 Overview

In addition to the presence of threatened and sensitive species, there are other issues concerning the health of the biological resources on the Kirtland Federal Complex (KFC). The diversity and interconnection of the habitat types and special habitat features that form the ecological landscape enhance the biodiversity of an area.

Each of the major habitat types on the KFC contains features that satisfy special habitat requirements of certain species, thereby allowing them to occur. Because these species might not be present on the KFC except for the existence of these special features, or at least might be less abundant, such features are important in maintaining the biodiversity of the ecological landscape of the KFC. These features can be relatively large, such as the area along the western boundary fence and other "patches" within the grassland where grama grass cactus appears in relatively high density and the hills that support the Santa Fe milkvetch, while others are much smaller, comprising a very small proportion of the habitat type in which they occur, but are a vital part of the habitat requirements of certain species. Because of their small size, these latter habitat features are sensitive to disruption. The following sections describe some of the sensitive ecological resources on the KFC.

7.2 Wetlands and Surface Water

Areas of natural wetlands and surface water on the Kirtland Federal Complex (KFC) are limited in both size and number. Nine springs occur on the KFC, six of which have jurisdictional wetlands associated with them (U.S. Army Corps. of Engineers, 1995). Two of these, Sol se Mete and Lurance Springs, are in the canyons within the Withdrawn Area. Both use masonry tubs for wildlife watering. Sol se Mete Spring still provides water to wildlife at its masonry tub, but was modified to supplement a series of wildlife drinkers, or trick tanks, farther down the canyon. At Lurance Spring, the tub contains sediment. Water only appears in a small hole in the rock, approximately two feet below the ground surface and inaccessible to most wildlife (Schwarz, 1994). The spring supports a thick growth of vegetation, which provides a degree of habitat diversity.

Coyote Springs is the largest natural wetland area on the KFC. It consists of four separate seep areas. Modifications to the seep areas include a graded parking area, concrete slabs, and a masonry-lined pit made inaccessible to people and most wildlife by a metal cage over the top. The springs support several large Fremont cottonwoods and a thick growth of salt cedars along its margin with Arroyo del Coyote. The seep areas have accessible surface water and include the following vegetation:

- Wire rush (*Juncus balticus*)
- Torrey rush (*Juncus torreyi*)
- Cattail (*Typha latifolia*)
- Yerba mansa (*Anemopsis californica*)
- Rabbitfoot grass (*Polypogon monspeliensis*)

These features make the site highly attractive to mule deer and a large number of birds, both breeding and migrants.

The five unnamed springs occurring around the Four Hills are very small. Three of these support wetland vegetation and are designated as jurisdictional wetlands. The other two are rock seeps and do not support wetland vegetation, but may provide surface water to wildlife. Other natural surface water sources on the KFC, which are not considered jurisdictional wetlands, include:

- G Spring, a semi-perennial riparian flow in Arroyo del Coyote, which is associated with the unnamed spring on the north end of the Four Hills.

- Some natural rock tanks in the canyons of the Manzanita Mountains that hold small amounts of water for some period after precipitation events (Biggs, 1991; U.S. Forest Service, Southwestern Region, 1996).

Manmade surface-water features supplement these natural sources. Four trick tanks were constructed on the KFC in addition to the ones in Sol se Mete Canyon. Two of these, however, fell into disrepair (U.S. Forest Service, Southwestern Region, 1996). Small ponds were built on the golf course that attract waterfowl, shorebirds, and other wildlife. In the southern part of the KFC, Christian Lake supports wetland vegetation around its perimeter and is reported to have once been successfully stocked with fish.

7.3 Cliffs, Crevices, and Caves

Exposures of bedrock provide an essential habitat for some wildlife species, especially as protected nesting or roosting sites for bats and birds. A variety of birds, including swifts, swallows, ravens, and birds-of-prey, such as golden eagles (*Aquila chrysaetos*) and peregrine falcons, use cliffs as nesting sites. Within the Kirtland Federal Complex (KFC) boundary, the west side of the Manzanita Mountains contains areas of exposed cliff faces that could be used by these species, although nesting by either golden eagles or peregrine falcons has not been reported. Narrow crevices within rock faces also provide potential roosting sites for some bat species such as the spotted bat, although the potential presence of this species in the Manzano Mountains may be limited by the lack of water (U.S. Forest Service, Southwestern Region, 1996).

Caves are also important as a bat habitat and may be used in the warm season for breeding or roosting and in the cold season as a hibernaculum (Altenbach, 1997). No natural caves are reported on the KFC, although such features may exist in the limestone exposures. However, several abandoned mines exist in the Manzanita Mountains and provide an equivalent habitat to bats. These mines include both vertical shafts and adits and present a hazard to personnel on the KFC. Therefore, those mines that provide a good bat habitat are being fitted with bat-compatible closures that allow bats to enter and exit freely, but prevent human access. Other mines are being closed by slow backfilling during the warm season, to allow any bats present in the mine to escape.

7.4 Large Trees, Motts, and Snags

Trees are important contributors to the diversity of habitat structure in all the major habitat types on the Kirtland Federal Complex (KFC). Large trees (i.e., 50 feet or more in height) are uncommon in the natural vegetation of the KFC. Trees of this size may be limited to the Fremont cottonwoods of Coyote Springs and G Spring, the ponderosa pines of the higher

elevations, and possibly some Siberian elms established along arroyos. These trees provide nesting sites, perches, and feeding sites for many species of birds and may also be used by bats, squirrels, and other mammals.

Motts are isolated, island-like thickets of trees, often formed by the growth of root-sprouts from a single parent tree. The tree-of-heaven produces such motts on the KFC, particularly along Arroyo del Coyote near Coyote Springs and G Spring. These sites may serve as focal points of wildlife activity, providing nesting sites for birds and protected resting areas for large mammals such as mule deer.

In the woodland habitat, standing dead trees, or snags, provide an important element of diversity for wildlife habitat. Many birds-of-prey use snags as perches from which the surrounding area can be surveyed during hunting and to which prey can be taken for eating.

7.5 Prairie Dog Towns

Prairie dogs often occur in colonies, called "towns," which are marked by many burrow entrances, each surrounded by mounded soil. The grazing of the prairie dogs around these burrows often leaves the vegetation cropped short and can alter the vegetation composition. On the Kirtland Federal Complex (KFC), the Gunnison's prairie dog is common to the grassland habitat. The prairie dog is particularly abundant, with well developed towns, on the margins of developed areas, such as around main Kirtland Air Force Base (KAFB) areas, Tech Area I, along roads and runways, and adjacent to the golf course. Prairie dog towns are important habitat features because they provide both hunting and nesting sites to the burrowing owl, which is a species of special management concern and is protected under the *Migratory Bird Treaty Act* and legislation commonly known as the "New Mexico Raptor Protection Act" (Hawks, Vultures and Owls; . . . , NMSA § 17-2-14). Burrowing owls are unusual in that they nest in underground chambers that they dig out from an abandoned mammal burrow (for example, a prairie dog burrow).

7.6 Corridors

Drainages and their associated riparian vegetation appear to be the most important wildlife corridors on the Kirtland Federal Complex (KFC). The sunken channel and taller vegetation along these routes provide visual protection, while the bed of the drainage may provide

8.2 General References

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On a larger scale, the Manzanita Mountains are part of an important corridor for the migration of birds through New Mexico. This corridor forms a link between the Sandia and Manzano Mountains, which are part of a series of mountain ranges that occur along the eastern side of the Rio Grande Valley through most of the state. Large numbers of Neotropical migrants, including several species of raptors, use the woodlands and meadows along the ridge east of Madera Canyon, which is an important ecological resource within the Withdrawn Area. The U.S. Forest Service (USFS) has determined this to be a unique area and is managing it accordingly.

8.0 REFERENCES

8.1 Regulations, Orders, and Laws

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Hawks, Vultures and Owls; Taking, Possessing, Trapping, Destroying, Maiming or Selling Prohibited; Exception by Permit; Penalty, ("New Mexico Raptor Protection Act") § 17-2-14 *et seq.*, NMSA 1978.

Migratory Bird Treaty Act, 16 U.S.C. §703 *et seq.*

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8.2 General References

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ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC

Scientific Name	Common Name	Habitat*
Class: Filicineae	Ferns	
Family: Polypodiaceae		
<i>Cheilanthes eatonii</i> ^p	Eaton's lip fern ^a	Woodlands (rock crevices)
<i>Pellaea fendleri</i>	Zigzag cliffbrake	Woodlands (rock crevices)
<i>Pellaea longimucronata</i>	Cliffbrake	Woodlands (rock crevices)
<i>Woodsia mexicana</i>	Woodsia ^a	Woodlands
Class: Gymnospermae	Cone-bearing plants	
Family: Ephedraceae		
<i>Ephedra nevadensis</i>	Rough joint-fir	Grasslands
<i>Ephedra viridis</i>	Green joint-fir	Grasslands
<i>Ephedra torreyana</i>	Mormon tea ^{a, b, c}	Grasslands
Family: Pinaceae		
<i>Pinus edulis</i>	Colorado piñon ^{a, f}	Woodlands/Riparian (canyons)
<i>Pinus ponderosa</i>	Ponderosa pine ^a	Woodlands (higher elevations)
Family: Cupressaceae		
<i>Juniperus scopulorum</i>	Rocky Mountain juniper ^a	Woodlands (higher elevations)
<i>Juniperus monosperma</i>	One-seed juniper ^{a, f}	Woodlands/Grasslands/Riparian
Class: Angiospermae	Flowering plants	
Subclass: Monocotyledoneae	Monocots	
Family: Typhaceae		
<i>Typha latifolia</i>	Cattail ^{a, e}	Riparian (wetlands)
Family: Poaceae		
<i>Aristida divaricata</i>	Poverty three-awn	Grasslands/Altered (disturbed ground)
<i>Aristida adscensionis</i>	Six-weeks three-awn ^a	Grasslands
<i>Aristida arizonica</i>	Arizona three-awn	Grasslands
<i>Aristida glauca</i>	Reverchon three-awn ^a	Woodlands (rocky slopes)
<i>Aristida wrightii</i>	Wright's three-awn	Grasslands
<i>Aristida fendleriana</i>	Fendler three-awn ^a	Grasslands
<i>Aristida purpurea</i>	Purple three-awn ^{a, b}	Grasslands
<i>Aristida longiseta</i>	Red three-awn ^{a, b, f}	Grasslands
<i>Oryzopsis micrantha</i>	Littleseed ricegrass ^a	Woodlands
<i>Oryzopsis hymenoides</i>	Indian ricegrass ^{a, b}	Grasslands
<i>Stipa neomexicana</i>	New Mexico porcupinegrass ^c	Grasslands/Woodlands
<i>Stipa scribneri</i>	Scribner needlegrass ^a	Woodlands
<i>Stipa comata</i>	Needle-and-thread	Woodlands
<i>Piptochaetium fimbriata</i>	Pinyon ricegrass	Woodlands
<i>Phleum pratense</i>	Timothy	Woodlands (higher elevations)
<i>Muhlenbergia pungens</i>	Sandhill muhly	Grasslands
<i>Muhlenbergia torreyi</i>	Ring muhly ^{b, c, f}	Grasslands
<i>Muhlenbergia arenicola</i>	Sand muhly ^a	Grasslands
<i>Muhlenbergia porteri</i>	Bush muhly ^{a, b}	Grasslands
<i>Muhlenbergia arenacea</i>	Ear muhly ^c	Grasslands
<i>Muhlenbergia asperifolia</i>	Scratchgrass ^a	Riparian (arroyos)
<i>Muhlenbergia sinuosa</i>	Marsh muhly	Riparian (canyons)

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
<i>Muhlenbergia richardsonis</i>	Mat muhly	Riparian (arroyos)
<i>Muhlenbergia wrightii</i>	Spike muhly ^a	Woodlands
<i>Muhlenbergia montana</i>	Mountain muhly ^a	Woodlands
<i>Muhlenbergia monticola</i>	Mesa muhly ^a	Woodlands
<i>Muhlenbergia pauciflora</i>	New Mexican muhly ^a	Woodlands
<i>Blepharoneuron tricholepis</i>	Pine dropseed	Woodlands
<i>Sporobolus flexuosus</i>	Mesa dropseed ^{a, c}	Grasslands
<i>Sporobolus cryptandrus</i>	Sand dropseed ^{a, c, f}	Grasslands
<i>Sporobolus airoides</i>	Alkali sacaton ^{a, c}	Riparian (arroyos)
<i>Sporobolus contractus</i>	Spike dropseed ^{a, c}	Grasslands
<i>Lycurus phleoides</i>	Wolftail	Woodlands
<i>Polypogon monspeliensis</i>	Rabbitfoot grass ^{a, e}	Riparian (wetlands)
<i>Koeleria cristata</i>	Junegrass	Woodlands
<i>Scleropogon brevifolius</i>	Burro grass ^{a, b, c}	Grasslands
<i>Enneapogon desvauxii</i>	Spike pappusgrass ^a	Grasslands/Woodlands
<i>Tridens pulchellus</i>	Fluffgrass ^{a, f}	Grasslands/Altered (disturbed ground)
<i>Tridens pilosus</i>	Hairy tridens ^a	Grasslands
<i>Munroa squarrosa</i>	False buffalo grass ^a	Grasslands
<i>Eragrostis cilianensis</i>	Stinkgrass ^a	Altered (disturbed ground)
<i>Eragrostis mexicana</i>	Mexican lovegrass ^b	Altered (disturbed ground)
<i>Eragrostis pilosa</i>	India lovegrass ^a	Altered (disturbed ground)
<i>Distichlis stricta</i>	Desert saltgrass ^a	Riparian (arroyos)
<i>Dactylis glomerata</i>	Orchard grass ^e	Riparian (wetlands)
<i>Poa pratensis</i>	Kentucky bluegrass ^a	Riparian/Altered
<i>Bromus polyanthus</i>	Foothills brome	Woodlands
<i>Bromus japonicus</i>	Japanese chess ^a	Altered (disturbed ground)
<i>Bromus tectorum</i>	Downy chess ^a	Altered (disturbed ground)
<i>Bromus anomalus</i>	Nodding brome	Riparian (canyons)
<i>Festuca octoflora</i>	Six-weeks fescue	Grasslands
<i>Festuca arizonica</i>	Arizona fescue	Woodlands
<i>Cynodon dactylon</i>	Bermuda grass ^a	Riparian/Altered (disturbed ground)
<i>Chloris virgata</i>	Feathery fingergrass ^a	Altered (disturbed ground)
<i>Chloris verticillata</i>	Windmill grass ^a	Altered (disturbed ground)
<i>Schedonnardus paniculatus</i>	Tumble grass	Grasslands
<i>Bouteloua aristidoides</i>	Needle grama ^a	Grasslands/Altered (disturbed ground)
<i>Bouteloua barbata</i>	Six-weeks grama ^a	Grasslands/Altered (disturbed ground)
<i>Bouteloua hirsuta</i>	Hairy grama	Grasslands
<i>Bouteloua curtipendula</i>	Side-oats grama ^a	Grasslands/Woodlands/Riparian
<i>Bouteloua gracilis</i>	Blue grama ^{a, b, c, f}	Grasslands/Woodlands
<i>Bouteloua eriopoda</i>	Black grama ^{a, b, c}	Grasslands
<i>Hilaria jamesii</i>	Galleta ^{a, b, c}	Grasslands/Woodlands
<i>Agropyron smithii</i>	Western wheatgrass ^a	Riparian (arroyos)
<i>Agropyron pseudorepens</i>	False quackgrass	Riparian
<i>Agropyron trachycaulum</i>	Slender wheatgrass	Riparian
<i>Hordeum jubatum</i>	Foxtail barley ^a	Altered (disturbed ground)

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
<i>Sitanion hystrix</i>	Squirreltail ^{a, b, f}	Grasslands/Woodlands/Riparian
<i>Elymus canadensis</i>	Canada wild rye ^a	Riparian
<i>Andropogon scoparius</i>	Little bluestem	Grasslands/Woodlands
<i>Andropogon barbinodis</i>	Cane beardgrass	Grasslands
<i>Sorghum halepense</i>	Johnson grass ^a	Riparian
<i>Cenchrus echinatus</i>	Sandbur ^a	Altered (disturbed ground)
<i>Setaria verticillata</i>	Bur bristlegrass ^a	Altered (disturbed ground)
<i>Setaria viridis</i>	Green bristlegrass ^a	Riparian/Altered (disturbed ground)
<i>Setaria macrostachya</i>	Plains bristlegrass ^{a, b}	Riparian/Altered (disturbed ground)
<i>Panicum capillare</i>	Witchgrass ^a	Riparian
<i>Panicum obtusum</i>	Vine mesquite	Riparian (arroyos)
<i>Echinochloa crusgalli</i>	Barnyard grass ^a	Riparian (wetlands)/Altered
<i>Digitaria sanguinalis</i>	Crabgrass ^a	Riparian/Altered
Family: Cyperaceae		
<i>Cyperus fendlerianus</i>	Fendler flatsedge	Riparian (wetlands)
<i>Cyperus esculentus</i>	Yellow nutgrass	Riparian (wetlands)
<i>Eleocharis montana</i>	Mountain spikerush	Riparian (wetlands)
<i>Scirpus americanus</i>	Three-square ^{a, e}	Riparian (wetlands)
Family: Juncaceae		
<i>Juncus balticus</i>	Wire rush ^{a, e}	Riparian (wetlands)
<i>Juncus saximontanus</i>	Rocky Mountain rush ^a	Riparian (wetlands)
<i>Juncus torreyi</i>	Torrey rush ^{a, e}	Riparian (wetlands)
Family: Liliaceae		
<i>Yucca baccata</i>	Banana yucca ^a	Woodlands
<i>Yucca glauca</i>	Soapweed yucca ^{a, c}	Grasslands
<i>Nolina microcarpa</i>	Bear grass ^a	Woodlands
<i>Asparagus officinalis</i>	Asparagus	Riparian/Altered (disturbed ground)
<i>Allium macropetalum</i>	Onion	Riparian (canyons)
<i>Allium cernuum</i>	Nodding onion	Riparian (higher elevations)
Subclass: Dicotyledoneae	Dicots	
Family: Saururaceae		
<i>Anemopsis californica</i>	Yerba mansa ^{a, e}	Riparian (wetlands)
Family: Salicaceae		
<i>Salix exigua</i>	Coyote willow	Riparian (arroyos)
<i>Populus fremontii</i>	Fremont cottonwood ^{a, e}	Riparian (arroyos and wetlands)
Family: Fagaceae		
<i>Quercus gambelii</i>	Gambel oak ^a	Woodlands
<i>Quercus turbinella</i>	Shrub live oak ^a	Woodlands
<i>Quercus grisea</i>	Gray oak ^a	Woodlands
Family: Ulmaceae		
<i>Celtis reticulata</i>	Netleaf hackberry	Riparian (arroyos)
<i>Ulmus pumila</i>	Siberian elm ^a	Riparian/Altered (disturbed ground)
Family: Loranthaceae		
<i>Phoradendron juniperinum</i>	Juniper mistletoe ^a	Woodlands (on junipers)
<i>Arceuthobium divaricatum</i>	Dwarf mistletoe	Woodlands (on pinyons)

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
Family: Polygonaceae		
<i>Eriogonum abertianum</i>	Wild buckwheat	Grasslands/Woodlands
<i>Eriogonum annuum</i>	Annual wild buckwheat	Grasslands
<i>Eriogonum polycladon</i>	Sorrel wild buckwheat^a	Riparian (arroyos)/Altered
<i>Eriogonum jamesii</i>	Antelope-sage	Grasslands/Woodlands
<i>Eriogonum wrightii</i>	Wright's wild buckwheat^a	Grasslands/Woodlands
<i>Rumex hymenosepalus</i>	Canaigre^{a, b}	Riparian (arroyos)/Altered
<i>Rumex mexicanus</i>	Dock	Riparian (arroyos)/Altered
<i>Polygonum convolvulus</i>	Black bindweed	Riparian (arroyos)/Altered
<i>Polygonum aviculare</i>	Knotweed^a	Riparian (wetlands)/Altered
Family: Chenopodiaceae		
<i>Salsola kali</i>	Russian thistle^{a, b, c, f}	Altered (disturbed ground)
<i>Eurotia lanata</i>	Winterfat^{a, b, c, f}	Grasslands/Woodlands/Riparian
<i>Atriplex canescens</i>	Four-wing saltbush^{a, b, f}	Grasslands/Riparian (arroyos)
<i>Chenopodium botrys</i>	Jerusalem oak	Altered (disturbed ground)
<i>Chenopodium album</i>	Lamb's quarters^{a, c}	Altered (disturbed ground)
<i>Chenopodium incanum</i>	Gray goosefoot^a	Grasslands
<i>Chenopodium fremontii</i>	Fremont goosefoot^{a, b}	Grasslands
<i>Kochia scoparia</i>	Summer cypress^a	Altered (disturbed ground)
Family: Amaranthaceae		
<i>Amaranthus graecizans</i>	Prostrate pigweed^a	Altered (disturbed ground)
<i>Amaranthus hybridus</i>	Pigweed	Altered (disturbed ground)
<i>Amaranthus powellii</i>	Pigweed^a	Altered (disturbed ground)
<i>Amaranthus retroflexus</i>	Green amaranth	Altered (disturbed ground)
<i>Acanthochiton wrightii</i>		Grasslands
<i>Tidestromia lanuginosa^a</i>		Grasslands/Riparian (arroyos)
Family: Nyctaginaceae		
<i>Allionia incarnata</i>	Umbrellawort^b	Grasslands/Altered (disturbed ground)
<i>Oxybaphus linearis^a</i>		Woodlands/Riparian
<i>Mirabilis multiflora</i>	Four o'clock^{a, b}	Woodlands
<i>Mirabilis oxybaphoides</i>	Four o'clock^a	Woodlands/Riparian
<i>Abronia fragrans</i>	Sand verbena^b	Grasslands/Riparian (arroyos)
Family: Aizoaceae		
<i>Mollugo verticillata</i>	Carpetweed	Altered (disturbed ground)
Family: Portulacaceae		
<i>Portulaca oleracea</i>	Common purslane^{a, f}	Altered (disturbed ground)
Family: Caryophyllaceae		
<i>Stellaria longifolia</i>	Chickweed^a	Woodlands (higher elevations)
Family: Ranunculaceae		
<i>Delphinium virescens</i>	Larkspur^b	Grasslands
Family: Berberidaceae		
<i>Berberis repens</i>	Creeping mahonia^a	Woodlands (higher elevations)
<i>Berberis haematocarpa</i>	Red barberry	Woodlands (higher elevations)
Family: Fumariaceae		
<i>Corydalis aurea</i>	Golden corydalis^b	Woodlands/Riparian

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
Family: Brassicaceae		
<i>Draba cuneifolia</i>	Whitlow grass	Woodlands/Riparian (arroyos)
<i>Erysimum capitatum</i>	Western wallflower ^a	Grasslands/Woodlands/Riparian
<i>Descurainia sophia</i>	Tansy mustard ^a	Altered (disturbed ground)
<i>Descurainia obtusa</i>	Tansy mustard ^c	Riparian/Altered (disturbed ground)
<i>Descurainia richardsonii</i>	Tansy mustard ^b	Altered (disturbed ground)
<i>Sisymbrium altissimum</i>	Tumble mustard ^a	Altered (disturbed ground)
<i>Sisymbrium irio</i>	London rocket ^a	Altered (disturbed ground)
<i>Rorippa nasturtium-aquaticum</i>	Water cress ^a	Riparian (wetlands)
<i>Dithyrea wislizenii</i>	Spectacle pod ^b	Grasslands/Riparian/Altered
<i>Lepidium montanum</i>	Peppergrass ^a	Woodlands/Riparian/Altered
<i>Lepidium medium</i>	Peppergrass	Grasslands/Riparian/Altered
<i>Capsella bursi-pastoris</i>	Shepherd's purse	Grasslands/Riparian/Altered
<i>Thlaspi alpestre</i>	Wild candytuft	Woodlands/higher elevations
<i>Lesquerella fendleri</i>	Bladderpod ^{a, b, c}	Grasslands/Riparian/Altered
Family: Capparidaceae		
<i>Cleome serrulata</i>	Rocky Mountain bee-plant	Woodlands/Riparian (arroyos)
<i>Polanisia trachysperma</i>	Clammyweed ^a	Riparian (arroyos)
Family: Saxifragaceae		
<i>Fendlera rupicola</i>	Cliff fendlerbush ^a	Riparian (canyons)
<i>Philadelphus microphyllus</i>	Mock-orange ^a	Riparian (canyons)
<i>Ribes cereum</i>	Wax currant	Riparian (canyons and higher elevations)
Family: Rosaceae		
<i>Prunus virginiana</i>	Western black chokecherry	Riparian (canyons)
<i>Rosa woodsii</i>	Woods' rose ^a	Riparian (canyons)
<i>Fallugia paradoxa</i>	Apache plume ^a	Riparian (arroyos and canyons)
<i>Cercocarpus montanus</i>	Alder-leaf mountain mahogany ^a	Woodlands
Family: Fabaceae		
<i>Calliandra humilis</i>	False mesquite	Grasslands
<i>Cassia bauhinioides</i>	Twin leaf ^b	Grasslands
<i>Hoffmanseggia jamesii</i>	Rush pea ^{a, b, c}	Grasslands
<i>Hoffmanseggia drepanocarpa</i> ^c		Grasslands
<i>Psoralea lanceolata</i>	Lemon scurfpea	Grasslands/Woodlands/Riparian
<i>Psoralea tenuiflora</i>	Slender scurfpea ^b	Grasslands/Riparian (arroyos)
<i>Dalea formosa</i>	Feather indigobush ^b	Grasslands/Riparian (arroyos)
<i>Dalea leporina</i>	Pea bush	Grasslands/Riparian (arroyos)
<i>Dalea scoparia</i>	Broom indigobush	Grasslands/Riparian (arroyos)
<i>Dalea nana</i>	Dwarf indigobush	Grasslands/Riparian (arroyos)
<i>Medicago sativa</i>	Alfalfa ^a	Altered (disturbed ground)
<i>Medicago lupulina</i>	Black medic ^a	Altered (disturbed ground)
<i>Melilotus albus</i>	White sweet clover ^a	Altered (disturbed ground)
<i>Melilotus officinalis</i>	Yellow sweet clover ^a	Altered (disturbed ground)
<i>Lotus wrightii</i>	Deer vetch	Woodlands

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
<i>Astragalus missouriensis</i>	Missouri milkvetch	Grasslands/Woodlands/Riparian
<i>Astragalus amphioxys</i>	Crescent milkvetch	Grasslands/Woodlands/Riparian
<i>Astragalus humistratus</i>	Ground milkvetch	Grasslands/Woodlands/Riparian
<i>Astragalus nuttallianus</i>	Nuttall milkvetch^b	Grasslands/Woodlands/Riparian
<i>Astragalus flexuosus</i>	Locoweed	Grasslands/Riparian (arroyos)
<i>Astragalus crassicaulis</i>	Ground plum	Grasslands/Riparian (arroyos)
<i>Astragalus emoryanus</i>	Emory milkvetch	Grasslands/Woodlands/Riparian
<i>Astragalus mollissimus</i>	Woolly locoweed	Grasslands/Woodlands/Riparian
<i>Astragalus lentiginosus</i>	Blue locoweed^b	Woodlands/Riparian (arroyos)
<i>Astragalus feensis</i>	Santa Fe milkvetch^b	Grasslands (limestone hills)
<i>Astragalus allochrous</i>	Hassayampa milkvetch	Grasslands/Woodlands/Riparian
<i>Astragalus tephrodes^c</i>		Grasslands
<i>Vicia americana</i>	American vetch ^f	Woodlands/Riparian (canyons)
<i>Petalostemum candidum</i>	White prairie clover	Grasslands/Woodlands/Riparian
<i>Robinia neomexicana</i>	New Mexico locust^a	Woodlands/Riparian (canyons)
<i>Oxytropis lambertii</i>	Lambert locoweed	Grasslands/Woodlands/Riparian
Family: Geraniaceae		
<i>Geranium caespitosum</i>	Purple geranium^a	Woodlands/Riparian (canyons)
<i>Erodium cicutarium</i>	Red-stem filaree^a	Grasslands/Altered (disturbed ground)
Family: Oxalidaceae		
<i>Oxalis stricta</i>	Yellow woodsorrel	Woodlands/Riparian (canyons)
Family: Linaceae		
<i>Linum lewisii</i>	Western blue flax^a	Grasslands/Riparian (arroyos)
<i>Linum aristatum</i>	Flax^b	Grasslands/Riparian (arroyos)
<i>Linum puberulum^c</i>		Grasslands/Riparian (arroyos)
Family: Zygophyllaceae		
<i>Larrea tridentata</i>	Creosote bush^b	Grasslands (dry slopes)
<i>Tribulus terrestris</i>	Goathead^a	Altered (disturbed ground)
<i>Kallstroemia californica</i>	California caltrop	Grasslands/Riparian (arroyos)/Altered
<i>Kallstroemia hirsutissima</i>	Hairy caltrop^a	Grasslands/Riparian (arroyos)/Altered
<i>Kallstroemia parviflora</i>	Caltrop	Grasslands/Riparian (arroyos)/Altered
Family: Rutaceae		
<i>Ptelea trifoliata</i>	Narrow-leaf hoptree^{a, e}	Riparian (canyons)
Family: Simaroubaceae		
<i>Ailanthus altissima</i>	Tree-of-heaven^a	Riparian
Family: Polygalaceae		
<i>Polygala alba</i>	White milkwort	Riparian (arroyos)
Family: Euphorbiaceae		
<i>Euphorbia stictospora</i>	Spurge	Grasslands/Riparian (arroyos)
<i>Euphorbia serpyllifolia</i>	Thymeleaf spurge^{b, f}	Grasslands/Riparian (arroyos)/Altered
<i>Euphorbia fendleri</i>	Fendler spurge^{a, b, c}	Grasslands/Riparian (arroyos)/Altered
<i>Euphorbia revoluta</i>	Spurge	Grasslands/Riparian (arroyos)
<i>Euphorbia exstipulata</i>	Spurge^a	Grasslands/Riparian (arroyos)/Altered
<i>Euphorbia dentata</i>	Spurge	Grasslands/Riparian (arroyos)
<i>Euphorbia lurida</i>	Spurge^a	Woodlands/Riparian (canyons)

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
<i>Croton texensis</i>	Doveweed ^a	Grasslands/Altered (disturbed ground)
<i>Tragia stylaris</i>	Noseburn ^a	Riparian (arroyos and canyons)
Family: Anacardiaceae		
<i>Rhus trilobata</i>	Skunkbush ^{a,b}	Woodlands/Riparian (canyons)
Family: Vitaceae		
<i>Vitis arizonica</i>	Canyon grape ^a	Riparian (canyons)
<i>Parthenocissus inserta</i>	Virginia creeper ^a	Riparian (canyons)
Family: Malvaceae		
<i>Malva neglecta</i>	Common mallow	Altered (disturbed ground)
<i>Sphaeralcea grossulariaefolia</i>	Globemallow ^a	Grasslands/Riparian (arroyos)/Altered
<i>Sphaeralcea leptophylla</i>	Silvery globemallow	Woodlands
<i>Sphaeralcea coccinea</i>	Red globemallow ^a	Grasslands/Riparian (arroyos)/Altered
<i>Sphaeralcea subhastata</i>	Globemallow ^a	Grasslands/Riparian (arroyos)/Altered
<i>Sphaeralcea incana</i>	Globemallow ^a	Grasslands/Riparian (arroyos)/Altered
<i>Sphaeralcea fendleri</i>	Fendler globemallow	Grasslands/Riparian (arroyos)/Altered
<i>Sphaeralcea angustifolia</i>	Globemallow ^{b,c,f}	Grasslands/Riparian (arroyos)/Altered
<i>Sphaeralcea wrightii</i>		Grasslands/Riparian (arroyos)/Altered
Family: Tamaricaceae		
<i>Tamarix pentandra</i>	Salt-cedar ^{a,e}	Riparian (arroyos)
Family: Loasaceae		
<i>Mentzelia pumila</i>	Stickleaf ^a	Grasslands/Riparian (arroyos)/Altered
<i>Mentzelia albicaulis</i>	Whitestem stickleaf ^b	Riparian (arroyos)/Altered
Family: Cactaceae		
<i>Opuntia imbricata</i>	Tree cholla ^{a,b}	Grasslands/Woodlands/Riparian (arroyos)
<i>Opuntia whipplei</i>	Whipple's cholla ^b	Grasslands (dry slopes)
<i>Opuntia clavata</i>	Club cholla ^{a,b}	Grasslands/Altered (disturbed ground)
<i>Opuntia polyacantha</i>	Plains prickly pear ^c	Grasslands/Woodlands
<i>Opuntia erinacea</i>	Prickly pear	Woodlands
<i>Opuntia macrorhiza</i>	Plains prickly pear	Grasslands/Woodlands
<i>Opuntia cymochila</i>	Prickly pear ^b	Grasslands
<i>Opuntia tortispina</i>	Prickly pear ^b	Grasslands
<i>Opuntia phaeacantha</i>	Prickly pear ^a	Grasslands/Woodlands
<i>Echinocereus triglochidiatus</i>	Red-flowered hedgehog ^a	Woodlands
<i>Echinocereus fendleri</i>	Hedgehog cactus ^b	Grasslands/Woodlands
<i>Pediocactus simpsonii</i>	Simpson's pediocactus	Grasslands/Woodlands
<i>Pediocactus papyracanthus</i>	Grama grass cactus ^{b,d}	Grasslands
<i>Neolloydia intertexta</i>	Pineapple cactus ^d	Grasslands/Woodlands
<i>Coryphantha vivipara</i>	Pincushion cactus ^{a,b}	Grasslands/Woodlands
<i>Mammillaria heyderi</i>	Pincushion cactus	Grasslands/Woodlands/Riparian (arroyos)
<i>Mammillaria wrightii</i>	Wright's pincushion ^d	Grasslands/Woodlands/Riparian (arroyos)
Family: Elaeagnaceae		
<i>Elaeagnus angustifolia</i>	Russian olive ^{a,e}	Riparian (arroyos and canyons)/Altered

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
Family: Onagraceae <i>Calylophus hartwegii</i> <i>Gaura coccinea</i> <i>Oenothera coronopifolia</i> <i>Oenothera albicaulis</i> <i>Oenothera pallida</i> <i>Oenothera primiveris</i>	Hartweg's primrose ^b Scarlet gaura ^b Evening primrose Evening primrose ^b Pale evening primrose Evening primrose ^b	Grasslands/Riparian (arroyos) Grasslands/Altered (disturbed ground) Woodlands Riparian/Altered (disturbed ground) Grasslands/Riparian (arroyos) Grasslands/Riparian (arroyos)
Family: Apiaceae <i>Cymopterus fendleri</i> <i>Aletes acaulis</i> ^a	Chimaya ^{b, c}	Grasslands/Woodlands/Riparian Woodlands/Riparian (canyons)
Family: Primulaceae <i>Androsace septentrionalis</i>	Rock jasmine ^a	Woodlands/Riparian (canyons)
Family: Oleaceae <i>Menodora scabra</i> <i>Forestiera neomexicana</i>	Rough menodora New Mexico olive	Woodlands/Riparian (arroyos) Riparian (canyons)
Family: Asclepiadaceae <i>Asclepias asperula</i> <i>Asclepias viridiflora</i> <i>Asclepias subverticillatus</i> <i>Asclepias latifolia</i>	Antelope horns ^b Green milkweed Poison milkweed ^a Broad-leaved milkweed ^a	Grasslands/Riparian (arroyos)/Altered Woodlands/Riparian (canyons) Grasslands/ Riparian (arroyos)/Altered Grasslands/Riparian (arroyos)
Family: Convolvulaceae <i>Cuscuta megalocarpa</i> <i>Evolvulus pilosa</i> ^c <i>Ipomoea hirsutula</i> <i>Ipomoea costellata</i> <i>Convolvulus sepium</i> <i>Convolvulus arvensis</i>	Dodder ^b Morning glory ^a Morning glory ^a Hedge bindweed Field bindweed	Grasslands/Woodlands Grasslands/Woodlands Altered (disturbed ground) Riparian (arroyos) Altered (disturbed ground) Altered (disturbed ground)
Family: Polemoniaceae <i>Ipomopsis longiflora</i> <i>Ipomopsis aggregata</i> <i>Gilia rigidula</i> <i>Gilia sinuata</i>	Skyrocket Gilia ^b Gilia ^b	Grasslands/Riparian (arroyos) Woodlands/Riparian (canyons) Grasslands/Woodlands Grasslands/Riparian (arroyos)
Family: Hydrophyllaceae <i>Nama hispidum</i> <i>Phacelia corrugata</i> <i>Phacelia crenulata</i>	Hairy nama ^b Scorpionweed ^b Scorpionweed	Riparian (arroyos and canyons) Grasslands/Riparian (arroyos) Grasslands/Woodlands
Family: Boraginaceae <i>Lappula redowskii</i> <i>Lithospermum incisum</i> <i>Cryptantha crassiseppala</i> <i>Cryptantha jamesii</i> <i>Cryptantha fulvocanescens</i> ^b	Stickweed ^{a, b} Puccoon Plains hiddenflower ^{b, c} James' hiddenflower ^b	Altered (disturbed ground) Grasslands/Woodlands Grasslands/Woodlands/Riparian (arroyos) Grasslands/ Riparian (arroyos) Grasslands/ Riparian (arroyos)
Family: Verbenaceae <i>Verbena bipinnatifida</i>	Dakota vervain ^a	Woodlands/Riparian (arroyos)

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
<i>Verbena ambrosifolia</i>	Vervain	Woodlands/Riparian (arroyos)
<i>Verbena wrightii</i>	Vervain ^a	Woodlands/Riparian (arroyos)
<i>Verbena macdougalii</i>	New Mexico vervain ^a	Riparian (higher elevations)
<i>Verbena bracteata</i>	Vervain ^a	Grasslands/Riparian (arroyos)/Altered
Family: Lamiaceae		
<i>Hedeoma drummondii</i>	False pennyroyal ^a	Grasslands/Woodlands
<i>Salvia reflexa</i>	Rocky Mountain sage ^a	Woodlands/Riparian (canyons)
<i>Marrubium vulgare</i>	Common horehound ^a	Riparian (canyons)
Family: Solanaceae		
<i>Lycium pallidum</i>	Pale wolfberry ^b	Grasslands/Riparian (arroyos)
<i>Datura meteloides</i>	Indian-apple ^a	Riparian (arroyos)/Altered
<i>Datura stramonium</i>	Jimsonweed	Riparian (arroyos)/Altered
<i>Physalis virginiana</i>	Groundcherry	Riparian (arroyos)/Altered
<i>Physalis hederifolia</i> ^a		Riparian (canyons and arroyos)/Altered
<i>Solanum elaeagnifolium</i>	Horse nettle ^{a, b, f}	Altered (disturbed ground)
<i>Chamaesaracha conoides</i>		Grasslands/Riparian (arroyos)
<i>Chamaesaracha coronopus</i>		Grasslands/Riparian (arroyos)
Family: Scrophulariaceae		
<i>Maurandya antirrhiniflora</i>	False snapdragon	Grasslands/Woodlands/Riparian
<i>Penstemon barbatus</i>	Scarlet beardtongue ^a	Woodlands/Riparian (canyons)
<i>Penstemon ambiguus</i>	Cow tobacco ^c	Grasslands/Riparian (arroyos)
<i>Penstemon jamesii</i>	Beardtongue ^a	Grasslands/Woodlands
<i>Mimulus glabrata</i>	Monkeyflower ^a	Riparian (canyons and wetlands)
<i>Cordylanthus wrightii</i>	Clubflower ^a	Woodlands
<i>Castilleja integra</i>	Indian paintbrush ^a	Woodlands
Family: Martyniaceae		
<i>Proboscidea altheaefolia</i>	Devil's claw ^b	Grasslands/Riparian (arroyos)
<i>Proboscidea parviflora</i>	Devil's claw	Grasslands/Riparian (arroyos)
Family: Orobanchaceae		
<i>Orobanche ludovicianus</i>	Broomrape ^b	Grasslands/Riparian (arroyos)
Family: Plantaginaceae		
<i>Plantago purshii</i>	Woolly Indian-wheat ^{b, c, f}	Grasslands/woodlands
<i>Plantago major</i>	Rippleseed plantain ^a	Altered (disturbed ground)
<i>Plantago lanceolata</i>	Buckhorn plantain ^a	Altered (disturbed ground)
Family: Rubiaceae		
<i>Hedyotis rubra</i> ^c		Grasslands
Family: Cucurbitaceae		
<i>Cucurbita foetidissima</i>	Buffalo gourd ^{a, b}	Grasslands/Altered (disturbed ground)
Family: Asteraceae		
<i>Stephanomeria neomexicana</i>	Wire lettuce ^c	Grasslands/Altered (disturbed ground)
<i>Stephanomeria pauciflora</i>	Wire lettuce ^a	Grasslands/Woodlands
<i>Tragopogon dubius</i>	Goat's beard ^a	Riparian (arroyos)/Altered
<i>Lactuca serriola</i>	Prickly lettuce ^a	Altered (disturbed ground)
<i>Taraxacum officinale</i>	Dandelion ^a	Altered (disturbed ground)
<i>Sonchus asper</i>	Sow thistle ^a	Altered (disturbed ground)

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
<i>Malacothrix fendleri</i>	Desert dandelion ^{b, c}	Grasslands/Woodlands/Riparian (arroyos)
<i>Perezia nana</i>	Dwarf desert-holly ^b	Riparian (arroyos)
<i>Cirsium neomexicanum</i>	New Mexican thistle ^{a, b}	Grasslands/Riparian (arroyos)/Altered
<i>Cirsium ochrocentrum</i>	Santa Fe thistle ^a	Grasslands/Woodlands/Riparian (arroyos)
<i>Arctium minus</i>	Burdock	Altered (disturbed ground)
<i>Xanthium strumarium</i>	Cocklebur ^a	Riparian/Altered (disturbed ground)
<i>Ambrosia artemisiifolia</i>	Common ragweed	Altered (disturbed ground)
<i>Ambrosia psilostachya</i>	Western ragweed	Riparian (arroyos and canyons)
<i>Franseria acanthicarpa</i>	Burweed ^a	Grasslands/Riparian (arroyos)/Altered
<i>Eupatorium herbaceum</i>	Thoroughwort ^{a, f}	Woodlands/Riparian (canyons)
<i>Kuhnia chlorolepis</i>	False boneset ^a	Grasslands/Woodlands
<i>Brickellia brachyphylla</i>	Bricklebush ^a	Riparian (arroyos and canyons)
<i>Brickellia californica</i>	California bricklebush ^a	Woodlands/Riparian (canyons)
<i>Brickellia grandiflora</i>	Bricklebush ^a	Riparian (canyons)
<i>Grindelia aphanactis</i>	Gumweed ^a	Altered (disturbed ground)
<i>Gutierrezia sarothrae</i>	Snakeweed ^{a, b, c, f}	Grasslands/Altered (disturbed ground)
<i>Gutierrezia microcephala</i>	Little-head snakeweed	Grasslands/Altered (disturbed ground)
<i>Chrysopsis villosa</i>	Hairy golden aster ^a	Grasslands/Woodlands/Riparian (arroyos)
<i>Solidago canadensis</i>	Canada goldenrod	Riparian (arroyos and canyons)
<i>Solidago occidentalis</i>	Western goldenrod	Riparian (arroyos and canyons)
<i>Solidago spathulata</i>	Dwarf goldenrod ^a	Riparian (Canyons)
<i>Haplopappus spinulosus</i>	Spiny goldenweed ^{a, b, c}	Altered (disturbed ground)
<i>Haplopappus gracilis</i>	Goldenweed	Grasslands/Riparian (arroyos)
<i>Haplopappus heterophyllus</i>	Rayless goldenrod ^a	Grasslands
<i>Townsendia exscapa</i>	Townsend's aster	Grasslands/Woodlands
<i>Townsendia formosa</i>	Townsend's aster ^a	Woodlands/Riparian (canyons)
<i>Conyza canadensis</i>	Horseweed ^a	Riparian (arroyos and canyons)/Altered
<i>Erigeron flagellaris</i>	Trailing fleabane ^b	Grasslands/Altered (disturbed ground)
<i>Erigeron divergens</i>	Spreading fleabane ^b	Altered (disturbed ground)
<i>Leucelene ericoides</i>	White aster ^{b, c}	Grasslands/Woodlands
<i>Aster commutatus</i>	Aster ^a	Riparian (arroyos)/Altered
<i>Aster hesperius</i>	Purple aster ^a	Riparian (canyons and wetlands)
<i>Baccharis wrightii</i>	Wright's baccharis ^b	Riparian (arroyos and canyons)
<i>Chrysothamnus nauseosus</i>	Rabbitbrush ^{a, b}	Grasslands/arroyos/lower slopes
<i>Senecio douglasii</i>	Threadleaf groundsel ^{a, b, c}	Grasslands/Riparian (arroyos)
<i>Senecio multicapitatus</i>	Shrub groundsel ^a	Grasslands/Woodlands/Riparian
<i>Artemisia bigelovii</i>	Bigelow sagebrush ^{a, b}	Grasslands/Woodlands
<i>Artemisia filifolia</i>	Sand sagebrush ^{a, b}	Grasslands/Riparian (arroyos)
<i>Artemisia dracunculus</i>	False tarragon ^a	Riparian (arroyos and canyons)
<i>Artemisia frigida</i>	Estafiata	Woodlands/Riparian (arroyos and canyons)
<i>Artemisia ludoviciana</i>	Louisiana wormwood ^a	Woodlands
<i>Dyssodia acerosa</i>	Dogweed ^b	Woodlands/Altered (disturbed ground)

ATTACHMENT 5-1 - PLANT SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat*
<i>Baileya multiradiata</i>	Desert-marigold ^{a, b}	Grasslands/Woodlands
<i>Psilostrophe tagetina</i>	Paper daisy ^a	Grasslands/Riparian (arroyos)
<i>Hymenoxys argentea</i>	Bitterweed ^a	Woodlands
<i>Hymenoxys richardsonii</i>	Colorado rubberweed	Woodlands
<i>Flaveria campestris</i> ^a		Grasslands/Riparian (arroyos)
<i>Hymenopappus filifolius</i>	White ragweed ^a	Grasslands/Woodlands/Riparian (arroyos)
<i>Gaillardia pinnatifida</i>	Blanketflower ^{a, b}	Grasslands/Riparian (arroyos)
<i>Bahia dissecta</i>	Yellow ragweed ^a	Grasslands/Woodlands/Riparian (arroyos)
<i>Melampodium leucacanthum</i>	Plains blackfoot ^{a, b, c}	Grasslands/Woodlands
<i>Parthenium incanum</i>	Mariola ^a	Woodlands/Riparian (arroyos)
<i>Engelmannia pinnatifida</i>	Engelmann daisy	Grasslands/Woodlands
<i>Berlandiera lyrata</i> ^a		Grasslands/Woodlands
<i>Zinnia grandiflora</i>	Rocky Mountain zinnia ^{a, c}	Grasslands/Woodlands
<i>Sanvitalia abertii</i> ^f		Grasslands/Riparian (arroyos)
<i>Thelesperma trifidum</i>	Greenthread ^f	Woodlands/Riparian (canyons)
<i>Thelesperma megapotamicum</i>	Hopi tea ^a	Grasslands/Riparian (arroyos)/Altered
<i>Ratibida tagetes</i>	Prairie coneflower	Riparian (arroyos)/Altered (disturbed ground)
<i>Verbesina encelioides</i>	Crownbeard ^a	Grasslands/Woodlands
<i>Helianthus annuus</i>	Annual sunflower ^a	Grasslands/Riparian (arroyos)/Altered
<i>Helianthus petiolaris</i>	Prairie sunflower ^a	Grasslands/Riparian (arroyos)/Altered
<i>Viguiera dentata</i>	Goldeneye ^a	Woodlands/Riparian (canyons)
<p>* Primary habitat type in which the species is found. Parentheses used to specify a particular part of that habitat.</p> <p>^a W. C. Martin and W. L. Wagner, 1974.</p> <p>^b R. M. Sullivan and P. J. Knight, 1994.</p> <p>^c R. R. Parmenter and M. Chavez, 1995.</p> <p>^d New Mexico Natural Heritage Program, 1995.</p> <p>^e U.S. Army Corps of Engineers, 1995.</p> <p>^f Stephanie Pope, 1997.</p> <p>Note: Species in bold are documented in one or more surveys indicated by superscript letters. Hypothetical species are based on N. T. Fischer, 1990.</p>		

ATTACHMENT 5-2 - AMPHIBIAN AND REPTILE SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC

Scientific Name	Common Name	Habitat
Class: Amphibia	Amphibians	
Order: Caudata	Salamanders	
Family: Ambystomatidae <i>Ambystoma tigrinum</i>	Tiger salamander ^{av, bv}	Riparian (ponds)
Order: Anura	Frogs and toads	
Family: Pelobatidae <i>Scaphiopus couchii</i> <i>Spea multiplicata</i> <i>Spea bomblifrons</i>	Couch's spadefoot New Mexico spadefoot^{bv, c} Plains spadefoot ^{av, bv}	Grasslands/Riparian (arroyos) Grasslands/Riparian (arroyos) Grasslands/Riparian (arroyos)
Family: Bufonidae <i>Bufo punctatus</i> <i>Bufo woodhousii</i> <i>Bufo cognatus</i>	Red-spotted toad ^{av, bv} Woodhouse's toad ^{av, bv} Great Plains toad ^{av, bv}	Grasslands/Riparian (arroyos/ canyons) Grasslands/Riparian (arroyos/ canyons) Grasslands/Riparian (arroyos)
Class: Reptilia	Reptiles	
Order: Testudines	Turtles	
Family: Emydidae <i>Terrapene ornata</i>	Western box turtle ^d	Grasslands
Order: Squamata	Lizards	
Suborder: Sauria		
Family: Crotaphytidae <i>Crotaphytus collaris</i> <i>Gambelia wislizenii</i>	Collared lizard ^{a♦, b♦} Longnose leopard lizard ^{b♦}	Grasslands/Woodlands Grasslands
Family: Phrynosomatidae <i>Holbrookia maculata</i> <i>Phrynosoma cornutum</i> <i>Phrynosoma douglassi</i> <i>Phrynosoma modestum</i> <i>Sceloporus undulatus</i> <i>Urosaurus ornatus</i> <i>Uta stansburiana</i>	Lesser earless lizard ^{a♦, b♦} Texas horned lizard ^{a♦, b♦} Short-horned lizard ^{a♦, b♦} Roundtail horned lizard ^{a♦, b♦} Prairie lizard ^{b♦} Tree lizard ^{a♦, b♦} Side-blotched lizard ^{a♦, b♦}	Grasslands/Riparian (arroyos) Grasslands All habitats Grasslands/Riparian (arroyos) Woodlands/Riparian (arroyos) Woodlands/Riparian (canyons) Grasslands/Woodlands
Family: Teiidae <i>Cnemidophorus exsanguis</i> <i>Cnemidophorus inornatus</i> <i>Cnemidophorus neomexicanus</i> <i>Cnemidophorus uniparens</i> <i>Cnemidophorus velox</i>	Chihuahuan spotted whiptail ^{a♦, b♦} Little striped whiptail ^{a♦, b♦} New Mexico whiptail ^c Desert grassland whiptail ^{a♦, b♦, c} Plateau striped whiptail ^{b♦}	Grasslands Grasslands Grasslands/Riparian (arroyos) Grasslands Woodlands/Riparian (canyons)
Family: Scincidae <i>Eumeces multivirgatus</i> <i>Eumeces obsoletus</i>	Many-lined skink ^{b♦} Great Plains skink ^{a♦, b♦}	Grasslands/Riparian (arroyos) Grasslands/Woodlands/Riparian

ATTACHMENT 5-2 - AMPHIBIAN AND REPTILE SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat
Suborder: Serpentes	Snakes	
Family: Leptotyphlopidae <i>Leptotyphlops dulcis</i>	Texas blind snake	Grasslands/Altered (lawns)
Family: Colubridae <i>Arizona elegans</i> <i>Diadophis punctatus</i> <i>Elaphe guttata</i> <i>Gyalopion canum</i> <i>Heterodon nasicus</i> <i>Hypsiglena torquata</i> <i>Masticophis flagellum</i> <i>Masticophis taeniatus</i> <i>Pituophis melanoleucus</i> <i>Rhinocheilus lecontei</i> <i>Salvadora grahamiae</i> <i>Tantilla nigriceps</i> <i>Thamnophis cyrtopsis</i> <i>Thamnophis elegans</i>	Glossy snake Ringneck snake Corn snake Western hooknose snake Western hognose snake Night snake Coachwhip^{a♦, b♦} Desert striped whipsnake^{b♦} Gopher snake^{a♦, b♦} Longnose snake^{b♦} Mountain patchnose snake Plains blackhead snake Blackneck garter snake Western terrestrial garter snake^d	Grasslands/Riparian (arroyos) Woodlands/Riparian (canyons) Grasslands/Riparian (canyons) Grasslands/Riparian (arroyos) Grasslands/Riparian (arroyos) Woodlands Grasslands/Riparian (arroyos) Riparian (arroyos and canyons) All habitats Grasslands/Riparian (arroyos) Woodlands Grasslands/Riparian (arroyos) Riparian (canyons and wetlands) Riparian (canyons and wetlands)
Family: Viperidae <i>Crotalus atrox</i> <i>Crotalus molossus</i> <i>Crotalus viridis</i> <i>Sistrurus catenatus</i>	Western diamondback rattlesnake^{a♦, c} Blacktail rattlesnake Western rattlesnake^{a♦, b♦, c} Massasauga^{a♦, b♦}	Grasslands/Riparian (arroyos) Woodlands/Riparian (canyons) All habitats Grasslands/Riparian (arroyos)
^{a♦, a^v} Observed and expected, respectively, according to Robert M. Sullivan, 1994. ^{b♦, b^v} Observed and expected, respectively, according to Robert M. Sullivan and Paul J. Knight, 1994. ^c Stephanie Pope, 1997. ^d Unpublished observation.		
Note: Species in bold are documented in one or more of the surveys indicated by superscript letters. Other species are based on N. T. Fischer, 1990.		

ATTACHMENT 5-3 - BIRD SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC

Scientific Name	Common Name	Habitat
Class: Aves	Birds	
Order: Ciconiiformes	Herons, egrets, and ibises	
Family: Ardeidae <i>Ardea herodias</i>	Great blue heron ^g	Wetlands/ponds
Family: Threskiornithidae <i>Plegadis chihi</i>	White-faced ibis ^{g, h}	Wetlands/ponds
Order: Anseriformes	Waterfowl	
Family: Anatidae <i>Anas platyrhynchos</i>	Mallard	Ponds
Order: Falconiformes	Birds-of-prey	
Family: Cathartidae <i>Cathartes aura</i>	Turkey vulture ^{a, c♦, d♦, e♦, g}	All habitats
Family: Accipitridae <i>Aquila chrysaetos</i> <i>Circus cyaneus</i> <i>Accipiter striatus</i> <i>Accipiter cooperii</i> <i>Accipiter gentilis</i> <i>Buteo jamaicensis</i> <i>Buteo swainsoni</i> <i>Buteo regalis</i>	Golden eagle ^{a, c♦, e♦} Northern harrier ^{c♦, e♦} Sharp-shinned hawk ^{a, b, c♦, e♦} Cooper's hawk ^{a, c♦, e♦, g} Northern goshawk ^{e♦} Red-tailed hawk ^{a, c♦, d♦, e♦, g} Swainson's hawk ^{a, c♦, d♦} Ferruginous hawk ^{d♦}	Grasslands/canyons Grasslands/open woodlands Canyons/woodlands Canyons/woodlands Canyons/higher elevations All habitats Grasslands/lower slopes Grasslands/lower slopes
Family: Falconidae <i>Falco sparverius</i> <i>Falco mexicanus</i> <i>Falco peregrinus</i>	American kestrel ^{a, c♦, d♦, e♦, g} Prairie falcon ^a Peregrine falcon ^a	All habitats Grasslands/open woodlands Canyons
Order: Galliformes	Quail	
Family: Phasianidae <i>Callipepla squamata</i> <i>Callipepla gambelii</i> <i>Meleagris gallopavo</i>	Scaled quail ^{a, c♦, d♦, g, h} Gambel's quail ^{c♦, d♦} Wild Turkey ^{e♦}	Grasslands/arroyos Grasslands/arroyos Woodlands/higher elevations
Order: Charadriiformes	Shorebirds	
Family: Charadriidae <i>Charadrius vociferus</i> <i>Charadrius montanus</i>	Killdeer ^{a, c♦, d♦, g} Mountain plover	Grasslands/arroyos/disturbed ground Grasslands/arroyos/disturbed ground
Family: Scolopacidae <i>Actitis macularia</i>	Spotted sandpiper	Wetlands/arroyos
Order: Columbiformes	Doves and pigeons	
Family: Columbidae <i>Columba fasciata</i> <i>Columba livia</i> <i>Zenaidura macroura</i>	Band-tailed pigeon ^{e♦} Rock dove ^{c♦, d♦} Mourning dove ^{a, b, c♦, d♦, e♦, g, h}	Canyons/higher elevations Urban areas All habitats
Order: Cuculiformes	Cuckoos	
Family: Cuculidae <i>Geococcyx californianus</i>	Greater roadrunner ^{a, c♦, d♦, e♦}	Grasslands/arroyos/lower slopes

ATTACHMENT 5-3 - BIRD SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat
Order: Strigiformes Family: Tytonidae <i>Tyto alba</i>	Owls Barn owl^f	All habitats
Family: Strigidae <i>Asio otus</i> <i>Bubo virginianus</i> <i>Otus kennicottii</i> <i>Otus flammeolus</i> <i>Glaucidium gnoma</i> <i>Aegolius acadicus</i> <i>Speotyto cunicularia</i>	Long-eared owl Great horned owl^{a, b, d♦, e♦} Western screech-owl ^{c▽, e▽} Flammulated owl ^{e▽} Northern pygmy-owl ^{eΠ} Northern saw-whet owl Burrowing owl^{a, c♦, d♦, g}	Canyons/woodlands All habitats Canyons/woodlands Canyons Canyons/higher elevations Canyons/higher elevations Grasslands/prairie dog towns
Order: Caprimulgiformes Family: Caprimulgidae <i>Caprimulgus vociferus</i> <i>Phalaenoptilus nuttallii</i> <i>Chordeiles minor</i>	Goatsuckers Whip-poor-will^{c♦} Common poorwill^{a, c♦, d♦} Common nighthawk^{a, b, e♦, h}	Canyons/woodlands Grasslands/rocky slopes Grasslands/rocky slopes
Order: Apodiformes Family: Apodidae <i>Cypseloides niger</i> <i>Aeronautes saxatalis</i>	Hummingbirds and swifts Black swift^{eΠ} White-throated swift^{a, eΠ, g}	Higher elevations Canyons
Family: Trochilidae <i>Archilochus alexandris</i> <i>Selasphorus platycercus</i> <i>Selasphorus rufus</i>	Black-chinned hummingbird^{a, e♦, g} Broad-tailed hummingbird^{a, b, e♦, g, h} Rufous hummingbird^{eΠ}	Canyons/woodlands Canyons/higher elevations Canyons/higher elevations
Order: Piciformes Family: Picidae <i>Colaptes auratus</i> <i>Melanerpes formicivorus</i> <i>Melanerpes lewis</i> <i>Sphyrapicus thyroideus</i> <i>Sphyrapicus nuchalis</i> <i>Picoides pubescens</i> <i>Picoides villosus</i> <i>Picoides scalaris</i>	Woodpeckers Northern flicker^{a, b, c♦, e♦, g, h} Acorn woodpecker^{b, c♦, e♦} Lewis' woodpecker^{c♦, eΠ} Williamson's sapsucker^{e♦, g} Red-naped sapsucker^{eΠ} Downy woodpecker^{e♦, g} Hairy woodpecker^{a, b, e♦, g} Ladder-backed woodpecker^{a, b, e♦, g, h}	Woodlands Canyons/higher elevations Canyons/woodlands Canyons Canyons/woodlands Canyons/higher elevations Canyons/higher elevations Canyons/woodlands
Order: Passeriformes Family: Tyrannidae <i>Tyrannus tyrannus</i> <i>Tyrannus verticalis</i> <i>Tyrannus vociferans</i> <i>Myiarchus cinerascens</i> <i>Contopus borealis</i>	Perching birds Flycatchers Eastern kingbird Western kingbird^{a, g, h} Cassin's kingbird^{a, e♦, g} Ash-throated flycatcher^{a, b, e♦, g, h} Olive-sided flycatcher^{a, eΠ}	Canyons/woodlands/wetlands Grasslands/arroyos/buildings Canyons/woodlands Woodlands/wetlands Canyons/woodlands

ATTACHMENT 5-3 - BIRD SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat
<i>Contopus sordidulus</i>	Western wood-pewee ^{a, b, e♦, g, h}	Canyons/woodlands/wetlands
<i>Sayornis nigricans</i>	Black phoebe	Canyons/wetlands/wetlands
<i>Sayornis saya</i>	Say's phoebe ^{a, b, c♦, d♦, e♦, g, h}	Arroyos/canyons/wetlands
<i>Empidonax wrightii</i>	Gray flycatcher ^{a, b, e♦, g}	Canyons/woodlands
<i>Empidonax oberholseri</i>	Dusky flycatcher ^{a, e, g}	Canyons/woodlands
<i>Empidonax hammondi</i>	Hammond's flycatcher ^{eV}	Canyons/woodlands
<i>Empidonax occidentalis</i>	Cordilleran flycatcher ^{a, c♦, d♦}	Canyons/woodlands
Family: Alaudidae	Larks	
<i>Eremophila alpestris</i>	Horned lark ^{a, c♦, d♦, e♦, g}	Grasslands/disturbed ground
Family: Hirundinidae	Swallows	
<i>Tachycineta bicolor</i>	Tree swallow	Canyons/woodlands/wetlands
<i>Tachycineta thalassina</i>	Violet-green swallow ^{b, c♦, e♦, g, h}	Canyons/woodlands/wetlands
<i>Riparia riparia</i>	Bank swallow ^{c♦}	Canyons/woodlands/wetlands
<i>Stelgidopteryx serripennis</i>	Northern rough-winged swallow ^{c♦}	Canyons/woodlands/wetlands
<i>Hirundo pyrrhonota</i>	Cliff swallow ^g	Canyons/woodlands/wetlands
<i>Hirundo rustica</i>	Barn swallow ^{a, e♦, g}	Buildings
Family: Corvidae	Crows, ravens, and jays	
<i>Aphelocoma coerulescens</i>	Scrub jay ^{a, b, c♦, d♦, e♦, g, h}	Woodlands/canyons
<i>Gymnorhinus cyanocephalus</i>	Pinyon jay ^{a, b, c♦, e♦, g, h}	Woodlands
<i>Cyanocitta stelleri</i>	Steller's jay ^{a, b, c♦, e♦, g}	Higher elevations
<i>Corvus brachyrhynchos</i>	American crow ^{e♦, g}	Buildings
<i>Corvus cryptoleucus</i>	Chihuahuan raven ^{c♦, d♦, g}	Grasslands/woodlands
<i>Corvus corax</i>	Common raven ^{a, b, c♦, d♦, e♦, g, h}	Canyons/higher elevations
Family: Paridae	Titmice and chickadees	
<i>Parus inornatus</i>	Plain titmouse ^{a, b, c♦, e♦, g, h}	Canyons/woodlands
<i>Parus atricapillus</i>	Black-capped chickadee ^{c♦}	Woodlands/higher elevations
<i>Parus gambeli</i>	Mountain chickadee ^{a, b, c♦, e♦, g}	Canyons/woodlands
Family: Aegithalidae	Bushtits	
<i>Psaltiriparus minimus</i>	Bushtit ^{a, c♦, e♦, g}	Canyons/woodlands
Family: Sittidae	Nuthatches	
<i>Sitta carolinensis</i>	White-breasted nuthatch ^{a, b, e♦, g}	Canyons/higher elevations
<i>Sitta canadensis</i>	Red-breasted nuthatch ^{c♦, e♦}	Canyons/higher elevations
<i>Sitta pygmaea</i>	Pygmy nuthatch ^{a, b, c♦, e♦, h}	Canyons/higher elevations
Family: Certhiidae	Creepers	
<i>Certhia americana</i>	Brown creeper ^{b, e♦}	Canyons/higher elevations
Family: Troglodytidae	Wrens	
<i>Campylorhynchus brunneicapillus</i>	Cactus wren ⁱ	Grasslands
<i>Salpinctes obsoletus</i>	Rock wren ^{a, c♦, e♦, g}	Canyons/rocky slopes
<i>Catherpes mexicanus</i>	Canyon wren ^{a, e♦}	Canyons
<i>Thryomanes bewickii</i>	Bewick's wren ^{a, b, e♦, g}	Canyons/arroyos/woodlands
<i>Troglodytes aedon</i>	House wren ^{c♦, e♦, h}	Canyons/woodlands/buildings

ATTACHMENT 5-3 - BIRD SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat
Family: Muscicapidae	Thrushes	
<i>Regulus satrapa</i>	Golden-crowned kinglet ^{e♦, g}	Canyons/higher elevations
<i>Regulus calendula</i>	Ruby-crowned kinglet ^{a, c♦, e♦}	Canyons/woodlands
<i>Poliophtila caerulea</i>	Blue-gray gnatcatcher ^{a, eII}	Canyons/woodlands
<i>Sialia mexicana</i>	Western bluebird ^{a, b, c♦, d♦, e♦, g}	Canyons/woodlands
<i>Sialia currucoides</i>	Mountain bluebird ^{b, e♦, g}	Canyons/woodlands
<i>Myadestes townsendi</i>	Townsend's solitaire ^{a, b, c♦, e♦, g}	Canyons/higher elevations
<i>Catharus guttatus</i>	Hermit thrush ^{a, b, e♦}	Canyons/woodlands
<i>Turdus migratorius</i>	American robin ^{a, b, c♦, d♦, e♦, g, h}	Canyons/higher elevations
Family: Mimidae	Thrashers	
<i>Mimus polyglottos</i>	Northern mockingbird ^{a, b, c♦, d♦, e♦, g, h}	All habitats
<i>Oreoscoptes montanus</i>	Sage thrasher ^{c♦, e♦, g}	Grasslands
<i>Toxostoma rufum</i>	Brown thrasher ^{c♦}	Canyons
<i>Toxostoma curvirostre</i>	Curve-billed thrasher ^{a, h}	Grasslands/lower slopes
<i>Toxostoma dorsale</i>	Crissal thrasher ^{a, g}	Grasslands/lower slopes
Family: Laniidae	Shrikes	
<i>Lanius ludovicianus</i>	Loggerhead shrike ^{a, c♦, d♦, e♦, g, h}	Grasslands/lower slopes
Family: Sturnidae	Starlings	
<i>Sturnus vulgaris</i>	European starling ^{c♦, d♦, e♦, g, h}	Buildings
Family: Vireonidae	Vireos	
<i>Vireo bellii</i>	Bell's vireo ^h	Canyons
<i>Vireo vicinior</i>	Gray vireo ^{a, b, c♦, e♦, g}	Canyons
<i>Vireo solitarius</i>	Solitary vireo ^{a, b, e♦, g, h}	Canyons/woodlands
<i>Vireo gilvus</i>	Warbling vireo ^{a, e♦}	Canyons
Family: Emberizidae	Warblers	
Subfamily: Parulinae		
<i>Vermivora celata</i>	Orange-crowned warbler ^{eII}	Woodlands/Riparian
<i>Vermivora virginiae</i>	Virginia's warbler ^{a, b, e♦}	Canyons/woodlands
<i>Dendroica coronata</i>	Yellow-rumped warbler ^{a, c♦, e♦, g, h}	Canyons/woodlands/higher elevations
<i>Dendroica nigrescens</i>	Black-throated gray warbler ^{a, b, e♦, g}	Canyons/woodlands/higher elevations
<i>Dendroica townsendi</i>	Townsend's warbler ^{eII}	Woodlands/Riparian
<i>Dendroica graciae</i>	Grace's warbler ^{a, e♦, g}	Higher elevations
<i>Dendroica petechia</i>	Yellow warbler	Canyons/woodlands/wetlands
<i>Oporornis tolmiei</i>	MacGillivray's warbler ^{a, eII, g}	Canyons/woodlands
<i>Wilsonia pusilla</i>	Wilson's warbler ^{a, eII, g}	Canyons/woodlands/higher elevations
Subfamily: Thraupinae	Tanagers	
<i>Piranga ludoviciana</i>	Western tanager ^{a, b, e♦, g, h}	Canyons/woodlands
<i>Piranga rubra</i>	Summer tanager	Canyons/woodlands/wetlands
<i>Piranga flava</i>	Hepatic tanager ^{a, e♦}	Canyons/woodlands/higher elevations

ATTACHMENT 5-3 - BIRD SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat
Subfamily: Cardinalinae <i>Pheucticus melanocephalus</i> <i>Guiraca caerulea</i> <i>Passerina cyanea</i> <i>Passerina amoena</i>	Grosbeaks and buntings Black-headed grosbeak ^{a, b, e♦, g, h} Blue grosbeak ^{a, g} Indigo bunting Lazuli bunting	Canyons/woodlands Canyons/woodlands/wetlands Canyons/woodlands Canyons/woodlands
Subfamily: Emberizinae <i>Pipilo chlorurus</i> <i>Pipilo erythrophthalmus</i> <i>Pipilo fuscus</i> <i>Melospiza melodia</i> <i>Chondestes grammacus</i> <i>Amphispiza bilineata</i> <i>Amphispiza belli</i> <i>Aimophila cassini</i> <i>Aimophila ruficeps</i> <i>Spizella passerina</i> <i>Spizella breweri</i> <i>Spizella atrogularis</i> <i>Junco hyemalis</i> <i>Zonotrichia leucophrys</i> <i>Calamospiza melanocorys</i>	Towhees and sparrows Green-tailed towhee ^{c♦, eII, g} Rufous-sided towhee ^{a, b, c♦, e♦, g, h} Brown towhee ^{a, b, c♦, d♦, e♦, g, h} Song sparrow ^{c♦, d♦, eII, g} Lark sparrow ^{a, b, c♦, d♦, e♦, g} Black-throated sparrow ^{a, b, c♦, d♦, e♦, g, h} Sage sparrow ^{c♦, d♦} Cassin's sparrow ^a Rufous-crowned sparrow ^a Chipping sparrow ^{a, b, c♦, d♦, e♦, g, h} Brewer's sparrow ^{c♦, d♦, eII} Black-chinned sparrow ^{a, b, e♦} Dark-eyed junco ^{a, b, c♦, d♦, e♦, g, h} White-crowned sparrow ^{a, c♦, eII, g} Lark bunting ^{c♦, d♦}	Canyons/woodlands/lower slopes Canyons/higher elevations Grasslands/arroyos/lower slopes Canyons/wetlands Grasslands/arroyos/lower slopes Grasslands/arroyos/lower slopes Grasslands/arroyos Grasslands Grasslands/arroyos/lower slopes Canyons/woodlands Grasslands/arroyos/lower slopes Canyons/woodlands All habitats All habitats Grasslands/arroyos
Subfamily: Icterinae <i>Sturnella magna</i> <i>Sturnella neglecta</i> <i>Molothrus ater</i> <i>Quiscalus mexicanus</i> <i>Icterus parisorum</i> <i>Icterus galbula</i>	Meadowlarks, blackbirds, and orioles Eastern meadowlark ^{a, b, e♦, g} Western meadowlark ^{a, b, c♦, d♦, e♦, g, h} Brown-headed cowbird ^{a, b, e♦, g, h} Great-tailed grackle ^{g, h} Scott's oriole ^{a, e♦, g, h} Northern oriole ^{a, g}	Grasslands/lower slopes Grasslands/lower slopes Grasslands/lower slopes Buildings Canyons/woodlands Canyons/woodlands
Family: Fringillidae <i>Carduelis pinus</i> <i>Carduelis psaltria</i> <i>Loxia curvirostra</i> <i>Carpodacus mexicanus</i> <i>Coccothraustes vespertinus</i>	Pine siskin ^{a, b, e♦, g} Lesser goldfinch ^{a, b, e♦, g} Red crossbill ^{b, e♦} House finch ^{a, b, d♦, eII, g, h} Evening grosbeak ^{c♦}	Woodlands/higher elevations Grasslands/arroyos/canyons Higher elevations All habitats Canyons/woodlands
Family: Passeridae <i>Passer domesticus</i>	House sparrow ^{c♦, d♦, g, h}	Buildings

ATTACHMENT 5-3 - BIRD SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat
^a New Mexico Heritage Program, 1995. ^b William Maynard, 1994. ^{c♦, c∇} Observed and expected, respectively, according to Robert M. Sullivan, 1994. ^{d♦, d∇} Observed and expected, respectively, according to Robert M. Sullivan and Paul J. Knight, 1994. ^{e♦, e∇, eΠ} Observed, possible, and transient, respectively, according to Hart Schwarz (no date). ^f U.S. Army Corps of Engineers, 1995. ^g Daniel B. Stephens and Associates Incorporated, 1996. ^h Stephanie Pope, 1997.		
Note: Species in bold are documented in one or more of the surveys indicated by superscript letters. Other species are based on N. T. Fischer, 1990.		

ATTACHMENT 5-4 - MAMMAL SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC

Scientific Name	Common Name	Habitat
Class: Mammalia	Mammals	
Order: Insectivora	Moles and shrews	
Family: Soricidae		
<i>Notiosorex crawfordi</i>	Desert shrew	Grasslands/arroyos/lower slopes
Order: Chiroptera	Bats	
Family: Vespertilionidae		
<i>Pipistrellus hesperus</i>	Western pipistrelle	Grasslands/arroyos
<i>Myotis yumanensis</i>	Yuma myotis	All habitats (below 7,000 feet)
<i>Myotis lucifugus</i>	Little brown myotis	Canyons/woodlands/wetlands
<i>Myotis auricolus</i>	Southwestern myotis^c	Canyons/woodlands
<i>Myotis thysanodes</i>	Fringed myotis	Canyons
<i>Myotis volans</i>	Long-legged myotis	Canyons/woodlands
<i>Myotis californicus</i>	California myotis	Grasslands
<i>Myotis ciliolabrum</i>	Small-footed myotis^c	Canyons/woodlands
<i>Euderma maculatum</i>	Spotted bat	Canyons/higher elevations
<i>Lasionycteris noctivagans</i>	Silver-haired bat ^{av}	All habitats
<i>Eptesicus fuscus</i>	Big brown bat ^{av}	All habitats
<i>Lasiurus cinereus</i>	Hoary bat ^{av}	All habitats
<i>Corynorhinus townsendii</i>	Townsend's big-eared bat^f	Canyons/woodlands
<i>Antrozous pallidus</i>	Pallid bat^c	All habitats (below 7,200 feet)
Family: Molossidae		
<i>Tadarida brasiliensis</i>	Brazilian free-tailed bat ^{av}	All habitats
Order: Lagomorpha	Rabbits and hares	
Family: Leporidae		
<i>Sylvilagus floridanus</i>	Mountain cottontail	Woodlands/canyons
<i>Sylvilagus auduboni</i>	Desert cottontail^{a♦, b♦}	Grasslands/arroyos
<i>Lepus californicus</i>	Black-tailed jackrabbit^{a♦, b♦}	Grasslands/arroyos
Order: Rodentia	Rodents	
Family: Sciuridae		
<i>Eutamias quadrivittatus</i>	Colorado chipmunk^{a♦}	Rocky slopes/canyons
<i>Ammospermophilus interpres</i>	Texas antelope squirrel	Rocky slopes/arroyos/canyons
<i>Spermophilus spilosoma</i>	Spotted ground squirrel^{d, e}	Grasslands/arroyos
<i>Spermophilus variegatus</i>	Rock squirrel^{a♦, b♦}	Canyons/rocky slopes
<i>Cynomys gunnisoni</i>	Gunnison prairie dog^{b♦}	Grasslands
Family: Geomyidae		
<i>Thomomys bottae</i>	Botta's pocket gopher^{a♦, b♦}	All habitats (in deep, friable soil)
Family: Heteromyidae		
<i>Perognathus flavus</i>	Silky pocket mouse^{a♦, b♦, d, e}	Grasslands/lower slopes
<i>Chaetodipus intermedius</i>	Rock pocket mouse^{a♦, b♦}	Rocky areas
<i>Dipodomys ordii</i>	Ord's kangaroo rat^{a♦, b♦, d}	Grasslands
<i>Dipodomys spectabilis</i>	Banner-tailed kangaroo rat^{a♦, b♦, d}	Grasslands
<i>Dipodomys merriami</i>	Merriam's kangaroo rat^{a♦, b♦}	Lower slopes

ATTACHMENT 5-4 - MAMMAL SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat
Family: Cricetidae		
<i>Reithrodontomys montanus</i>	Plains harvest mouse ^d	Grasslands
<i>Reithrodontomys megalotis</i>	Western harvest mouse ^{a♦, b♦, d}	All habitats
<i>Peromyscus maniculatus</i>	Deer mouse ^{a♦, b♦, e}	All habitats
<i>Peromyscus leucopus</i>	White-footed mouse ^d	Grasslands/arroyos/lower slopes
<i>Peromyscus boylii</i>	Brush mouse ^{a♦, b♦, e}	Woodlands/canyons
<i>Peromyscus truei</i>	Pinyon mouse ^{a♦, b♦, e}	Woodlands
<i>Peromyscus difficilis</i>	Rock mouse ^{b♦}	Rocky slopes/canyons
<i>Onychomys leucogaster</i>	Northern grasshopper mouse ^{a♦, b♦, d}	Grasslands/arroyos
<i>Onychomys arenicola</i>	Texas grasshopper mouse ^d	Grasslands
<i>Neotoma micropus</i>	Southern plains woodrat ^d (on Pueblo of Isleta)	Grasslands/arroyos
<i>Neotoma albigua</i>	White-throated woodrat ^{a♦, b♦}	Rocky slopes/canyons
Family: Muridae		
<i>Mus musculus</i>	House mouse	Buildings
Family: Erethizontidae		
<i>Erethizon dorsatum</i>	Porcupine ^{a✓}	Arroyos/canyons/woodlands
Order: Carnivora		
Family: Canidae		
<i>Canis latrans</i>	Coyote ^{a♦, b♦}	All habitats
<i>Vulpes macrotis</i>	Kit fox ^g	Grasslands/arroyos
<i>Urocyon cinereoargenteus</i>	Gray fox ^{a♦}	Canyons
Family: Procyonidae		
<i>Bassariscus astutus</i>	Ringtail ^{a✓}	Canyons/rocky slopes
<i>Procyon lotor</i>	Raccoon	Canyons
Family: Ursidae		
<i>Ursus americanus</i>	Black bear ^{a♦}	Canyons/higher elevations
Family: Mustelidae		
<i>Mustela frenata</i>	Long-tailed weasel	All habitats
<i>Taxidea taxus</i>	Badger ^{b♦}	Grasslands/arroyos
<i>Spilogale gracilis</i>	Western spotted skunk ^{a♦}	Arroyos/canyons/rocky slopes
<i>Mephitis mephitis</i>	Striped skunk ^{a♦, b♦}	All habitats
Family: Felidae		
<i>Lynx rufus</i>	Bobcat ^{a♦, b♦}	All habitats
<i>Felis concolor</i>	Mountain lion ^{a✓}	Canyons/higher elevations
Order: Artiodactyla		
Family: Cervidae		
<i>Odocoileus hemionus</i>	Mule deer ^{a♦, b♦}	Woodlands/canyons

ATTACHMENT 5-4 - MAMMAL SPECIES KNOWN OR EXPECTED TO OCCUR ON THE KFC (Continued)

Scientific Name	Common Name	Habitat
a♦, a ^v	Observed and expected, respectively, according to Robert M. Sullivan, 1994.	
b♦, b ^v	Observed and expected, respectively, according to Robert M. Sullivan and Paul J. Knight, 1994.	
c	New Mexico Natural Heritage Program, 1995.	
d	Robert R. Parmenter and Melissa Chavez, 1995.	
e	Stephanie Pope, 1997.	
f	J. S. Altenbach, 1997.	
g	Unpublished observation.	
Note: Species in bold are documented in one or more of the surveys indicated by superscript letters. Other species are based on N. T. Fischer, 1990.		

ATTACHMENT 5-5 - PAST ECOLOGICAL RISK ASSESSMENT STUDIES

Ecological risk assessments (ERAs) evaluate the potential for adverse impacts on biological resources resulting from a proposed action, existing condition, or unplanned event. ERAs are now used extensively to assess the probability that chemical or radiological contaminants in the environment pose a risk to the health of an ecological system or a threat to specific populations within that system, thereby determining the need for corrective action. Ecological stressors evaluated in ERAs, however, are not limited to chemical contaminants, but may include physical stressors, such as habitat destruction, noise, traffic, and other factors that can lead to injury, death, or loss of reproductive potential. ERAs are used in environmental assessments (EAs) as a tool to evaluate the potential risks from a proposed action and to compare risks between alternative actions. Two such ERAs have been conducted for DOE operations at the Kirtland Federal Complex (KFC). These are described in the following sections of this attachment. Other ERAs are currently in progress at SNL/NM. An ERA was also performed as part of DOE's *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (U.S. Department of Energy, 1997), however, it is limited in scope to potential consequences of transportation spills and does not directly address risk at the individual DOE facilities. For this reason, it is not summarized here.

Coyote Test Field (CTF)

The Physical Science Laboratory (PSL) of New Mexico State University performed an ecological risk assessment (ERA) as part of the environmental assessment (EA) for continued testing operations at the Coyote Test Field (CTF) (Silver et al., 1992). Stressors identified from these operations include:

- Habitat destruction due to construction activities
- Fugitive dust generated during construction activities
- Vehicular traffic
- Fragmentation of test materials
- Explosive-generated overpressure

ATTACHMENT 5-5 - PAST ECOLOGICAL RISK ASSESSMENT STUDIES (Continued)

- Accidental brushfire
- Accidental chemical releases

The evaluation of risks were limited to those identified as sensitive and protected species that had been documented in the Coyote Canyon Test Complex (CCTC) area at the time that the ERA was performed. These included two plants (the grama grass cactus and the Santa Fe milkvetch), two reptiles (the Texas horned lizard and the massasauga), and six birds (the northern harrier, the Swainson's hawk, the ferruginous hawk, the great horned owl, the burrowing owl, and the loggerhead shrike). The annual rate of mortality in each of these species from each of the stressors was conservatively estimated using probabilistic models. Risks of mortality were expressed as the inverse of the annual rate, such as "one individual lost per X number of years." The mortality due to traffic was limited to the Texas horned lizard.

In conclusion, no risk was associated with habitat destruction because all new construction would occur in a previously disturbed habitat, and the risks due to fugitive dust were inconsequential. It was estimated that fewer than one Texas horned lizard would be killed in 25 years due to traffic and a similar loss rate was predicted for fragmentation. Fragmentation was predicted to result in less than one sensitive bird fatality in five years, less than one massasauga fatality in 11 years, and less than one grama grass cactus loss in eight years. Mortality due to overpressure was determined to be an extremely unlikely event. The potential for accidental brushfires was predicted to result in the loss of one grama grass cactus in 30 years and the cumulative risk of the loss of an individual of any sensitive species due to a chemical spill was predicted at less than one in 40 years. The cumulative risks to these species from all stressors were regarded as negligible with respect to natural mortality rates.

Environmental Restoration (ER) Project

The environmental assessment (EA) for the SNL/NM Environmental Restoration (ER) Project (U.S. Department of Energy, 1996) evaluated the environmental consequences of corrective action alternatives for the sites identified in the ER project as containing chemical or radiological contaminants. Because of the likelihood for contaminated dust to be generated by these corrective actions and deposited in areas beyond the limit of the physical disturbance, the potential for impact to biological resources due to exposure to this dust was evaluated through an ecological risk assessment (ERA).

ATTACHMENT 5-5 - PAST ECOLOGICAL RISK ASSESSMENT STUDIES (Continued)

The deposition of dust from corrective actions was predicted using airborne particulate dispersal models and the resulting soil concentrations were estimated for each chemical of concern. The chemicals of potential ecological concern were limited to cadmium, chromium, and lead. Gamma-emitting radionuclides were also of potential concern. Ecological risks were evaluated for two general groups of potential receptors—plants and small mammals (rodents). Exposure in the small rodent was limited to the ingestion pathway. Toxicity benchmarks were compared to the predicted soil concentrations for the evaluation of risk to plants and to predicted oral intake for the evaluation of risk to the rodent. For risk due to gamma radiation dose, the total predicted dose from deposited dust was compared to a standard benchmark of 0.1 rad per day for the protection of ecological systems. In all cases, the predicted exposures were well below the benchmark values, indicating no risk to ecological systems due to fugitive dust. Site-specific ERAs are currently being performed for the evaluation of risk to ecological receptors due to existing conditions at ER sites.

ATTACHMENT 5-6 - DATA GAPS

Data describing the biological and ecological resources of the Kirtland Federal Complex (KFC) has been largely collected on a project-specific basis. Efforts that have been broad in geographic scope, that is, covering essentially the entire KFC area, have been limited in focus to particular species (for example, the sensitive species surveys of IT Corporation [1995] and New Mexico Natural Heritage Program [1995]), particular habitats (for example, the wetland survey of U.S. Army Corps of Engineers [1995]), or to nonquantitative species lists (for example, Martin and Wagner, 1974). Those studies that provide more in-depth information on community composition and habitat relationships (for example, Sullivan and Knight [1994] and Parmenter and Chavez [1995]) are limited to localized areas within the KFC boundary, resulting in gaps in information of an equivalent level of detail for the intervening areas.

The following sections describe the extent of data gaps existing in the current information record concerning the biological and ecological resources of the KFC. These have been divided into the following three general categories of information:

- Species inventories
- Community composition studies
- Geographic studies, including mapping

The identification of major habitat types on the KFC is considered complete, and therefore, is not further discussed here.

Species Inventories

Species inventories result in lists of species that occupy a specific geographic area. In their most general form, these lists are generated by the use of published species' range maps, such as those found in field guides and taxonomic references. This results in a list of potentially occurring species (or "hypothetical species"), which may be refined by knowledge of the habitats available on the study site and the habitat preferences of the potential species. Floristic and faunistic field studies provide substantiation of the inventories; however, relatively complete substantiation often requires a significant field effort. In some cases, these efforts require special techniques and a high level of expertise in field personnel. Although many species inventories have been reported for the Kirtland Federal Complex (KFC), and field

ATTACHMENT 5-6 - DATA GAPS (Continued)

ATTACHMENT 5-6 - DATA GAPS (Continued)

amphibians are limited to the belt transect data in Sullivan and Knight (1994) for the Coyote Test Field (CTF) in the southwestern corner of the KFC.

In summary, large areas of the KFC have not been studied to identify vegetation associations, particularly in the middle and upper elevations of the grassland habitat and in the riparian habitat. Quantitative analyses of vegetative communities are inadequate in number to describe these associations or to draw conclusions about habitat correlations. They also lack consistency in methodology. Bird communities are fairly well studied on the KFC, but those of small mammals and reptiles have only been quantitatively studied in a small portion of the KFC. Almost no quantitative information is known about larger mammal populations.

Geographic Studies and Mapping

Geographic studies of biological and ecological resources are directed at delineating the aerial extent of ecological units, such as habitat or vegetation types, or the locations of individuals, territories, or populations of interest. Geographic information is commonly expressed in the form of maps. Computer-based geographic information systems (GISs) provide a powerful tool for the storage and analyses of geographic data, but these data must first be collected in a form that provides the necessary geographic information. To date, the collection, storage, and use of geographic data concerning the biological and ecological resources on the Kirtland Federal Complex (KFC) are limited. Map information exists on the locations of sensitive species findings on the KFC; however, these are based on discrete survey areas, and gaps of unsurveyed land exist in this record.

The U.S. Forest Service (USFS) has recently completed a GIS-based inventory map for soil and vegetation within the Withdrawn Area. A vegetation map has also been produced for the entire KFC (IT Corporation and Concensus Planning Incorporated/Zephyr Design, 1993; IT Corporation, 1996). This map is based primarily on the interpretation of aerial photography for the western part of the KFC, but relies also on topographic and soils data for much of the woodland area in the Withdrawn Area. The vegetation units were transferred to 7.5-minute topographic base maps of the U.S. Geological Survey and later digitized into the SNL/NM GIS database. Although useful in showing the boundaries of the major habitat types and some of the minor habitat features, such as grasslands with dune formation and riparian tree thickets, the mapping units do not correspond to vegetation units at the level of the association as described in this document. A more extensive, quantitative study of the vegetation of the

ATTACHMENT 5-6 - DATA GAPS (Continued)

Community Composition Studies

Community composition studies result in a quantitative or semi-quantitative description of the biotic community that occupies a particular site or habitat type. In contrast with species inventories, which simply document the presence of a species, community composition studies identify the relative importance of these species within an area in terms of such measures as biomass, density, abundance, and coverage. Based on such studies, communities are often classified by the dominant or codominant species, particularly the codominant plant species that form identifiable vegetation associations. These are often visually identified rather than determined by measurement. Vegetation associations are commonly correlated with particular habitat conditions, such as soil type, slope, aspect, and history of disturbance. Animal community structure and composition are also correlated with vegetation associations, making them a useful tool in resource management.

The identification of vegetation associations on the KFC has been limited. Sullivan and Knight (1994) identified associations within the grasslands in the southwestern corner of the KFC through visual determination of the dominant or codominant species. The U.S. Forest Service (1996) has applied a classification of habitat types to the woodland vegetation of the Withdrawn Area, which is similar to the approach used by Sullivan and Knight in that it is a visual identification of dominant plant species.

Measurements of the vegetation communities on the KFC are extremely limited in number and scope. Sullivan (1994) performed line-intercept measurements on both sides of the Sol se Mete Canyon Aerial Cable Facility. Parmenter and Chavez (1995) also performed line-intercept measurements on two grassland study plots near the southern boundary of the KFC that included early and late growing season measurements over a two-year period. Pope (1997) performed microplot measurements of vegetation at two study sites near the northern boundary (one being in the Withdrawn Area). The data from these studies can be used to identify dominant and codominant species at the respective study areas; however, the different method used in latter study makes the data incompatible with that of the first two for more refined comparisons.

Quantitative analyses of animal communities are somewhat limited. These are largely restricted to bird surveys (Sullivan, 1994; Sullivan and Knight, 1994; Maynard, 1994; New Mexico Natural Heritage Program, 1995; Daniel B. Stephens and Associates Incorporated, 1996; and Pope, 1997) and small mammals (Sullivan, 1994; Sullivan and Knight, 1994; Parmenter and Chavez, 1995; and Pope, 1997). Quantitative methods applied to reptiles and

ATTACHMENT 5-6 - DATA GAPS (Continued)

amphibians are limited to the belt transect data in Sullivan and Knight (1994) for the Coyote Test Field (CTF) in the southwestern corner of the KFC.

In summary, large areas of the KFC have not been studied to identify vegetation associations, particularly in the middle and upper elevations of the grassland habitat and in the riparian habitat. Quantitative analyses of vegetative communities are inadequate in number to describe these associations or to draw conclusions about habitat correlations. They also lack consistency in methodology. Bird communities are fairly well studied on the KFC, but those of small mammals and reptiles have only been quantitatively studied in a small portion of the KFC. Almost no quantitative information is known about larger mammal populations.

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ATTACHMENT 5-6 - DATA GAPS (Continued)

correspondence on a vegetation map. Geographic information on other special habitat features, such as large trees, prairie dog towns, cliffs, large mines, trick tanks, and wetlands, should also be incorporated into the GIS database.

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1		0720	D. R. Bleakly, 06804
1		0747	T. A. Wheeler, 06412
1		0749	T. M. Cohen, 06217
1		0873	A. O. Bendure, 14302
1		0926	K. A. Kuzio, 07932
1		1035	F. S. Vigil, 07572
1		1042	J. M. Harris, 07575
1		1042	J. M. Bonaguidi, 07575
1		1042	M. L. du Mond, 07575
1		1042	H. A. Hwang, 07575
2		1043	ES&H Library, 07522
1		1050	R. W. Rohde, 07500
1		1050	L. A. West, 07500
1		1089	W. B. Cox, 06132
1		1116	J. L. Jackson, 07442
1		1149	J. F. Jarry, 07577
1		1173	P. R. Fleming, 07523
16		1173	J. V. Guerrero, 07575
2		1173	W. H. Johns, 07523
1		1173	L. S. Bayliss, 07523
1		9221	B. L. Larsen, 08816
1		9018	Central Technical Files, 8940-2
2		0899	Technical Library, 4916
1		0612	Review & Approval Desk, 4912
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