U-006-409.6

5453

U.S. DEPARTMENT OF ENERGY NEVADA OPERATIONS OFFICE ANNUAL SITE ENVIRONMENTAL REPORT - 1990 VOLUME 1 SEPTEMBER 1991 (USED AS A REFERENCE IN THE OU 2 FS, OU 4 FS AND OU 3 PP/EA)

09/01/91

DOE/NV/10630-20
DOE-NEVADA
319
REPORT
OU4

U-006-409.6

5453

DOE/NV/10630-20
Volume I

DOE/NV/10630-20
Volume I

U.S. DEPARTMENT OF ENERGY NEVADA OPERATIONS OFFICE ANNUAL SITE ENVIRONMENTAL REPORT - 1990

Volume I

Editors: Elizabeth M. McDowell and Stuart C. Black

September 1991

OU 4 FS
OU 2 FS
OU 3 FP

Work Performed Under
Contract No. DE-AC08-89NV10630

prepared by:

RETURN TO NV TECHNICAL LIBRARY

Reynolds Electrical & Engineering Co., Inc.
Post Office Box 98521
Las Vegas, Nevada 89193-8521

0 1

Property of
U.S. DEPARTMENT OF ENERGY
NV TECHNICAL LIBRARY
Las Vegas, NV 89193

5453

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the:

Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, Tennessee 37831

Prices available from (615) 576-8401, FTS 626-8401.

Available to public from the:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Rd.
Springfield, VA 22161

0 2

AUTHORS AND CONTRIBUTORS

- 5453

Reynolds Electrical & Engineering Co., Inc.

Lawrence E. Barker, Ph.D.
Stuart C. Black, Ph.D.
Charles W. Burhoe
Glen A. Clark, Ph.D.
Dean L. Cox
Daniel A. Gonzalez
Richard B. Hunter, Ph.D.
Robert R. Kinnison, Ph.D.
Kevin R. Krenzien
Yun Ko Lee, Ph.D.
Omer W. Mullen
Steve J. Nacht
Carlton S. Soong
Mary E. Thompson
Scott A. Wade

Profession Analysis, Inc.

Donald T. Wruble

Lawrence Livermore National Laboratory

Scott E. Patton

EG&G Energy Measurements, Inc.

Bruce Gillen

Environmental Monitoring Systems Laboratory - Las Vegas, EPA

Milton W. Chilton
Bruce B. Dicey
David G. Easterly
Christopher A. Fontana
Anita A. Mullen
Victoria E. Niemann
William G. Phillips
Donald D. Smith, D.V.M.

0 3

FOREWORD

Prior to 1989 annual reports of environmental monitoring and assessment results for the Nevada Test Site (NTS) were prepared in two separate parts. Onsite effluent monitoring and environmental monitoring results were reported in an onsite report prepared by the U.S. Department of Energy, Nevada Operations Office (DOE/NV). Results of the offsite radiological surveillance program conducted by the U.S. Environmental Protection Agency (EPA), Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, were reported separately by that Agency.

Beginning with the 1989 annual Site environmental report for the NTS, these two documents were combined into a single report to provide a more comprehensive annual documentation of the environmental protection program conducted for the nuclear testing program and other nuclear and non-nuclear activities at the Site. The two agencies have coordinated preparation of this second combined onsite and offsite report through sharing of information on environmental releases and meteorological, hydrological, and other supporting data used in dose-estimate calculations.

5453 ACKNOWLEDGEMENTS

The skill, dedication, and perseverance of Angela L. McCurdy in word processing and desktop publishing support were crucial to the production of this report. The review and advice offered by Basic Environmental Compliance and Monitoring Program (BECAMP) and EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV), reviewers were valuable. Compilation and verification of data were provided by Sheryl L. Pfeuffer and Frank R. Grossman. The Geographic Information System (GIS) graphics were developed and provided by Steven M. Kowalkowski, EG&G/Energy Measurements, Inc. Darryl Randerson of the Weather Services Nuclear Support Office, National Oceanic and Atmospheric Administration, provided the wind rose information seen in Section 2.

The cooperative support of Charles F. Costa, William G. Phillips, and Christopher A. Fontana of the EMSL-LV in production of this combined onsite and offsite environmental report was appreciated.

0 5

5453

DOE/NV/10630-20
Volume I

U.S. DEPARTMENT OF ENERGY NEVADA OPERATIONS OFFICE ANNUAL SITE ENVIRONMENTAL REPORT - 1990

VOLUME I

Editors: Elizabeth M. McDowell and Stuart C. Black

September 1991

Work Performed Under
Contract No. DE-AC08-89NV10630

Prepared for the

U.S. Department of Energy
Nevada Operations Office

Prepared by:

Reynolds Electrical & Engineering Co., Inc.
Post Office Box 98521
Las Vegas, Nevada 89193-8521

0 6

TABLE OF CONTENTS

Volume I — Page

Authors and Contributors iii
Foreword iv
Acknowledgements v
Table of Contents vi
List of Figures xii
List of Tables xiv
Measurement Units and Nomenclature xvii
List of Acronyms and Expressions xviii

1.0 Summary 1-1
1.1 Environmental Management 1-1
1.2 Radiological Environment 1-2
1.2.1 Offsite Monitoring 1-2
1.2.2 Onsite Monitoring 1-4
1.2.3 Low-Level Waste Disposal 1-7
1.3 Nonradiological Monitoring 1-7
1.4 Compliance Activities 1-8
1.5 Groundwater Protection 1-9
1.6 Radioactive and Mixed Waste Disposal 1-9
1.7 Quality Assurance 1-10
1.7.1 Onsite Nonradiological Quality Assurance 1-10
1.7.2 Onsite Radiological Quality Assurance 1-10
1.7.3 Offsite Radiological Quality Assurance 1-10
1.8 Issues and Accomplishments 1-11

2.0 Introduction 2-1
2.1 NTS Operations 2-1
2.1.1 NTS Description 2-1
2.1.2 Mission and Nature of Operations 2-3
2.1.3 1990 Test Activities 2-6
2.1.3.1 Nuclear Tests 2-6
2.1.3.2 Liquified Gaseous Fuels Spill Test Facility 2-7
2.1.4 Topography and Terrain 2-8
2.1.5 Geology 2-8
2.1.6 Hydrogeology 2-14
2.1.7 Climate and Meteorology 2-16
2.1.8 Flora and Fauna 2-17
2.1.9 Archaeological and Historical Values 2-19
2.1.10 Demography 2-20
2.1.11 Surrounding Land Use 2-20
2.2 Non-NTS Facilities 2-23
2.2.1 Amador Valley Operations 2-23
2.2.2 Kirtland Operations 2-23
2.2.3 Las Vegas Area Operations 2-25
2.2.4 Los Alamos Operations 2-25
2.2.5 Santa Barbara Operations 2-25

2.2.6 Special Technologies Laboratory 2-25
2.2.7 Washington Aerial Measurements Department 2-26
2.2.8 Woburn Cathode Ray Tube Operations 2-26
2.3 Non-NTS Underground Event Sites 2-26

3.0 Compliance Summary 3-1
3.1 National Environmental Policy Act (NEPA) 3-1
3.1.1 Environmental Assessments 3-2
3.1.1.1 Completed Environmental Assessments 3-2
3.1.1.2 In-Process Environmental Assessments 3-2
3.1.1.3 Withdrawn Environmental Assessments 3-3
3.1.2 Categorical Exclusions 3-3
3.1.3 Memoranda to File 3-3
3.2 Clean Air Act 3-3
3.2.1 NTS Operations 3-3
3.2.1.1 NESHAP Asbestos Compliance 3-3
3.2.1.2 Radioactive Emissions 3-7
3.2.1.3 Ambient Air Quality Standards 3-8
3.2.1.4 Air Quality Permits 3-9
3.2.2 Non-NTS Facilities 3-9
3.2.2.1 Radiological Reporting 3-9
3.2.2.2 Air Quality Permits 3-9
3.3 Clean Water Act 3-10
3.3.1 NTS Operations 3-10
3.3.2 Non-NTS Facilities 3-10
3.4 Safe Drinking Water Act 3-11
3.4.1 NTS Operations 3-11
3.4.2 Non-NTS Facilities 3-13
3.5 Resource Conservation and Recovery Act 3-13
3.5.1 State of Nevada/RCRA Activities 3-13
3.5.1.1 Comments on the RCRA Part B Application 3-13
3.5.1.2 RCRA Issues Resulting from NDEP Visit of March 6 to 8, 1990 3-15
3.5.1.3 Potential Violations - Inspection of August 19, 1990 3-15
3.5.2 Hazardous Waste Reporting 3-16
3.5.3 RCRA Part A Permit Application 3-17
3.5.4 Area 6 Decontamination Facility Evaporation Pond 3-17
3.5.5 Underground Storage Tanks 3-18
3.5.6 Waste Minimization 3-18
3.5.6.1 NTS Operations 3-18
3.5.6.2 Non-NTS Facilities 3-19
3.6 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)/Superfund Amendments and Reauthorization Act (SARA) 3-20
3.6.1 NTS Operations 3-20
3.6.2 Non-NTS Facilities 3-21
3.7 Toxic Substances Control Act 3-21
3.8 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) 3-21
3.9 Solid/Sanitary Waste 3-21
3.10 Archaeological and Cultural History Preservation 3-22

3.11 Endangered Species Protection 3-23
3.12 DOE Environmental Surveys 3-24
3.12.1 NTS Operations 3-24
3.12.2 EG&G/EM Las Vegas Area Operations Audit 3-25
3.13 Tiger Team Compliance Assessment 3-25
3.14 Radiation Protection 3-25
3.14.1 NTS Operations 3-25
3.14.2 Non-NTS Facilities 3-26
3.15 Unusual Occurrences 3-26
3.16 Permit Summary 3-26

4.0 Environmental Program Information 4-1
4.1 Radiological Monitoring 4-1
4.1.1 Onsite Monitoring 4-1
4.1.1.1 Criteria 4-1
4.1.1.2 Effluent Monitoring 4-7
4.1.1.3 Environmental Surveillance 4-7
4.1.1.4 Special Environmental Studies 4-10
4.1.2 Offsite Monitoring 4-11
4.1.2.1 Air Monitoring 4-11
4.1.2.2 Water Monitoring 4-12
4.1.2.3 Milk Surveillance Network 4-12
4.1.2.4 Biomonitoring 4-16
4.1.2.5 External Gamma Exposure Monitoring 4-16
4.1.2.6 Pressurized Ion Chamber Network 4-21
4.1.2.7 Offsite Dosimetry Program 4-21
4.1.2.8 Community Radiation Monitoring Program Stations 4-23
4.1.3 Non-NTS Facility Monitoring 4-25
4.2 Nonradiological Monitoring 4-26
4.2.1 NTS Operations Monitoring 4-26
4.2.1.1 Routine Monitoring 4-26
4.2.1.2 Ecological Studies 4-26
4.2.2 Offsite Monitoring 4-27
4.2.3 Non-NTS Facility Monitoring 4-28
4.3 Environmental Permits 4-30
4.3.1 Air Quality Permits 4-30
4.3.1.1 NTS Air Quality Permits 4-30
4.3.1.2 Non-NTS Air Quality Permits 4-32
4.3.2 Drinking Water System Permits 4-32
4.3.3 Sewage Discharge Permits 4-33
4.3.3.1 NTS Sewage Hauling Inspection 4-33
4.3.3.2 NTS Tweezer Facility Evapotranspiration Bed Variance . 4-34
4.3.3.3 NTS Sewage Lagoon Operations and Maintenance (O&M) Manuals 4-35
4.3.3.4 Non-NTS Sewage Permits 4-35
4.3.4 Injection Well Permits 4-35
4.3.5 RCRA Permits 4-35
4.3.5.1 NTS Operations 4-35
4.3.5.2 Non-NTS Facilities 4-37

4.3.6 Endangered Species Act Permits 4-37

5.0 Radiological Monitoring Results 5-1
5.1 Radiological Effluent Monitoring 5-1
5.1.1 Airborne Effluents 5-1
5.1.1.1 Nuclear Event Monitoring 5-2
5.1.1.2 Tunnel Complex Effluent 5-7
5.1.1.3 Radioactive Waste Management Sites 5-7
5.1.2 Liquid Effluents 5-11
5.1.2.1 Tunnels 5-11
5.1.2.2 Radionuclide Migration Study 5-12
5.1.2.3 Decontamination Facility 5-12
5.2 Radiological Environmental Surveillance 5-14
5.2.1 Onsite Environmental Surveillance 5-14
5.2.1.1 Radioactivity in Air 5-14
5.2.1.2 Particulate Sampling Results 5-15
5.2.1.3 Noble Gas Sampling Results 5-19
5.2.1.4 Tritiated Water Vapor Sampling Results 5-26
5.2.1.5 Radioactivity in Surface Water 5-28
5.2.1.6 Radioactivity in Groundwater 5-36
5.2.1.7 Radioactivity in Drinking Water 5-39
5.2.1.8 External Gamma Exposures - Onsite Area 5-42
5.2.1.9 Special Environmental Studies 5-42
5.2.2 Offsite Environmental Surveillance 5-45
5.2.2.1 Air Monitoring Network 5-47
5.2.2.2 Water Monitoring 5-48
5.2.2.3 Biomonitoring 5-48
5.2.2.4 External Gamma Exposure Monitoring 5-59
5.2.2.5 Pressurized Ion Chamber Network 5-68
5.2.2.6 Offsite Dosimetry Program 5-71
5.2.2.7 Milk Surveillance Network 5-72

6.0 Dose Assessment 6-1
6.1 Estimated Dose From NTS Activities 6-1
6.2 Estimated Dose From Worldwide Fallout 6-2
6.3 Estimated Dose From Radioactivity in an NTS Deer 6-3
6.4 Dose From Background Radiation 6-3
6.5 Summary 6-3

7.0 Nonradiological Monitoring 7-1
7.1 Environmental Samples 7-1
7.1.1 Safe Drinking Water Act 7-1
7.1.1.1 Bacteriological Sampling 7-1
7.1.1.2 Chemical Analysis 7-4
7.1.1.3 Volatile Organic Compound Analysis 7-4
7.1.1.4 Inorganic Compound Analysis and Water Quality 7-4
7.1.2 Clean Water Act 7-6
7.1.2.1 NTS Operations 7-6
7.1.2.2 Non-NTS Sampling Results 7-10

Table of Contents, cont. Page

7.1.3 Toxic Substances Control Act (TSCA) 7-11
7.1.4 National Emission Standards for Hazardous Air Pollutants 7-11
7.1.5 Resource Conservation and Recovery Act 7-12
7.1.6 Federal Insecticide, Fungicide, and Rodenticide Act 7-12
7.1.7 Special Studies 7-12
7.2 Environmental Conditions 7-12
7.2.1 Flora 7-14
7.2.2 Fauna 7-15
7.2.3 Monitoring of Disturbed Areas 7-17
7.2.4 Flora and Fauna Downwind from the Liquified Gaseous Fuels Spill Test Facility 7-18

8.0 Radioactive and Mixed Waste Disposal 8-1
8.1 Waste Disposal Operations 8-1
8.1.1 Area 5 Radioactive Waste Management Site 8-1
8.1.2 Area 3 Bulk Waste Management Facility 8-2
8.2 Waste Disposal Environmental Monitoring 8-3
8.2.1 Air Monitoring 8-3
8.2.2 External Gamma Exposures 8-3
8.2.3 Water Sampling 8-4
8.2.4 Strategic Materials Storage Area 8-4
8.2.5 Vadose Zone Monitoring for Mixed Waste Disposal 8-4
8.2.6 Transuranic Waste Storage 8-5
8.2.7 Tritium Migration Studies at the Area 5 RWMS 8-5

9.0 Groundwater Protection 9-1
9.1 DOE/NV Groundwater at Testing Sites 9-1
9.1.1 NTS Groundwater 9-1
9.1.2 Non-NTS Groundwater 9-2
9.1.3 Groundwater Protection Policy 9-2
9.1.4 Areas of Known Contamination 9-3
9.1.5 Groundwater Programs 9-5
9.1.5.1 Groundwater Protection 9-5
9.1.5.2 Groundwater Characterization 9-7
9.1.5.3 Groundwater Monitoring 9-7
9.1.5.4 Groundwater Remediation 9-8
9.1.5.5 Special Studies 9-8
9.2 NTS Long-Term Hydrological Monitoring Program 9-12
9.2.1 Radiological Status of Sampled Groundwater 9-13
9.2.2 Nonradiological Monitoring on the NTS 9-22
9.3 Off-NTS Long-Term Hydrological Monitoring Program 9-23
9.3.1 Results 9-25
9.3.2 Discussion 9-39
9.3.3 Special Study for the LTHMP - Tatum Dome Test Site, Mississippi 9-39
9.3.3.1 History 9-42
9.3.3.2 1990 Sampling Program 9-43
9.3.3.3 1990 Results 9-43
9.3.3.4 Summary 9-43

Table of Contents, cont. Page

9.3.3.5 Conclusions 9-43

10.0 Onsite Radiological Quality Assurance 10-1
10.1 Overview of the Onsite Quality Assurance Program 10-1
10.2 Sample Control 10-2
10.3 Instrument Control 10-2
10.4 Radioanalysis Control 10-3
10.5 Data Control 10-3
10.6 External Quality Assurance Assessment Programs 10-4
10.7 Compliance Audits and Surveillance 10-5
10.8 Recent Developments in the QA/QC Program 10-5

11.0 Onsite Nonradiological Quality Assurance 11-1
11.1 Overview of the Onsite Nonradiological Quality Assurance Program 11-1
11.2 Sample Acceptance and Control 11-2
11.3 Quality Control 11-2
11.3.1 Interlaboratory Comparison Programs 11-2

12.0 Offsite Radiological Quality Assurance 12-1
12.1 Policy 12-1
12.2 Standard Operating Procedures 12-1
12.3 Data Quality Objectives 12-1
12.3.1 Decision to be Made 12-2
12.3.2 Why Environmental Data Were Needed and How They Were Used 12-2
12.3.3 Time and Resources Required 12-3
12.3.4 Description of Data Collected 12-3
12.3.5 Domain of the Decision 12-4
12.3.6 Calculations to be Performed on the Data 12-4
12.4 Data Validation 12-4
12.5 Quality Control 12-5
12.5.1 Milk Surveillance Network 12-5
12.5.2 Bioassay 12-6
12.5.3 Internal Dosimetry 12-6
12.5.4 Pressurized Ion Chamber Network 12-7
12.5.5 Dosimetry Network 12-7
12.6 Health Physics Oversight 12-7
12.7 Precision of Analysis 12-7
12.8 Accuracy of Analysis 12-8
12.9 Laboratory Quality Control 12-9

5453

LIST OF FIGURES

Page

Figure 2.1 NTS Location 2-2
Figure 2.2 NTS Area Designations, Principal Facilities, and Testing Areas 2-4
Figure 2.3 Location of Safety Shots in the NAFB Range Complex 2-5
Figure 2.4 Topography of the NTS 2-9
Figure 2.5 Formation of an Underground Nuclear Explosive Test Cavity, Rubble Chimney, and Surface Subsidence Crater 2-10
Figure 2.6 Surface Drainage Channel Pattern for the NTS 2-11
Figure 2.7 Basic Lithologic Structure of the NTS 2-12
Figure 2.8 Drill Hole Locations on the NTS 2-13
Figure 2.9 Groundwater Hydrologic Units of the NTS and Vicinity 2-15
Figure 2.10 1990 Wind Rose Patterns for the NTS 2-18
Figure 2.11 Population Distribution in Counties Surrounding the NTS 2-21
Figure 2.12 Land Use Around the NTS 2-22
Figure 2.13 Locations of Non-NTS Facilities and Underground Event Sites 2-24

Figure 3.1 Comparison of Individual Water Sampling Results to Regulation Limits 3-12

Figure 4.1 Air Sampling Stations on the NTS - 1990 4-2
Figure 4.2 Thermoluminescent Dosimeter Stations on the NTS - 1990 4-3
Figure 4.3 Supply Well and Potable Water Sampling Stations on the NTS - 1990 4-4
Figure 4.4 Surface Water Sampling Locations on the NTS - 1990 4-5
Figure 4.5 Air Surveillance Network Stations - 1990 4-13
Figure 4.6 Standby Air Surveillance Network Stations - 1990 4-14
Figure 4.7 Offsite Noble Gas and Tritium Surveillance Network Stations - 1990 4-15
Figure 4.8 Milk Surveillance Network Stations - 1990 4-17
Figure 4.9 Standby Milk Surveillance Network Stations - 1990 4-18
Figure 4.10 Collection Sites for Animals Sampled - 1990 4-19
Figure 4.11 Gamma Exposure Monitoring Stations - 1990 4-20
Figure 4.12 Pressurized Ion Chamber Network and Community Radiation Monitoring Stations - 1990 4-22
Figure 4.13 Location of Families in the Offsite Dosimetry Program - 1990 4-24

Figure 5.1 Typical RAM Array for a Nuclear Test 5-6
Figure 5.2 RWMS Air Sampling Annual Average Results - 1990 5-8
Figure 5.3 RWMS Tritiated Water Vapor Annual Average Results - 1990 5-9
Figure 5.4 RWMS TLD Annual Average Results - 1990 5-10
Figure 5.5 NTS Airborne Gross Beta Annual Average Concentrations - 1990 5-17
Figure 5.6 NTS Airborne $^{239+240}Pu$ Annual Average Results - 1990 5-20
Figure 5.7 NTS $^{85}Kr/^{133}Xe$ Annual Average Concentrations - 1990 5-24
Figure 5.8 NTS Tritiated Water Vapor Annual Average Concentrations - 1990 5-27
Figure 5.9 NTS Open Reservoir Annual Average Gross Beta Concentrations - 1990 . 5-30
Figure 5.10 NTS Natural Spring Annual Average Gross Beta Concentrations - 1990 . . 5-32
Figure 5.11 NTS Containment Pond Annual Average Gross Beta Concentrations - 1990 5-35
Figure 5.12 NTS Supply Well Annual Average Gross Beta Concentrations - 1990 5-38
Figure 5.13 NTS Potable Water Gross Beta Annual Averages - 1990 5-41

013

List of Figures, cont. Page

Figure 5.14 Basic Environmental Compliance and Monitoring Program Assessment Model - 1990 5-46
Figure 5.15 Monthly Average Gross Beta in Air Samples, Las Vegas, Nevada - 1981-90 5-48
Figure 5.16 Network Weekly Average ^{85}Kr Concentrations in Air - 1990 5-58
Figure 5.17 Annual EMSL-LV Network Average ^{85}Kr Concentration - 1972-1990 5-58
Figure 5.18 Average ^{90}Sr Concentrations in Animal Bone Ash - 1955-90 5-61
Figure 5.19 Range of Ambient Gamma Exposures at Fixed Environmental Stations by State - 1990 5-67
Figure 5.20 Historical Trends - TLD Exposures at Offsite Fixed Stations - 1971-90 5-67
Figure 5.21 Range of Ambient Gamma Exposures of Offsite Residents by State - 1990 5-72
Figure 5.22 Annual PIC Averages by Station In Milliroentgens per Year - 1990 5-74
Figure 5.23 Correlating TLD and PIC Results - 1990 5-74
Figure 5.24 Mean and Standard Deviation for the Concentration of Tritium in the Urine of Offsite Residents - 1979-90 5-77
Figure 5.25 ^{90}Sr in Pasteurized Milk Network Samples - 1960-90 5-77

Figure 8.1 Statistical Comparison of Gamma Exposure Rates 8-4

Figure 9.1 Wells On the NTS Included in the LTHMP 9-14
Figure 9.2 Wells Outside the NTS Included in the LTHMP 9-15
Figure 9.3 Wells with Decreasing Trends of Tritium Concentration in Groundwater 9-17
Figure 9.4 Wells with Increasing Trends of Tritium Concentration in Groundwater 9-18
Figure 9.5 Annual Average Gross Beta in NTS Supply Well Water - 1979-1990 9-24
Figure 9.6 LTHMP Sampling Locations for Project SHOAL - 1990 9-26
Figure 9.7 LTHMP Sampling Locations for Project FAULTLESS - 1990 9-27
Figure 9.8 LTHMP Sampling Locations for Project RIO BLANCO - 1990 9-28
Figure 9.9 LTHMP Sampling Locations for Project RULISON - 1990 9-29
Figure 9.10 LTHMP Sampling Locations for Project Dribble, Near Ground Zero - 1990 9-30
Figure 9.11 LTHMP Sampling Locations for Project Dribble, Towns and Residences - 1990 9-31
Figure 9.12 LTHMP Sampling Locations for Project GASBUGGY - 1990 9-32
Figure 9.13 LTHMP Sampling Locations for Project GNOME - 1990 9-33
Figure 9.14 Tritium Trends in Groundwater - Tatum Salt Dome Area 9-40
Figure 9.15 Tritium Trends in Groundwater - Project GASBUGGY 9-41

LIST OF TABLES

Page

Table 1.1 Radionuclide Emissions on the NTS - 1990 1-3
Table 1.2 Summary of Annual Effective Dose Equivalent from NTS Operations during 1990 1-5

Table 2.1 Announced Underground Nuclear Tests at the NTS - 1990 2-7
Table 2.2 Non-NTS Nuclear Explosive Test Sites Studied in 1990 2-27

Table 3.1 Categorical Exclusions Approved and In Progress - 1990 3-4
Table 3.2 Memoranda to File - 1990 3-7
Table 3.3 NESHAP Notifications to the State of Nevada for NTS Asbestos Renovation Projects - 1990 3-8
Table 3.4 Underground Storage Tank Activities - 1990 3-19
Table 3.5 Environmental Survey Action Plan Items - 1990 3-24
Table 3.6 Unusual Occurrences - 1990 3-26
Table 3.7 Environmental Permit Summary - 1990 3-32

Table 4.1 Summary of Onsite Environmental Sampling Program - 1990 4-6
Table 4.2 Nevada Air Quality Operating Permits Renewed in 1990 4-31
Table 4.3 NTS Active Air Quality Permits, NTS - 1990 4-31
Table 4.4 Active Air Quality Permits, Non-NTS Facilities - 1990 4-32
Table 4.5 NTS Drinking Water Supply System Permits - 1990 4-33
Table 4.6 NTS Sewage Discharge Permits - 1990 4-33
Table 4.7 Non-NTS Sewage Discharge Permits - 1990 4-34
Table 4.8 RCRA Hazardous Waste Permits - 1990 4-36

Table 5.1 NTS Radionuclide Emissions - 1990 5-3
Table 5.2 Nuclear Event Release Summary - 1990 5-4
Table 5.3 Tritium in NTS Effluents - 1990 5-12
Table 5.4 Radionuclide Concentration Guides for Air and Water 5-16
Table 5.5 Airborne Gross Beta Concentrations on the NTS - 1990 5-18
Table 5.6 Airborne $^{239+240}$Pu Concentrations on the NTS - 1990 5-21
Table 5.7 Airborne ^{238}Pu Concentrations on the NTS - 1990 5-22
Table 5.8 Summary of All ^{85}Kr Concentrations - 1990 5-25
Table 5.9 Atypical NTS ^{85}Kr Concentrations - 1990 5-25
Table 5.10 Summary of 1990 NTS ^{85}Kr Concentrations with Atypical Values Omitted . . 5-26
Table 5.11 Summary of NTS ^{133}Xe Concentrations - 1990 5-26
Table 5.12 Airborne Tritium Concentrations on the NTS - 1990 5-28
Table 5.13 NTS Open Reservoir Gross Beta Analysis Results - 1990 5-31
Table 5.14 NTS Natural Spring Gross Beta Analysis Results - 1990 5-33
Table 5.15 NTS Containment Pond Gross Beta Analysis Results - 1990 5-36
Table 5.16 NTS Water Supply Well Radioactivity Averages - 1990 5-39
Table 5.17 NTS Drinking Water Sources - 1990 5-39
Table 5.18 Radioactivity in NTS Drinking Water - 1990 5-40
Table 5.19 Radium-226 Analysis Results for NTS Drinking Water - 1990 5-42
Table 5.20 NTS Boundary Gamma Monitoring Result Summary - 1990 5-43
Table 5.21 NTS TLD Control Station Comparison - 1984-1990 5-43
Table 5.22 Gross Beta Results at Air Surveillance Network Stations - 1989-90 5-49

Table 5.23 Gross Beta Results at Standby Air Surveillance Network Stations - 1990 . . 5-50
Table 5.24 Concentrations of ^{238}Pu and $^{239+240}Pu$ in Offsite Composited Air Samples - 1989-90 5-52
Table 5.25 Offsite Noble Gas Surveillance Results - 1990 5-56
Table 5.26 Offsite Tritium Surveillance Results - 1990 5-57
Table 5.27 Radionuclide Concentrations in Desert Bighorn Sheep Samples taken in 1989 5-59
Table 5.28 Radiochemical Results For Animal Samples - 1990 5-60
Table 5.29 Offsite Station TLD Results - 1990 5-62
Table 5.30 Offsite Fixed Station TLD Statistics - 1990 5-66
Table 5.31 Offsite Resident TLD Results - 1990 5-69
Table 5.32 Offsite Resident TLD Statistics - 1990 5-71
Table 5.33 Pressurized Ion Chamber Readings - 1990 5-73
Table 5.34 Tritium in Urine, Offsite Human Surveillance Program - 1990 5-75
Table 5.35 Milk Surveillance Network Results - 1990 5-78

Table 6.1 Summary of Annual Effective Dose Equivalent from NTS Operations during 1990 6-2

Table 7.1 Monthly Monitoring Results for NTS Potable Water Systems - 1990 7-3
Table 7.2 Water Chemistry Analysis for Potable Water Wells at the NTS - 1990 7-5
Table 7.3 Sampling Results that Exceeded Drinking Water Standards - 1990 7-6
Table 7.4 pH, BOD, and TSS in NTS Sewage Lagoon Influents - 1990 7-7
Table 7.5 Number of RCRA Samples Analyzed - 1990 7-8
Table 7.6 RCRA Constituents in NTS Sewage Lagoons - 1990 7-9
Table 7.7 Quantity of Waste Disposed of in Sanitary Landfills - 1990 7-11
Table 7.8 Summary of Liquified Gaseous Chemical Spill Tests - 1990 7-13
Table 7.9 Counts of Live Perennial Plants by Species on a 100 m^2 Baseline Plot in Southwestern Yucca Flat, 1987-1990, and Percent Change from 1987 to 1990 7-14
Table 7.10 Estimated Live Volumes (L/100 m^2) of Perennial Plants on a Baseline Plot in Southwestern Yucca Flat, 1987-1990, and Percent Change from 1987 to 1990 7-15
Table 7.11 Estimated Densities of the Lizard *Uta stansburiana* in Summer 1990 on the Yucca Flat Baseline Plot, NTS 7-16
Table 7.12 Estimated Spring 1990 Densities of Mammals on the Yucca Flat Baseline Plot, NTS 7-16
Table 7.13 Perennial Plant Species and Numbers of Live and Dead Shrubs and Grasses on Two 1950s Blast Areas and Adjacent Control Areas, NTS - 1990 7-17
Table 7.14 Number of Species and Individual Animals Trapped on 1.1 Hectare Plots on Two Ground Zeroes and Control Areas on Yucca Flat - 1990 7-18

Table 9.1 Water Samples Containing Man-Made Radioactivity 9-4
Table 9.2 Summary of Long-Term Hydrological Monitoring Program Information 9-9
Table 9.3 Summary of Trends in Tritium in Sampled Groundwater 9-16
Table 9.4 LTHMP Results for the NTS Semi-Annual Network - 1990 9-19
Table 9.5 LTHMP Tritium Results for the Monthly NTS Network - 1990 9-23
Table 9.6 LTHMP Non-NTS Locations Water Sample Results - 1990 9-34
Table 9.7 Locations Having Device-Related Tritium in Groundwater 9-39

List of Tables, cont.

Page

Table 9.8 Tatum Salt Dome Events Summary 9-42
Table 9.9 Result of Tatum Dome Test Site Monitoring - 1990 9-44

Table 10.1 Results of EPA/EMSL-LV Nuclear Radiation Assessment and Cross Checks - 1990 10-5
Table 10.2 Results of the DOE/EML Quality Assessment Program - 1990 10-8

Table 11.1 NIOSH PAT Program Interlaboratory Comparison - 1990 11-3
Table 11.2 CAP Program Interlaboratory Comparison - 1990 11-7
Table 11.3 AAR Program Interlaboratory Comparison - 1990 11-8

Table 12.1 Standards Used to Evaluate Compliance with ICRP and National Authorities 12-3
Table 12.2 Offsite Surveillance QA Samples and Analyses for Duplicate Sampling Program - 1990 12-8
Table 12.3 Offsite Surveillance QA Sampling and Analytical Precision - 1990 12-9
Table 12.4 EPA QA Intercomparison Results - 1990 12-10
Table 12.5 QA Results from DOE Program - 1990 12-13
Table 12.6 QA Results for the Bioenvironmental Program - 1990 12-14

5458

MEASUREMENT UNITS AND NOMENCLATURE

Radioactivity data in this report are expressed in curies, microcuries (one millionth of a curie), and picocuries (one millionth of a millionth). The curie (Ci) is the fundamental unit used to express the rate of radiations being produced from atomic nuclei transformations each second. A curie is 37 billion (37×10^9) nuclear transformations per second. The unit of becquerel is also used. A becquerel (Bq) is equal to one disintegration per second; therefore, it takes 3.7×10^{10} bequerels to make one curie.

The roentgen (R) is the fundamental unit used to describe the intensity of gamma radiation at a given measurement point (in air). The radiation exposure rate to external sources of penetrating radioactivity is expressed in milliroentgens per hour (mR/h), or one-thousandth of a roentgen per hour. A typical radiation exposure rate from natural radioactivity of cosmic and terrestrial sources is 0.005 to 0.025 mR/h.

The rem (for roentgen equivalent man) is a unit describing dose equivalent, or the energy imparted to human tissue when exposed to radiation. Dose is expressed in rem, millirem (mrem), or microrem (μrem). A typical annual dose rate from natural radioactivity (excluding exposure to radon in homes) is 100 to 130 mrem per year. The unit of sievert (Sv) is also used. One sievert is equivalent to 100 rem.

The elements and corresponding symbols used in this report are:

Element	Symbol	Element	Symbol
Actinium	Ac	Lead	Pb
Americium	Am	Polonium	Po
Argon	Ar	Plutonium	Pu
Boron	B	Protactinium	Pa
Beryllium	Be	Radium	Ra
Bismuth	Bi	Rhodium	Rh
Carbon	C	Radon	Rn
Calcium	Ca	Ruthenium	Ru
Cerium	Ce	Sulfur	S
Colbalt	Co	Antimony	Sb
Cesium	Cs	Strontium	Sr
Hydrogen	H	Technetium	Tc
Iodine	I	Thallium	Tl
Potassium	K	Thorium	Th
Krypton	Kr	Thulium	Tm
Lithium	Li	Tritium	^3H
Lutetium	Lu	Uranium	U
Nitrogen	N	Xenon	Xe
Oxygen	O		

018

LIST OF ACRONYMS AND EXPRESSIONS

AAR	AIHA Asbestos Analysts Registry
AEC	U.S. Atomic Energy Commission
AIHA	American Industrial Hygiene Association
AIRDOSE-PC	EPA software program for estimating doses
ALARA	as low as reasonably achievable
ALI	Annual Limit of Intake
ANSI	American National Standard Institute
ASME	American Society Mechanical Engineer
ASN	Air Surveillance Network
AVO	Amador Valley Operations, EG&G/EM
BECAMP	Basic Environmental Compliance and Monitoring Program
BNA	base/neutral/acid
BOD	biochemical oxygen demand
BWMF	Bulk Waste Management Facility
BWMS	Bulk Waste Management Site
CAA	Clean Air Act
CAP	College of American Pathologists
CCSD	Clark County Sanitation District
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
COD	chemical oxygen demand
CP	Control Point
CRMP	Community Radiation Monitoring Program (EMSL-LV)
CX	Categorical Exclusion
DAC	Derived Air Concentration
DCG	Derived Concentration Guide
DF	diesel fuel
DNA	Defense Nuclear Agency
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE/HQ	DOE Headquarters
DOE/NV	DOE, Nevada Operations Office
DOI	U.S. Department of Interior
DOT	U.S. Department of Transportation
DQO	Data Quality Objectives
DRI	Desert Research Institute
DSC	discrete state compartment
DWB	DOE, Defense Waste Branch
EA	Environmental Assessment
EG&G	EG&G, Inc.
EG&G/EM	EG&G/Energy Measurements, Inc.
E-MAD	Engine Maintenance and Dissassembly
EML	DOE Environmental Measurements Laboratory
EMSL-LV	EPA Environmental Monitoring Systems Laboratory, Las Vegas
EOD	Explosive Ordnance Disposal
EPA	U.S. Environmental Protection Agency

List of Acronyms, cont.

EPTox	extraction procedure toxicity
ESA	Endangered Species Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GCD	Greater Confinement Disposal
GIS	geographical information system
GOES	geostationary operational environmental satellite
GZ	ground zero
HEPA	high-efficiency particulate aerosol
HPD	REECo Health Physics Department
HRMP	Hydrology/Radionuclide Migration Program (DRI)
HTO	tritiated water
ICP	inductively coupled plasma
ICRP	Internal Commission on Radiation Protection
ID	identification
IHD	REECo Industrial Hygiene Department
IRCR	International Reference Center for Radioactivity
KAFB	Kirtland Air Force Base
KO	Kirtland Operations, EG&G/EM
LANL	Los Alamos National Laboratory
LAO	Los Alamos Operations, EG&G/EM
LDAS	REECo Laboratory Data Analysis System
LDR	Land Disposal Regulations
LGFSTF	Liquified Gaseous Fuels Spill Test Facility
LINAC	DOE-EG&G/EM linear accelerator
LLD	lower limit of detection
LLNL	Lawrence Livermore National Laboratory
LLW	low-level (radioactive) waste
LTHMP	Long-Term Hydrological Monitoring Program (EMSL-LV)
LVAO	Las Vegas Area Operations, EG&G/EM
MCL	Maximum Contaminant Levels
MDC	minimum detectable concentration
MGD	million gallons per day
MBAS	methylene blue active substances
MSL	mean sea level
MSN	Milk Surveillance Network (EMSL-LV)
MWMF	Mixed Waste Management Facility
MWMU	Mixed Waste Management Unit
NAC	Nevada Administrative Code
NAEG	Nevada Applied Ecology Group
NAFB	Nellis Air Force Base
NCR	nonconformance report
NCRP	National Council on Radiation Protection and Measurement
NDEP	Nevada Division of Environmental Protection
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEST	Nuclear Emergency Search Team
NGTSN	Noble Gas and Tritium Surveillance Network (EMSL-LV)
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology

5453

NLV	North Las Vegas, Nevada
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
NPL	National Priority List
NRACC	Nuclear Radiation Assessment Cross Check Program (EMSL-LV)
NRC	National Response Center
NRD	EMSL-LV Nuclear Radiation Assessment Division
NRDS	Nuclear Rocket Development Station
NRS	Nevada Revised Statutes
NTS	Nevada Test Site
NTSO	DOE Nevada Test Site Operations Office
NVLAP	National Voluntary Laboratory Accreditation Program
offsite	in the immediate area off the NTS
onsite	on the NTS
O&M	Operations and Maintenance
OP	Operating Permit
PAT	NIOSH Proficiency Analytical Testing Program
PCB	polychorinated biphenyl
PHS	U.S. Public Health Service
PIC	pressurized ion chamber
ppb	parts per billion
ppm	parts per million
PTC	permit to construct
QA	quality assurance
QAP	Quality Assessment Program
QC	quality control
RAM	remote area monitor
RC	residual chlorine
RCRA	Resource Conservation and Recovery Act
R&D	Research and Development
REECo	Reynolds Electrical & Engineering Company, Inc.
RIDP	Radionuclide Inventory and Distribution Program
RI/FS	remedial investigation and feasibility study
RPD	relative percent difference
RSTN	Remote Seismic Test Network
RWMS	Radioactive Waste Management Site
s	sample standard deviation
SAM	Sample and Analysis Management System
SARA	Superfund Amendments and Reauthorization Act
SASN	Standby Air Surveillance Network (EMSL-LV)
SBO	Santa Barbara Operations, EG&G/EM
SCARS	System Control and Receiving Station
SDWA	Safe Drinking Water Act
se	standard error of the mean
SEE	specific effective energy
sem	standard error of the mean
SGZ	surface ground zero
SLB	shallow land burial
SLD	shallow land disposal

021

List of Acronyms, cont.

SMS	Strategic Materials Storage
SMSN	Standby Milk Surveillance Network (EMSL-LV)
SNL	Sandia National Laboratory
SOP	Standard Operating Procedure
STL	Special Technologies Laboratory, EG&G/EM
TCLP	toxicity characteristic leaching procedure
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TP	TRU Pad
TRU	transuranic
TSCA	Toxic Substances Control Act
TSI	Thermal System Insulation
TSS	total suspended solids
TTR	Tonopah Test Range
UCLA	University of California, Los Angeles
UNLV	University of Nevada, Las Vegas
UOR	Unusual Occurrence Report
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	underground storage tank
UTM	Universal Transmercater
VOC	volatile organic compound
WAMD	Washington Aerial Measurements Department, EG&G/EM
WCO	Woburn Cathode Ray Tube Operations, EG&G/EM
WEB	Waste Examination Building
WHO	World Health Organization
WIPP	Waste Isolation Pilot Plant

1.0 SUMMARY

- 5459

Stuart C. Black and Donald T. Wruble

Monitoring and surveillance on and around the NTS by DOE contractors and Site user organizations during 1990 indicated that underground nuclear testing operations were conducted in compliance with regulations, i.e., the dose the maximally exposed offsite individual could have received was less than 0.05 percent of the guideline for air exposure. All discharges of radioactive liquids remained onsite in containment ponds, and there was no indication of potential migration of radioactivity to the offsite area through groundwater. Surveillance around the NTS indicated that airborne radioactivity from test operations was not detectable offsite, and no measurable net exposure to members of the offsite population was detected through the offsite dosimetry program. Using the AIRDOS-PC model and NTS radionuclide emissions data, the calculated maximum effective dose equivalent offsite would have been 4.7×10^{-3} mrem. Any person receiving this dose was also exposed to 123 mrem from natural background radiation. There were no nonradiological releases to the offsite area. Hazardous wastes were shipped to EPA-approved disposal facilities. Compliance with the various regulations stemming from the National Environmental Policy Act is being achieved and, where mandated, permits for air and water discharges and waste management have been obtained from the appropriate agencies.

Non-NTS support facilities complied with the requirements of air quality permits and state or local wastewater discharge and hazardous waste permits.

1.1 ENVIRONMENTAL MANAGEMENT

The DOE Nevada Operations Office (DOE/NV) is committed to increase the quality of its management of NTS environmental resources. This has been promoted by the establishment of an Environmental Protection Division and a Health Protection Division within the Office of Environment, Safety, and Health that work with the Environmental Restoration and Waste Management Division to address those environmental issues that arise in the course of performing the primary mission of the DOE/NV, underground testing of nuclear explosive devices. An environmental survey in 1987 and a Tiger Team assessment in 1989 identified numerous issues that must be resolved before DOE/NV can be considered in full compliance with environmental laws and regulations. At the end of 1990, 20 of the 105 environmental survey items and 38 of 149 Tiger Team findings remain to be addressed. Some of the remaining items require more time and funding before they can be completed. Progress on corrective actions to bring operations into compliance is reported to DOE Headquarters Environment and Health in a Quarterly Compliance Action Report.

Operational releases of radioactivity are reported soon after the occurrence to the Idaho National Engineering Laboratory through an Unusual Occurrence Report. In compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP), the data from these reports each year are cumulated and used as input to EPA's AIRDOS software program to

023

calculate annual effective dose equivalents to people living beyond the boundaries of the NTS and the surrounding exclusion areas.

1.2 RADIOLOGICAL ENVIRONMENT

Radiological effluents in the form of air emissions and liquid discharges are released into the environment as a routine part of operations on the NTS. Radioactivity in liquid discharges released to onsite waste treatment or disposal systems (containment ponds) is monitored to assess the efficacy of treatment and control and to provide a quantitative and qualitative annual summary of the radioactivity released onsite. Air emissions are monitored for source characterization and operational safety as well as environmental surveillance purposes.

Air emissions in 1990 consisted primarily of small amounts of radioactive xenon, krypton, argon, and tritium released to the atmosphere during:

- Post-test drilling, mining, and/or sampling operations for four 1990 underground nuclear tests.
- Continuing seepage of radioactive noble gases from a 1989 test (which varied with atmospheric pressure changes) that began with post-test sampling operations in 1989.

There was no "prompt venting" (dynamic release of radioactivity within the first hour following a test) from any of the eight announced underground nuclear tests. Approximately 66 curies of radioactivity were released as a result of gaseous seepage to the surface or small releases during post-test operations for recovery of drilling cores and other samples from the underground detonation vicinity. Table 1.1 shows the quantities of radionuclides released. None of the radioactive materials listed in this table were detected offsite.

Onsite liquid discharges to containment ponds included a total of 220 curies of tritium. An additional 450 curies were released to the Area 5 Radionuclide Migration Study ditch and pond (see Section 5.1.2 for a complete description) for a total NTS release of 670 curies to onsite ponds. Evaporation could have contributed tritiated water vapor to the atmosphere, but the amounts were too small to be detected by the tritium monitors offsite. No known liquid effluents were discharged offsite.

1.2.1 OFFSITE MONITORING

The offsite radiological monitoring program is conducted around the NTS by the EPA's Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV), under an Interagency Agreement. This program consists of several extensive environmental sampling, radiation detection, and dosimetry networks.

In 1990 the Air Surveillance Network (ASN) was made up of 33 continuously operating sampling locations surrounding the NTS and 78 standby stations (operated one or two weeks each quarter) in all states west of the Mississippi River. The 33 ASN stations included 18 located at Community Radiation Monitoring Program (CRMP) stations, described below. During 1990 no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from the ASN. Other than naturally occurring ^{7}Be, the only specific radionuclide detected by this network was ^{238}Pu on one composite air filter sample from Rachel, Nevada, in March 1990.

The Noble Gas and Tritium Surveillance Network (NGTSN) consisted of 19 offsite sampling stations (outside of the NTS and exclusion areas) in 1990. In addition to 18 CRMP stations, there was a NGTSN station at Lathrop Wells, Nevada. At Pioche and Amargosa Center, Nevada, and Salt Lake City, Utah, samples were collected for tritium analysis but not for noble gas. During 1990 no NTS-related radioactivity was detected at

5459

Table 1.1 Radionuclide Emissions on the NTS - 1990

Radionuclide	Half-life (years)	Quantity Released (Ci)
Airborne Releases		
^{3}H	12.35	28
^{37}Ar	0.096	2.4
^{39}Ar	269	0.0013
^{85}Kr	10.72	4.4
^{131m}Xe	0.0326	1.2
^{133}Xe	0.0144	30
^{133m}Xe	0.0071	0.18
^{135}Xe	0.001	0.08
^{131}I	0.022	0.0013
^{133}I	0.0024	0.0002
Tunnel and Radionuclide Migration Ponds		
^{3}H	12.35	670
^{238}Pu	87.743	0.0000064
$^{239+240}Pu$	24065	0.00026
^{90}Sr	29	0.08
^{131}I	0.022	0.00058
^{137}Cs	30.17	0.012
Gross Beta	---	0.013

any NGTSN sampling station. As in previous years, results for xenon and tritium were typically below the minimum detectable concentration (MDC). The results for krypton, although exceeding the MDC, were within the range of worldwide values expected from sampling background levels. The annual arithmetic average for ^{85}Kr was 26.4×10^{-12} µCi/mL, similar to last year's level.

Sampling of Long-Term Hydrological Monitoring Program (LTHMP) wells and surface waters around the NTS showed only background radionuclide concentrations. The LTHMP also included groundwater and surface water monitoring at locations in Alaska, Colorado, Mississippi, New Mexico, and Nevada where underground tests were conducted. The results obtained from analysis of samples collected at those locations were consistent with previous data. At the request of Senator Lott (Mississippi), more extensive collecting and analyzing of samples from the Tatum Salt Dome area near Baxterville, Mississippi (the site of Project Dribble events that began in 1964), was conducted. There were no concentrations of radioactivity of any health significance detected in water, milk, vegetation, soil, fish, or animal samples.

The Milk Surveillance Network (MSN) consisted of 26 sampling locations within 300 kilometers of the NTS and 109 Standby Milk Surveillance Network (SMSN) locations throughout the Western U.S., except Texas. Tritium was detected in one SMSN sample. Radiostrontium above the MDC was found in four samples at two different locations in the MSN during the year. Seventeen samples from the SMSN contained detectable ^{90}Sr

025

that was attributed to worldwide fallout. The levels in the SMSN have tended to decrease over time since peaking in 1964.

Other foods were analyzed regularly, most of which were meat from domestic or game animals collected on and around the NTS. The radionuclide most frequently found in the edible portion of the sampled animals was ^{137}Cs. However, the concentrations of ^{137}Cs have been near the MDC since 1968. The ^{90}Sr levels in samples of animal bone remained very low, as did $^{239+240}Pu$ in both bone and liver samples. Carrots, beets and potatoes from several offsite locations contained no detectable radioactivity other than normal ^{40}K.

External exposure was monitored by a network of thermoluminescent dosimeters (TLDs) at 134 fixed locations surrounding the NTS and by TLDs worn by 71 offsite residents (Figure 4.11 shows the locations). No apparent net exposures were related to NTS activities. There were no apparent net exposures above natural background when tests for statistical significance of variation were applied. The range of exposures measured, varying with altitude and soil constituents, was similar to the range of such exposures found in other areas of the U.S. The average absorbed dose over all stations was 79.0 mrem and for all monitored persons was 76.2 mrem.

Internal exposure was assessed by whole-body counting through use of a single germanium detector, lung counting with six semi-planar detectors, and bioassay through radiochemical procedures. In 1990 counts were made on 236 individuals, of whom 120 were participants in the Offsite Human Surveillance Program. In general, the spectra obtained were representative of natural background with only normal ^{40}K being detected. No transuranics were detected in any lung counting data. Physical examination of offsite residents revealed only a normal, healthy population consistent with the age and sex distribution of that population.

No radioactivity attributable to NTS operations was detected by any of the monitoring networks. However, based on the NTS releases reported in Section 5, Table 5.1, atmospheric dispersion model calculations (AIRDOS-PC) indicated that the maximum effective dose equivalent to any offsite individual would have been 4.7×10^{-3} mrem (4.7×10^{-5} mSv), and the dose to the population within 80 kilometers of the NTS Control Point would have been 1.5×10^{-2} person-rem (1.5×10^{-4} person-Sv). The hypothetical person receiving that dose was also exposed to 123 mrem from natural background radiation. A summary of the effective dose equivalents due to operations at the NTS is presented in Table 1.2. In the unlikely event that a certain mule deer had been collected by a hunter rather than by EMSL-LV personnel, that hunter could have received a dose equivalent of 6×10^{-3} mrem (6×10^{-5} mSv) if the hunter had eaten all the kidney and meat from the deer. This would be a negligible additional exposure.

A network of CRMP stations is operated by local residents. Each station is an integral part of the ASN, NGTSN, and TLD networks. In addition, they are equipped with a pressurized ion chamber connected to a gamma-rate recorder. Each station also has satellite telemetry transmitting equipment so that gamma exposure measurements acquired by the pressurized ion chambers are transmitted via the geostationary operational environmental satellite to the NTS and from there to the EMSL-LV by dedicated telephone line. Samples and data from these stations are analyzed and reported by EMSL-LV and interpreted and reported by the Desert Research Institute, University of Nevada System.

Data from these stations are an integral part of the environmental monitoring networks. All measurements for 1990 were within the normal background range for the U.S.

1.2.2 ONSITE MONITORING

The onsite environmental surveillance program consists of 52 air sampling stations

Table 1.2 Summary of Annual Effective Dose Equivalent from NTS Operations during 1990

	Maximum Dose at NTS Boundary[a]	Maximum dose to an Individual[b]	Collective Dose to Population within 80 km of the NTS Control Point
Dose	8.9×10^{-3} mrem (8.9×10^{-5} mSv)	$6 \pm 0.6 \times 10^{-3}$ mrem (6×10^{-5} mSv)	1.5×10^{-2} person-rem (1.5×10^{-4} person-Sv)
Location	Site boundary 30 km south of NTS CP-1 at 191°	Crystal, Nevada, 52 km south of NTS CP-1	7700 people within 80 km of NTS CP-1
NESHAP Standard	-----	10 mrem per year (0.1 mSv per year)	-----
Percentage of NESHAP	-----	6×10^{-2}	-----
Background	123 mrem (1.2 mSv)	123 mrem (1.2 mSv)	759 person-rem (7.6 person Sv)
Percentage of Background	7.2×10^{-3}	5×10^{-3}	2×10^{-3}

(a) The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the NTS boundary located 30 km from CP-1 in the direction 191° south.

(b) The maximum individual dose is to an individual outside the NTS boundary at a residence where the highest dose-rate occurs as calculated by AIRDOS-PC (Version 3.0) using NTS effluents listed in Table 5.1 and assuming all tritiated water input to containment ponds was evaporated.

collecting particulates and reactive gases; 17 samplers collecting atmospheric moisture for tritium analysis; 7 samplers collecting samples for noble gas analysis; 59 water sampling locations that include wells, springs, reservoirs, and ponds onsite; and 184 locations where TLDs are positioned for measurement of external gamma exposures. The locations of these environmental surveillance stations are shown in Section 4, Figures 4.1 through 4.4.

Most of the radioactive air effluents on the NTS in 1990 arose from underground nuclear explosives tests conducted by the Defense Nuclear Agency/Department of Defense; Lawrence Livermore National Laboratory; and Los Alamos National Laboratory. The primary release mechanism for these effluents was operational activities such as drill-backs, mine-backs, and tunnel purgings. Seepage of noble gases through the soil column to ground surface was a minor contributor to the measured effluents. The radioactive air effluents summarized in Table 1.2 are described specifically in Section 5, Table 5.2.

Approximately 2700 air samples were analyzed by gamma spectroscopy. Only six of these samples contained fission products, and these levels were all less than 10^{-15} µCi/mL. Plutonium analyses of monthly composited air filters indicated an annual arithmetic average of less than 10^{-16} µCi/mL for $^{239+240}Pu$ and about 10 percent of that level for ^{238}Pu. A slightly higher average was

found in samples from the Bulk Waste Management Facility (BWMF), but that level was calculated to be only 0.01 percent of the Derived Air Concentration. Higher than background levels of plutonium are to be expected in some air samples because atmospheric testing in the 1950s and nuclear safety tests (where chemical explosives are used to blow apart nuclear devices) deposited plutonium on the surface of the NTS.

The annual average concentration of ^{85}Kr from the seven noble gas monitoring stations was 24 x 10^{-12} µCi/mL, which is somewhat less than the average reported by EMSL-LV for the offsite network. This concentration is similar to that reported in previous years and is attributed to worldwide distribution of fallout from the use of nuclear technology. As has been the case in the past, the ^{133}Xe results were below the detection limit except for a few instances when ^{133}Xe seeped through the ground after an underground test.

Throughout the year atmospheric moisture was collected for two-week periods at 17 locations on the NTS and analyzed for tritiated water content (HTO). The annual arithmetic average of (6.9 ± 11) x 10^{-12} µCi/mL was similar to last year's average. The locations with the highest concentrations were those near the Radioactive Waste Management Site (RWMS) in Area 5, as would be expected, and at the Area 15 EPA Farm, which probably reflects a contribution from the SEDAN crater.

The primary radioactive liquid discharge to the onsite environment in 1990 was water pumped from the well in Area 5 used for the Radionuclide Migration Study. Almost one billion (10^9) liters containing 454 curies of tritium were pumped from the well and discharged to a ditch. Seepage from the test tunnels in Rainier Mesa (Area 12) contributed 71 million liters of water containing 216 curies of tritium to containment ponds near the tunnels. Contaminated water discharges to the pond for the Area 6 Decontamination Facility (used for equipment decontamination) contributed 2.3 x 10^{-3} curies of tritium to the pond.

Surface water sampling was conducted at 15 open reservoirs, 7 springs, 10 containment ponds, and 3 sewage lagoons. A grab sample was taken each month from each of these surface water sites for analysis of gross beta, tritium, and gamma-emitter concentrations. Each quarter a sample was taken for plutonium analysis, and ^{90}Sr was analyzed once per year.

Water samples from the springs, reservoirs, and lagoons contained background levels of gross beta, tritium, plutoniums, and strontium. Samples collected from the tunnel containment ponds, Area 6 Decontamination Facility pond, and Reynolds Electrical & Engineering Company, Inc. (REECo), Radiological Laboratory pond contained elevated levels of radioactivity as would be expected. Water samples collected from Well U5e contained tritium at concentrations exceeding the National Primary Drinking Water Regulation level of 2 x 10^{-5} µCi/mL, but it was not used for drinking.

Onsite water derived from onsite drinking water wells and industrial-use distribution systems was sampled and analyzed monthly for gross beta, gross alpha, ^{90}Sr, ^{3}H, ^{238}Pu, $^{239+240}Pu$, and gamma-emitting radionuclides. The network average gross beta activity of 5.6 x 10^{-9} µCi/mL was 2.0 percent of the Derived Concentration Guide (DCG) for ^{40}K (used for comparison purposes); gross alpha was 3.6 x 10^{-9} µCi/mL, which was below the screening level of 5 x 10^{-9} µCi/mL; ^{90}Sr was 4.3 x 10^{-10} or 5 percent of the DCG; ^{3}H was 7.8 x 10^{-8} µCi/mL or 0.4 percent of the DCG; $^{239+240}Pu$ was 1.3 x 10^{-11} µCi/mL or 0.04 percent of the DCG, and ^{238}Pu with the same concentration was 0.03 percent of the DCG.

External gamma radiation exposure data from the onsite TLD network indicated the gamma exposure rates recorded during 1990 were not statistically different from the data collected in 1989. Recorded exposure rates

ranged from 69 mR/year in Mercury to 5581 mR/year in a contaminated area in Area 5. Average annual exposure rates at NTS boundary TLD stations ranged from 81 to 207 mR/year and the annual average for all onsite "control" stations (considered uncontaminated) was 110 mR/year.

Ecological studies related to environmental radioactivity on the NTS continued under the Basic Environmental Compliance and Monitoring Program (BECAMP). The studies included (1) investigating the movement of radionuclides on and around the NTS through horizontal movement, water-driven erosion, vertical migration, and wind-driven erosional resuspension; (2) development of a human dose-assessment model specifically for the environmental and radiological conditions of the NTS; (3) preparation of a peer-reviewed publication that will address the impact of activities on the NTS; and (4) monitoring of flora and fauna on the NTS to assess changes over time in the ecological condition of the NTS.

BECAMP experiments conducted at the NTS included resuspension monitoring at the CLEAN SLATE III site on the Tonopah Test Range and sensitivity and uncertainty analyses of the Nevada Applied Ecology Group dose assessment model (Kercher and Anspaugh 1989). A paper by Anspaugh, et al. (1990) provides a history of radiation-related monitoring and environmental research at the NTS. A paper by McArthur (1990) summarizes the results of the Radionuclide Inventory and Distribution Program for the NTS. Monitoring of the flora and fauna on the NTS suggests that the drought of the last few years has had more effect on these populations than any NTS activity has.

1.2.3 LOW-LEVEL WASTE DISPOSAL

Environmental monitoring at and around the low-level Area 5 RWMS and Area 3 BWMF indicated that no measurable radioactivity was detectable off the waste management site areas. This monitoring included air sampling, water sampling, tritium migration studies, and vadose zone monitoring for hazardous constituents.

Groundwater samples have not been collected from the 800-foot deep aquifer below the waste management facility since waste constituent migration times from the surface to the aquifer have been calculated to be on the order of thousands of years. An unsaturated zone (vadose zone) sampling system has been installed as a more timely and responsive method of detecting any downward migration of radioactive waste.

1.3 NONRADIOLOGICAL MONITORING

Nonradiological environmental monitoring of NTS operations involved onsite monitoring only because there were no nonradiological discharges offsite. The primary environmental permit areas for the NTS were monitored to verify compliance with air quality and the Resource Conservation and Recovery Act (RCRA) requirements. Air emissions sources common to the NTS included particulates from construction aggregate production, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. These emissions were covered by a series of 28 air quality permits from the state of Nevada. The only nonradiological air emission of regulatory concern under the Clean Air Act was asbestos removal during building renovation projects and from insulated piping at various locations onsite. These were reported to the EPA under NESHAP requirements.

RCRA-required monitoring included waste management and environmental compliance activities that necessitated the analysis of soil, water, sediment and oil samples. Low levels of targeted chemicals were found in several samples. The principal chemicals found were various phthalates in discharges to onsite sewage lagoons.

As there are no liquid discharges to navigable waters, offsite surface water drainage systems, or publicly owned treatment works, no Clean Water Act National Pollution Discharge Elimination System permits were required for NTS operations. Under the conditions of state of Nevada operating permits, liquid discharges to 14 onsite sewage lagoons are regularly tested for biochemical oxygen demand, pH, and total suspended solids. In addition to the state-required monitoring, these influents were also tested for RCRA-related constituents as an internal initiative to further protect the NTS environment. These results were reported to the state, and action guidance is pending state consideration.

In compliance with the Safe Drinking Water Act and five state of Nevada drinking water supply system permits for onsite distribution systems supplied by onsite wells, drinking water systems are sampled monthly for residual chlorine, pH, bacteria, and, less frequently, for other water quality parameters. Federal and state standards were slightly exceeded in five wells for fluorides, nitrates, pH, and dissolved solids. Mitigation procedures are being explored, although dilution with water from other wells is being used as a temporary expedient.

Monitoring for polychlorinated biphenols as required by the Toxic Substances Control Act involved analysis of 217 oil and 12 soil samples. Only 10 of the oil samples exceeded 500 ppm, and all the soil samples contained less than 1 ppm.

At the Liquified Gaseous Fuels Spill Test Facility, 129 spills that involved eight different chemicals were conducted during 1990. None of the spill constituents were detected at the NTS boundary during or after the spill tests.

Monitoring of flora and fauna on the NTS in control and disturbed areas indicated that the extended drought conditions that affected the Western U.S. had more effect on those populations than any human activity. This was also true for flora and fauna on a previously studied plot downwind of the Liquified Gaseous Fuels Spill Test Facility.

1.4 COMPLIANCE ACTIVITIES

Besides conducting the nuclear explosives testing program in compliance with the various radiation protection standards and guides as issued by the International Commission on Radiological Protection and national authorities, DOE/NV is required to comply with various environmental protection acts and regulations. Monitoring activities required for compliance with the Clean Air Act, Clean Water Act, Safe Drinking Water Act, Toxic Substances Control Act, and RCRA are summarized above. Also, National Environmental Policy Act activities included preparation of Environmental Assessments, one of which was approved and nine that are in various stages of processing. Five DOE Memoranda to File were written, and 121 Categorical Exclusion documentations were also completed.

A study to assess the air quality on the NTS measured CO, NO_x, SO_2, and suspended particulates at three active locations. All results for samples taken over a one-month period were well below the ambient air quality standards.

Wastewater discharges on the NTS are not regulated under National Pollutant Discharge Elimination System permits because all such discharges are to onsite sewage lagoons. Wastewater discharges from the non-NTS support facilities of EG&G Energy Measurements, Inc., were always under the regulated levels established by city or county publicly owned treatment works.

Sixteen underground storage tanks that contained, or had contained, petroleum products were either removed, closed in place, or temporarily closed. Of the eight tanks temporarily closed, five will be upgraded to meet stricter standards and three will be replaced with above-ground storage tanks.

In 1990, 22 pre-activity surveys required by the Archeological and Cultural History Preservation Act identified 60 sites on the NTS that contained previously unknown archeological information. In response to those findings, five data recovery plans were prepared, six data recovery programs were started, and four technical reports were issued.

1.5 GROUNDWATER PROTECTION

DOE/NV instituted the LTHMP in 1972 that is operated by the EMSL-LV under the above-mentioned Interagency Agreement. Groundwater was monitored on and around the NTS, at eight sites in other states, and at two off-NTS sites in Nevada to detect the presence of any radioactivity that might have been related to nuclear testing activities at those locations. No radioactivity was detected in the groundwater sampling network around the NTS. Tritium from the LONG SHOT test on Amchitka Island (released shortly after the test in 1965) contaminated the groundwater in the vicinity of the emplacement well. Also, during cleanup and disposal operations in 1972, shallow, non-potable groundwater at the Tatum Dome site in Mississippi was contaminated by tritium. The levels at both of these sites are decreasing and are well below the National Primary Drinking Water Regulation levels. NTS supply wells were monitored for gross alpha and beta activity, gamma activity, and tritium levels.

Because wells on the NTS that were drilled for water supply or exploratory purposes are used in the present monitoring program instead of wells that are drilled specifically for groundwater monitoring, an extensive program of well drilling for groundwater characterization has been started. The design of the program is for installation of approximately 90 wells at strategic locations on and near the NTS.

In 1990 a special study was conducted at the Tatum Salt Dome site that included sampling of vegetation, soil, animals, fish, and milk in addition to normal groundwater monitoring and some additional private well sampling. No test-related radioactivity was found outside the immediate vicinity of the emplacement hole marker at the Tatum Dome site, although there is some indication that tritium is moving slowly north in the shallow groundwater. The concentration in the monitoring holes near the surface ground zero has decreased somewhat faster than radioactive decay calculations would have indicated.

Other activities in 1990 included studies of groundwater transport of contaminants on the NTS (radionuclide migration studies) and nonradiological monitoring for water quality assessment and RCRA requirements.

1.6 RADIOACTIVE AND MIXED WASTE DISPOSAL

Two radioactive waste disposal facilities are operated on the NTS; the Area 5 RWMS and Area 3 BWMF. During 1990 the RWMS received low-level and mixed wastes generated at other DOE facilities. Waste is disposed of in shallow pits, trenches, and intermediate-depth, large-diameter augured shafts. Transuranic wastes are stored in surface containers pending shipment to the Waste Isolation Pilot Plant in New Mexico. The Area 3 BWMF is used for disposal of low-level waste that cannot be packaged for disposal at the Area 5 RWMS.

Environmental monitoring included air sampling, water sampling, tritium migration studies, and vadose zone monitoring for hazardous constituents. Environmental monitoring results for 1990 indicated that although the annual average $^{239+240}Pu$ measured on BWMF boundary air samples was slightly higher than general NTS levels and the HTO concentration at the boundary of the RWMS was slightly higher than overall NTS levels, no measurable radioactivity from waste disposal operations was detectable in air samples away from the waste disposal sites.

Hazardous waste disposal (RCRA-regulated) operations at the NTS require shipment of non-radioactive hazardous materials to licensed disposal facilities offsite. The only disposal of hazardous materials done at the NTS is the constituents of mixed waste received from the Rocky Flats Plant in Colorado. Currently, vadose monitoring for mixed waste disposal is accumulating baseline data. The data are being derived from neutron logging, gas chromatography, and gamma spectrometry.

Four studies that measure the migration of tritium from emplaced waste have been conducted by the University of California, Berkeley. The tritium release rates are low but tend to increase exponentially with time. The most recent report on these studies was published by the University of California, Los Angeles, in July 1990 and was titled "Tritium Migration Studies at the Nevada Test Site."

1.7 QUALITY ASSURANCE

The quality assurance (QA) program covering NTS activities has three components. There are QA programs for nonradiological analyses, onsite radiological analyses, and offsite radiological analyses conducted by EMSL-LV.

1.7.1 ONSITE NONRADIOLOGICAL QUALITY ASSURANCE

The nonradiological program included sample acceptance and control criteria, quality control (QC) procedures, and interlaboratory comparisons through participation in the National Institute of Occupational Safety and Health Proficiency Analytical Testing Program, the American Industrial Hygiene Association (AIHA) Asbestos Analysts Registry Program, the AIHA Bulk Asbestos Analysis Program, National Voluntary Laboratory Accreditation Program Bulk Asbestos Fiber Analysis Program, and the College of American Pathologists Analysis of Lead in Blood Program. Proficiency testing through participation in the EPA Contract Laboratory Program was continued.

1.7.2 ONSITE RADIOLOGICAL QUALITY ASSURANCE

The onsite radiological QA program included conformance to accepted procedures and provision for external quality assurance through participation in intercomparison programs. External quality assurance or radiological data consisted of participation in the DOE Quality Assessment Program administered by the DOE Environmental Measurements Laboratory (EML); participation in the Nuclear Radiation Assessment and Cross Check Program conducted by the EMSL-LV; and participation in the quality assessment program sponsored the World Health Organization International Reference Center for Radioactivity. Where applicable, the provisions of NQA-1 issued by ANSI/ASME were followed.

1.7.3 OFFSITE RADIOLOGICAL QUALITY ASSURANCE

The quality assurance program conducted by the Nuclear Radiation Assessment Division of EMSL-LV included standard operating procedures, data quality objectives, data validation, quality control, health physics oversight, and efforts to determine the precision and accuracy of analysis. Duplicate samples were analyzed for the ASN, NGTSN, Dosimetry Network, MSN, and LTHMP, and the data were used to estimate the precision of analysis. The coefficient of variation of replicate samples for these networks varied from a median value of 0.5 percent for the MSN to 17 percent for the LTHMP. The EPA to DOE/EML ratios from the DOE program for 1990 varied from 0.79 to 1.32, indicating good correlation between the two laboratories. The results of participation in the EPA QA Intercomparison Study Program indicated that the analytical procedures were in control.

5453

1.8 ISSUES AND ACCOMPLISHMENTS

Two principal compliance problems this year were the "Notice of Alleged Violation" issued by the state following an assessment of waste disposal operations and a continued uncertainty regarding listing of NTS areas under the Comprehensive Environmental Response and Compensation Liability Act. The Notice of Alleged Violation may affect receipt and storage of mixed transuranic waste.

Some of the accomplishments for 1990 include completion of four Agreements, progress on an active Waste Minimization Program, and significant progress on Environmental Survey and Tiger Team assessments.

The four compliance Agreements were (1) an Agreement on the American Indian Religious Freedom Act compliance program, (2) an *Astragalus beatleyea* Conservation Agreement under the Endangered Species Act, (3) an Agreement in Principle with the state of Mississippi for activities at the Tatum Dome Site, and (4) an Agreement in Principle with the state of Nevada for implementation of Environmental Survey and Tiger Team findings.

The Waste Minimization Program was expanded to include Site user organizations and offsite support facilities of DOE/NV contractors.

By the end of 1990, 85 of 105 action items identified in the 1987 Environmental Survey were closed. There was 149 findings from the Tiger Team assessment in 1989. All but 38 of those findings have been resolved, and work is in progress to complete those remaining by the end of 1991.

The environmental monitoring results presented in this report document the conduct of 1989 nuclear test operations with no detectable radiation exposure to the offsite public. Calculation of the highest individual dose that could have been received by an offsite resident (based on onsite measurement of radioactive releases to the atmosphere) equated to 0.00047 mrem. This may be compared to that individual's exposure to 123 mrem from natural background radiation.

There were no major incidents of nonradiological contaminant releases to the environment, and ever more intensive efforts to continue characterizing and protecting the NTS environment implemented in 1989 were continued in 1990.

033

2.0 INTRODUCTION

Stuart C. Black, H. Bruce Gillen, and Donald T. Wruble

The NTS, located in Southern Nevada, has been the primary location for testing of nuclear explosives in the continental U.S. since 1951. Historical testing has included (1) atmospheric testing in the 1950s and early 1960s, (2) underground testing in drilled, vertical holes and horizontal tunnels, (3) earth-cratering experiments, and (4) open-air nuclear reactor and engine testing. During 1990 eight underground nuclear tests at the NTS were announced by the DOE. Limited non-nuclear testing included spills of hazardous material at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF). Radioactive and mixed waste disposal facilities for U.S. defense waste were also operated on the NTS.

The NTS environment is characterized by desert valley and Great Basin mountain terrain and topography, with a climate, flora, and fauna typical of the Great Basin deserts of the southwest. Restricted access and extended wind transport times are notable features of the remote location of the NTS and adjacent U.S. Air Force lands. The area is also lacking in surface water, and great depths to slow-moving groundwaters are characteristic of this area. These features afford protection of surrounding residents from potential radiation exposures as a result of releases of radioactivity or other contaminants from nuclear testing operations. Population density within 150 kilometers of the NTS is only 0.5 persons per square kilometer versus approximately 29 persons per square kilometer in the 48 contiguous states. The predominant land use surrounding the NTS is open range used for livestock grazing with scattered mining and recreational areas.

In addition to the NTS, DOE/NV is responsible for nine non-NTS facilities operated by EG&G Energy Measurements, Inc. (EG&G/EM), in eight different cities. These facilities support the DOE/NV test program in activities ranging from aerial measurements and aircraft maintenance to the production of printed circuit boards. All of these facilities are located in metropolitan areas.

The EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV), conducts hydrological studies at eight continental U.S. nuclear testing locations off the NTS. No 1990 tests were conducted at these sites.

2.1 NTS OPERATIONS

2.1.1 NTS DESCRIPTION

The NTS is operated by the DOE as the on-continent test site for nuclear weapons testing, and is located in Nye County, Nevada, with the southeast corner lying about 56 miles (90 kilometers) northwest of the city of Las Vegas, Nevada, as shown in Figure 2.1. (This figure and other figures in this chapter were generated with a computer-based geographical information system

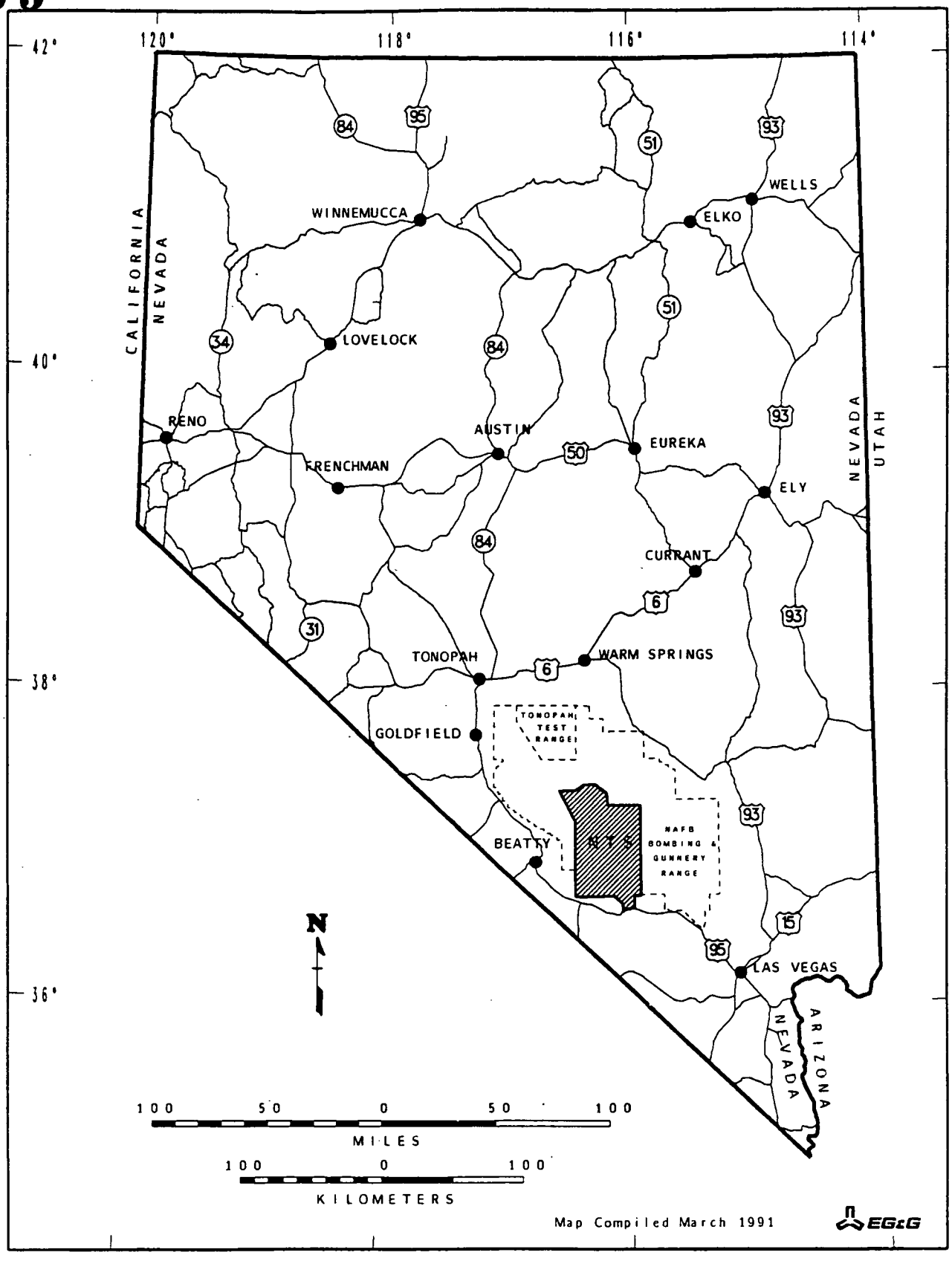


Figure 2.1 NTS Location

[GIS]. GIS-generated graphics in this report were prepared by EG&G Energy Measurements, Inc., Las Vegas, Nevada.) The NTS encompasses about 3500 square kilometers (1350 square miles), an area larger than the state of Rhode Island. The dimensions of the NTS vary from 46 to 56 kilometers (28 to 35 miles) in width (eastern to western border) and from 64 to 88 kilometers (40 to 55 miles) in length (northern to southern border). The NTS is surrounded on the east, north, and west sides by public access exclusion areas consisting of the Nellis Air Force Base (NAFB) Bombing and Gunnery Range and the Tonopah Test Range. These two areas comprise the NAFB Range Complex, which provides a buffer zone between the test areas and public lands. This buffer area varies from 24 to 104 kilometers (15 to 65 miles) between the test areas and public lands. The combination of the NAFB Range Complex and the NTS is one of the larger unpopulated land areas in the U.S., comprising some 14,200 square kilometers (5470 square miles). Figure 2.2 shows the general layout of the NTS, including the location of major facilities and area numbers referred to in this report. The shaded areas in Figure 2.2 indicate the principal geographical areas used for underground nuclear testing over the history of NTS operations. Mercury, Nevada, at the southern end of the NTS, is the main base camp for worker housing and administrative operations for the Site. Area 12 Base Camp, at the northern end of the Site, is the other major worker housing and operations support facility.

2.1.2 MISSION AND NATURE OF OPERATIONS

The NTS has been the primary location for testing the nation's nuclear explosive devices since January 1951. Tests conducted through the 1950s were predominantly atmospheric tests. These tests involved a nuclear explosive device detonated while on the ground surface, on a steel tower, suspended from tethered balloons, or dropped from an aircraft. Several of the tests were non-nuclear, i.e., "safety" tests, involving destruction of a nuclear device with non-nuclear explosives. Safety tests resulted in dispersion of plutonium in the test vicinity. One of these test areas lies just north of the NTS boundary on the NAFB Range Complex (see Figure 2.3). All announced tests are listed in DOE/NV report NVO-209 (1990).

Underground nuclear tests were first conducted in 1957. Testing was discontinued during a moratorium from October 1958 through September 1961. Four small atmospheric (surface) tests were conducted in 1961 and 1962 following the resumption of underground and atmospheric testing. Two additional safety test series were conducted in the mid-1960s, one on the NAFB Bombing and Gunnery Range and one on the Tonopah Test Range. Since late 1962 nearly all tests have been conducted in sealed (1) vertical shafts drilled into the valley floor of Yucca Flat and the top of Pahute Mesa or (2) horizontal tunnels mined into the face of Rainier Mesa. Six earth-cratering (shallow-burial) tests were conducted over the period of 1962 through 1968 as part of the Plowshare Program, which explored peaceful uses of nuclear explosives. Five of these were in the northwestern quadrant of the NTS. The largest (SEDAN) was detonated at the northern end of Yucca Flat.

Other nuclear testing over the history of the NTS has included the Bare Reactor Experiment - Nevada series of experiments in the 1960s. These tests were performed with a 14-MeV neutron generator mounted on a 1530-foot (465-meter) steel tower used to conduct neutron and gamma-ray interaction studies on shielding materials, electronic components, live organisms, and tissue-equivalent simulations for biomedical and environmental research. From 1959 through 1973 a series of open-air nuclear reactor, nuclear engine, and nuclear furnace tests were conducted in Area 25 at the Nuclear Rocket Development Station (now the Nevada Research and Development

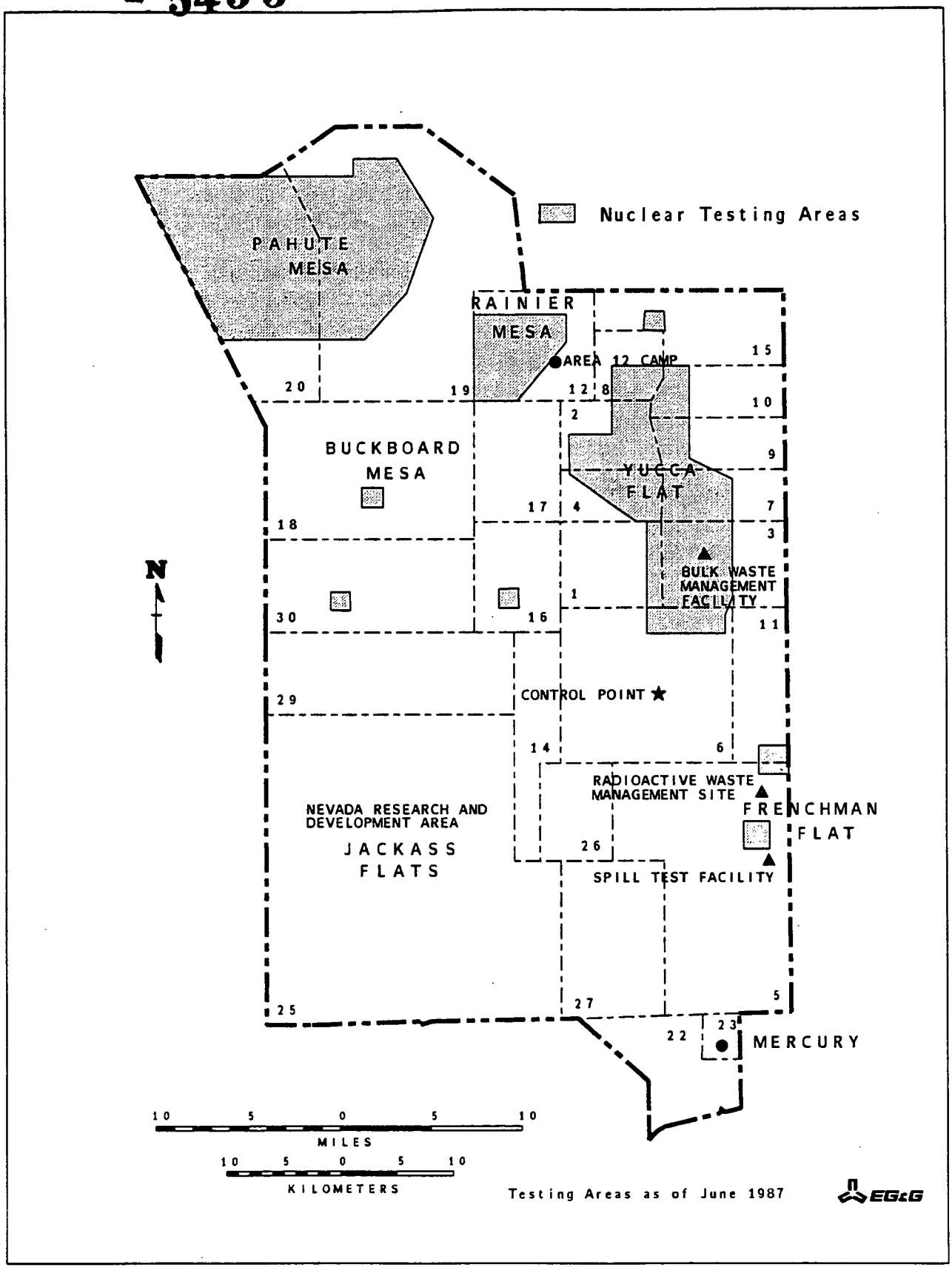


Figure 2.2 NTS Area Designations, Principal Facilities, and Testing Areas

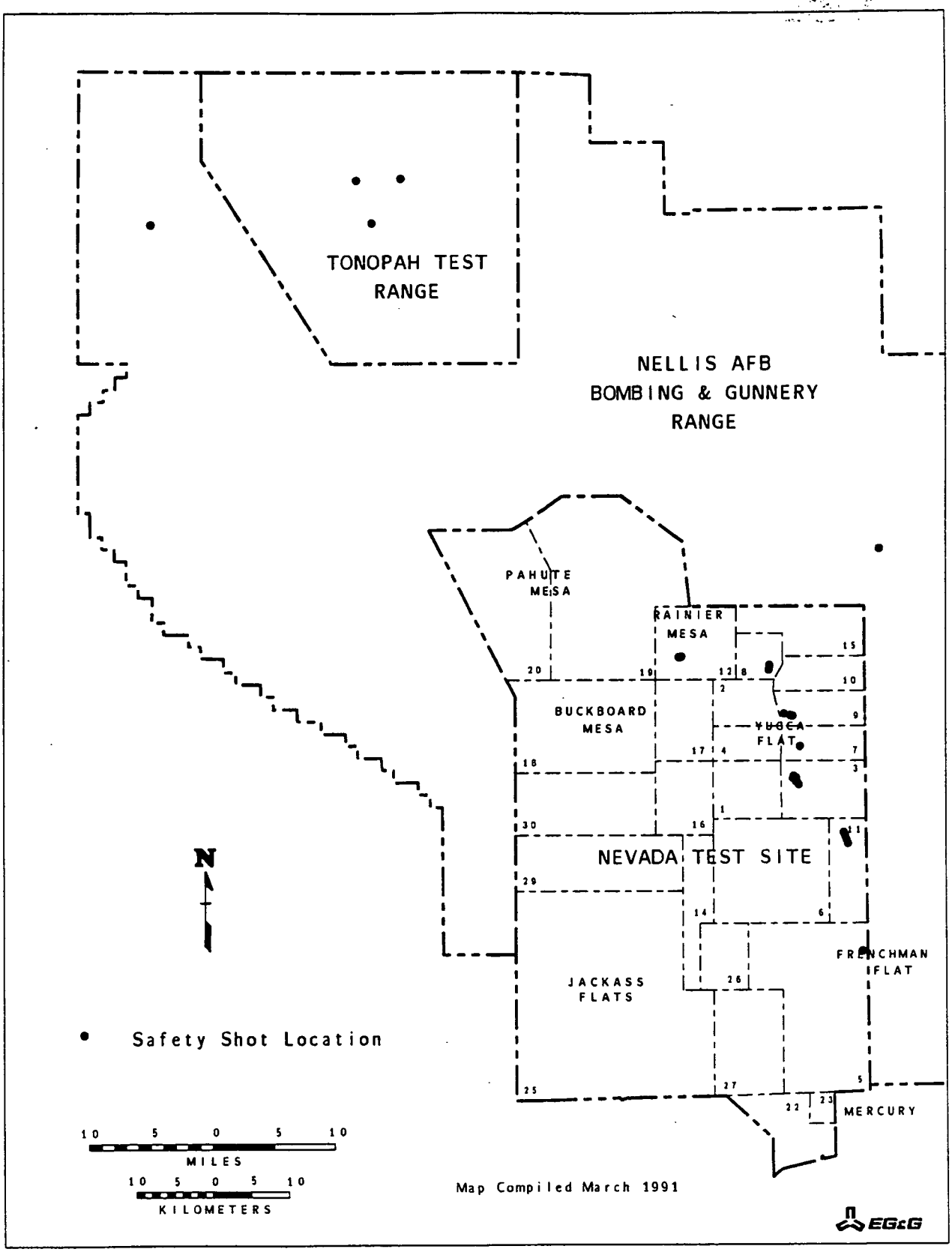


Figure 2.3 Location of Safety Shots in the NAFB Range Complex

038

Area). Another series of tests with a nuclear ramjet engine was conducted in Area 26 by the Lawrence Livermore National Laboratory, Livermore, California (LLNL).

Limited non-nuclear testing has also occurred at the NTS, including spills of hazardous materials at the LGFSTF in Area 5. These tests, conducted during the latter half of the 1980s and in 1990, involved controlled spilling of liquid materials to study (1) spill control and mitigation measures and (2) dispersion and transport of airborne clouds resulting from these spills. These tests are cooperative studies involving private industry, the U.S. Department of Transportation (DOT), and the DOE.

Waste disposal facilities for radioactive and mixed waste are also operated on the NTS for DOE defense waste disposal. Disposal sites are located in Area 5 and in Area 3. At the Area 5 Radioactive Waste Management Site (RWMS), low-level radioactive waste from DOE-affiliated onsite and offsite generators and mixed waste from one offsite generator (Rocky Flats) are disposed of using standard shallow land disposal techniques. The Greater Confinement Disposal facility consists of a 10-foot (3.05-meter) diameter shaft 120 feet (37.6 meters) deep and is located at the Area 5 RWMS. This facility is used for experimental disposal of wastes not suited for shallow land burial because of high specific activity or potential for migration into biopathways.

Transuranic wastes are retrievably stored in surface containers at the Area 5 RWMS pending shipment to the Waste Isolation Pilot Plant facility in New Mexico. Nonradioactive hazardous wastes are also accumulated at the Area 5 RWMS before shipment to an offsite disposal facility. At the Area 3 Bulk Waste Management Site, only low-level radioactive waste in bulk form (such as debris collected from atmospheric nuclear test locations) is emplaced and buried in surface subsidence craters (formed as a result of underground nuclear tests).

2.1.3 1990 TEST ACTIVITIES

2.1.3.1 NUCLEAR TESTS

The underground nuclear tests conducted during 1990 (the period covered by this annual NTS environmental report) were designed and conducted by two national laboratories and the Defense Nuclear Agency (DNA). The Los Alamos National Laboratory (LANL) of Los Alamos, New Mexico, and LLNL conducted tests in support of DOE nuclear testing program objectives. Sandia National Laboratories (SNL) of Albuquerque, New Mexico, supported tests conducted by the DNA, which uses the NTS as a nuclear testing facility under an agreement with the DOE.

The DOE announced eight underground nuclear tests at the NTS during 1990. A list of these tests is provided in Table 2.1. (A summary of the environmental monitoring observations for each of these tests is provided in Section 5, Table 5.2.)

Underground testing is carefully designed to ensure containment of the explosive energy and radioactivity resulting from each nuclear explosion. After the nuclear device and related diagnostic equipment are lowered into the prepared vertical shaft or emplaced in the excavated tunnel, the hole or tunnel is closed with a containment system. Vertical holes are back-filled with sand and gravel, and three to six solid plugs are spaced throughout (referred to as "stemming") to enhance containment capabilities. Stemming, including the plugs, forms a seal against leakage of gases to the atmosphere.

The stemming material in tunnel tests normally consists of rock-matching grout emplaced close to the device and backed up by varying types, amounts, and combinations of grout and other stemming materials. Some tests may include a "line-of-sight" pipe with mechanical closure systems in the pipe to contain radioactivity. In addition, several large concrete and steel plugs block the tunnel between the experimental area and

Table 2.1 Announced Underground Nuclear Tests at the NTS - 1990

Test Name	Date	Testing Organization
METROPOLIS	03/10/90	LLNL
BULLION	06/13/90	LLNL
AUSTIN	06/21/90	LANL
MINERAL QUARRY	07/12/90	DNA
SUNDOWN	09/20/90	LANL
LEDOUX	09/27/90	LANL
TENABO	10/12/90	LLNL
HOUSTON	11/14/90	LANL

the portal to afford added protection against the possibility of gas escaping from the stemmed area.

During and following each test, both onsite and offsite monitoring are conducted to document radioactivity that might be released to the atmosphere. Releases might occur immediately following a test as a result of dynamic release (called a "venting" or "prompt" release) of material through cracks, fissures, or the containment system. During later hours, days, or weeks, a release may also occur as a result of slow transfer of gases (seepage) through the soil and rock overburden or through controlled releases as part of post-test diagnostic and sampling operations. The onsite effluent detection and monitoring systems, onsite and offsite environmental surveillance systems, and 1990 results from these monitoring efforts are described in this report.

2.1.3.2 LIQUIFIED GASEOUS FUELS SPILL TEST FACILITY

A total of 129 spill tests were conducted at the LGFSTF in Area 5 of the NTS. (Monitoring results of these tests are shown in Section 7.) The LGFSTF is maintained by EG&G, Inc., and is the basic research tool for studying the dynamics of accidental releases of various hazardous materials. Discharges from the LGFSTF occur at a controlled rate and consist of a measured volume of hazardous test fluid on a surface especially prepared to meet the test requirements. LGFSTF personnel monitor and record operating data, close-in and downwind meteorological data, and downwind gaseous concentration levels. Calculation of the potential path of the test effluent is used to help control the test and monitor the data, which is done from a remote location. Spills of eight different chemicals under a variety of conditions were conducted in 1990 and the results monitored.

An array of diagnostic sensors may be placed up to 16 kilometers downwind of the spill point to obtain cloud-dispersion data. Deployment of the array is test dependent and is not used for all experiments. The array can consist of up to 20 meteorological stations to gather wind speed and wind direction data and up to 41 sensor stations to gather data from a variety of sensors at various levels above ground. The array and associated data-acquisition system are linked to the LGFSTF control point by means of telemetry. The operation and performance of the LGFSTF are controlled and monitored from the Command Control and Data Acquisition System building located one mile from the test fluid spill area.

040

2.1.4 TOPOGRAPHY AND TERRAIN

The topography of the NTS is typical of much of the Basin and Range physiographic province of Nevada, Arizona, and Utah. North-south-trending mountain ranges are separated by broad, flat-floored, and gently-sloped valleys. The topography is depicted in Figure 2.4. Elevations range from about 3000 feet (910 meters) above mean sea level (MSL) in the south and east, rising to 6900 feet (2100 meters) in the mesa areas toward the northern and western boundaries. The slopes on the upland surfaces are steep and dissected, whereas the slopes on the lower surfaces are gentle and alluviated with rock debris from the adjacent highlands.

The principal effect upon the terrain from nuclear testing has been the creation of numerous dish-shaped surface subsidence craters, particularly in Yucca Flat. Most underground nuclear tests conducted in vertical shafts produced surface subsidence craters created when the overburden above a nuclear cavity collapsed and formed a rubble "chimney" to the surface (Figure 2.5). A few craters have been formed as a result of tests conducted on or near the surface during atmospheric testing, by shallow depth-of-burial cratering experiments, or following tunnel events.

There are no continuously flowing streams on the NTS. Surface drainages for the Yucca Flat and Frenchman Flat are in closed-basin systems, which drain onto the dry lake beds (playas) in each valley. The remaining area of the NTS drains via arroyos and dry stream beds that carry water only during unusually intense or persistent storms. Rainfall or snow melt typically infiltrates quickly into the moisture-deficient soil or runs off in normally dry channels, where it evaporates or seeps into permeable sands and gravels. During extreme conditions, flash floods may occur. The surface drainage channel pattern for the NTS and its immediate vicinity is displayed in Figure 2.6. The northwest portion (Pahute Mesa) of the NTS has integrated channel systems which carry runoff beyond NTS boundaries into the closed basins and playas in Kawich Valley and Gold Flat on the NAFB Range Complex. The western half and southernmost part of the NTS have channel systems which carry runoff from intense storms towards the southern boundary of the NTS and offsite towards the Amargosa Desert.

2.1.5 GEOLOGY

The basic lithologic structure of the NTS is depicted in Figure 2.7. Investigations of the geology of the NTS, including detailed studies of numerous drill holes and tunnels, have been in progress by the U.S. Geological Survey and other organizations since 1951. As a result the geology of the NTS is probably one of the better characterized large areas within the U.S. The distribution of drill holes is shown in Figure 2.8.

In general the geology consists of three major rock units. These are (1) complexly folded and faulted sedimentary rocks of Paleozoic age overlain at many places by (2) volcanic tuffs and lavas of Tertiary age, which (in the valleys) are covered by (3) alluvium of late Tertiary and Quaternary age. The sedimentary rocks of Paleozoic age are many thousands of feet thick and are comprised mainly of carbonate rocks (dolomite and limestone) in the upper and lower parts, separated by a middle section of clastic rocks (shale and quartzite). The volcanic rocks in the valleys are down-dropped and tilted along steeply dipping normal faults of late Tertiary age. The alluvium is rarely faulted. Compared to the Paleozoic rocks, the Tertiary rocks are relatively undeformed, and dips are generally gentle. The alluvium is derived from erosion of the nearby hills of Tertiary and Paleozoic rocks.

The volcanic rocks of Tertiary age are predominantly tuffs, which erupted from various volcanic centers, and lavas, mostly of rhyolitic composition. The aggregate thickness of the volcanic rocks is many

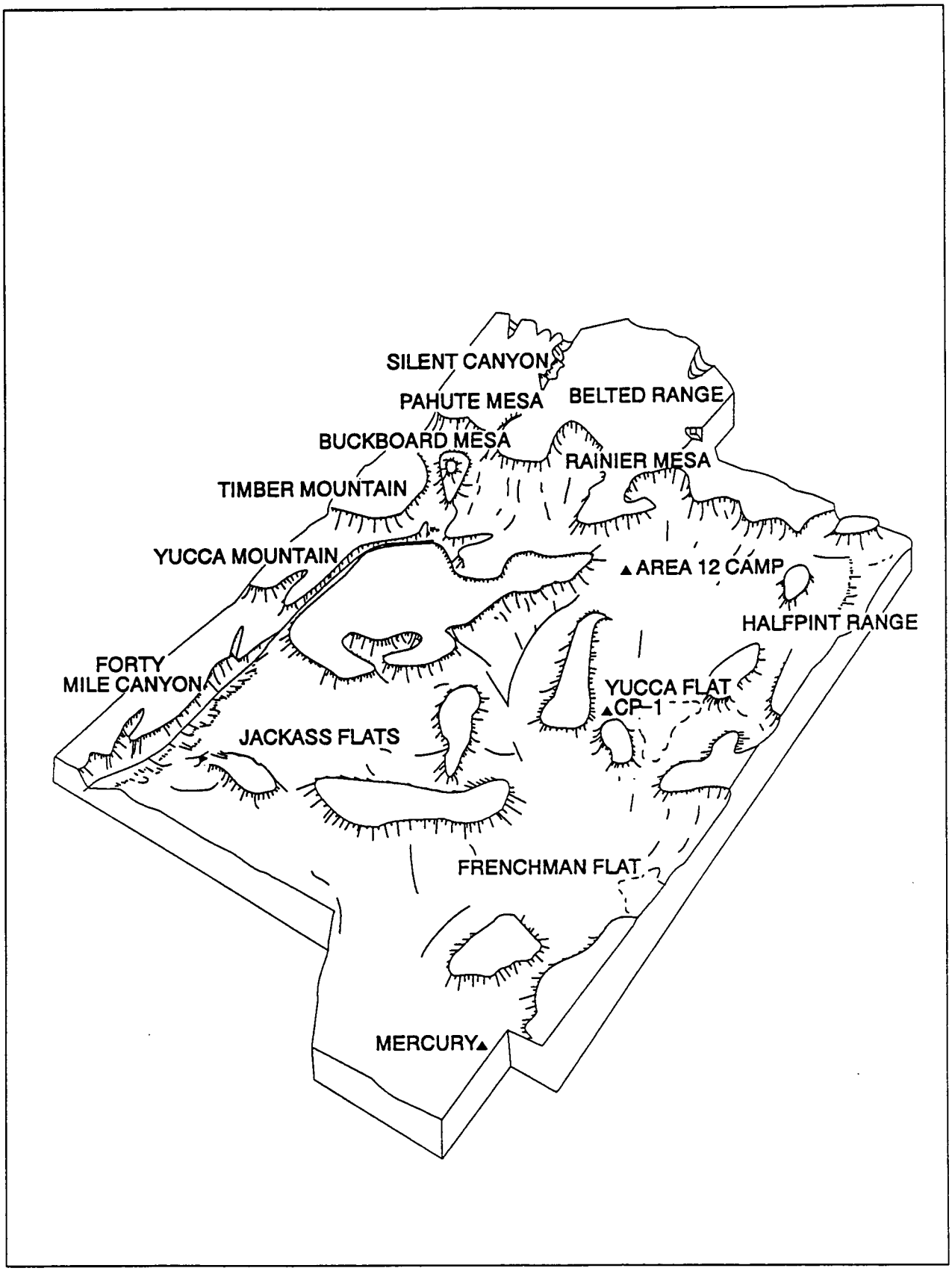


Figure 2.4 Topography of the NTS

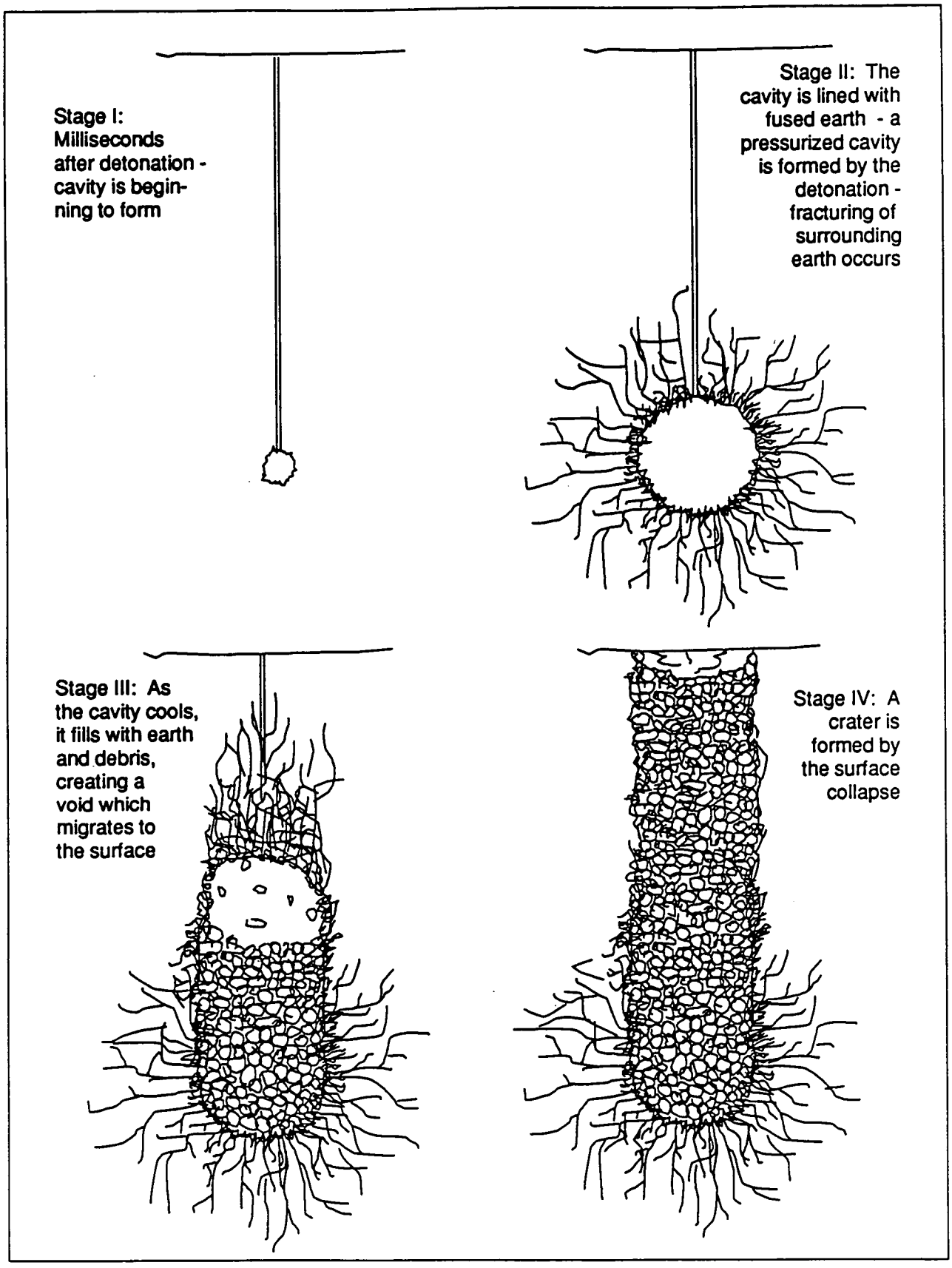


Figure 2.5 Formation of an Underground Nuclear Explosive Test Cavity, Rubble Chimney, and Surface Subsidence Crater

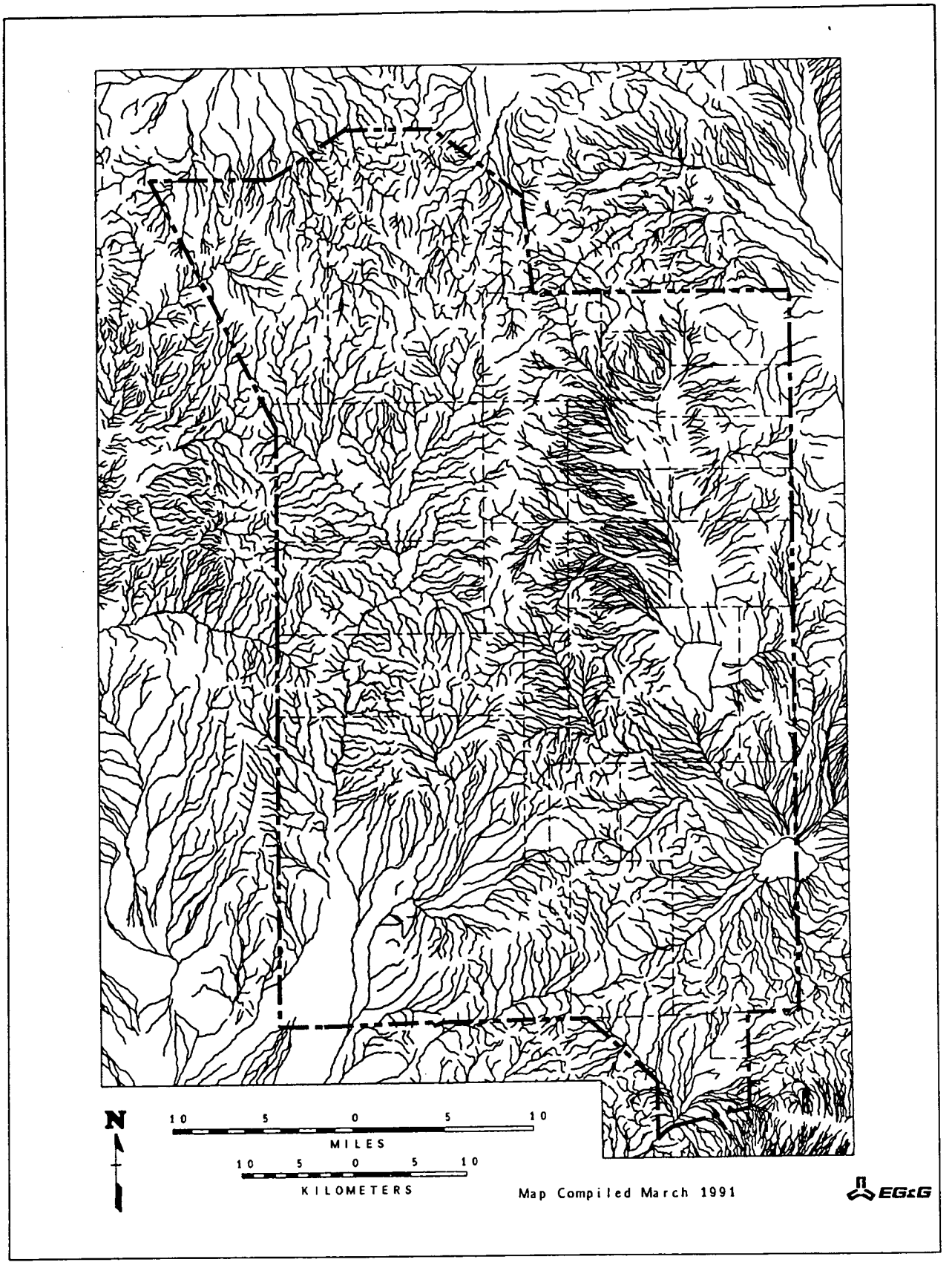


Figure 2.6 Surface Drainage Channel Pattern for the NTS

044

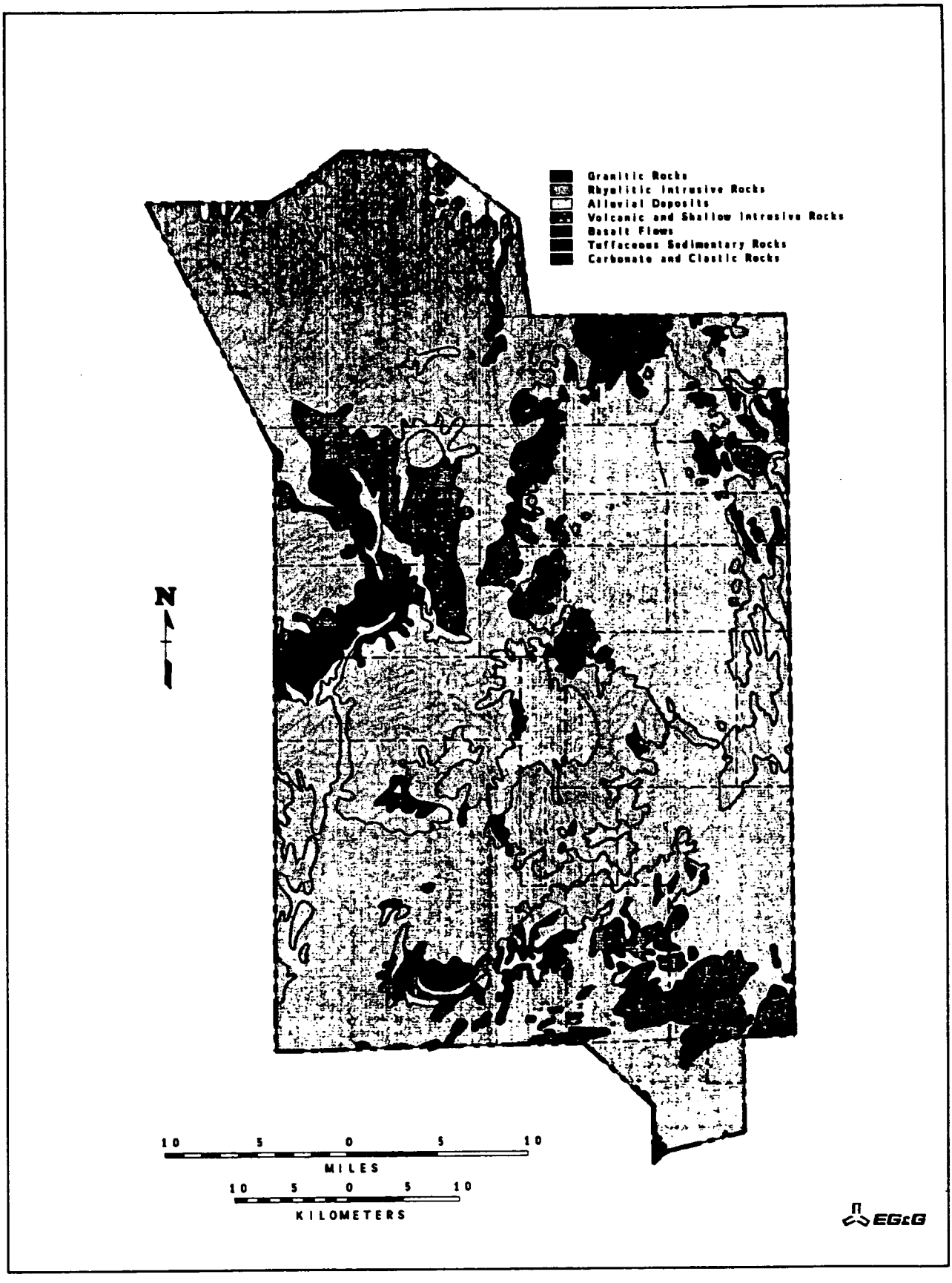


Figure 2.7 Basic Lithologic Structure of the NTS

045

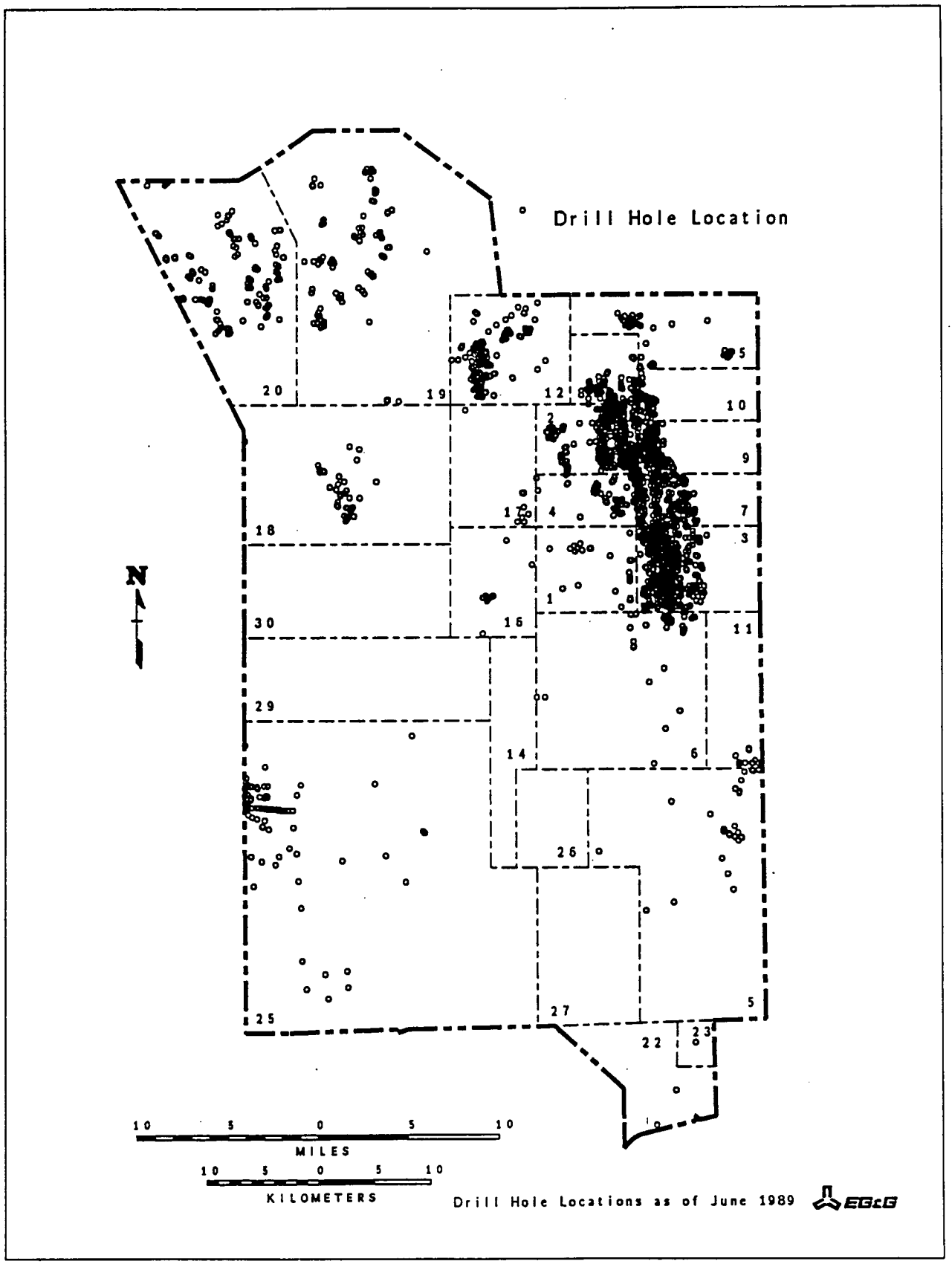


Figure 2.8 Drill Hole Locations on the NTS

thousands of feet, but in most places the total thickness of the section is far less because of erosion or nondeposition. These materials erupted before the collapse of large volcanic centers known as *calderas*. Alluvial materials fill the intermountain valleys and cover the adjacent slopes. These sediments attain thicknesses of 2000 to 3000 feet (600 to 900 meters) in the central portions of the valleys. The alluvium in Yucca Flat is vertically offset along the prominent north-south-trending Yucca fault.

2.1.6 HYDROGEOLOGY

Some nuclear tests are conducted below the groundwater table; the others are at varying depths above the groundwater table. Great depths to the groundwater table and the slow velocity of water movement in the saturated and unsaturated zones beneath the NTS are of particular significance in terms of low potential for radioactivity transport to offsite areas from nuclear tests or from shallow burial waste disposal sites. The deep aquifers, slow groundwater movement, and exceedingly slow downward movement of water in the overlying unsaturated zone serve as significant barriers to transport of radioactivity from underground sources via groundwater, greatly limiting the potential for transport of radioactivity to offsite areas.

Depths to groundwater beneath NTS vary from about 515 feet (157 meters) beneath the Frenchman Flat playa (Winograd and Thordarson 1975) in the southern part of the NTS to more than 2000 feet (610 meters) beneath part of Pahute Mesa. In the eastern portions of the NTS, the water table occurs generally in the alluvium and volcanic rocks above the regional carbonate aquifer. The flow in the shallower parts of the groundwater body is generally toward the major valleys (Yucca and Frenchman) where it deflects downward to join the regional drainage to the southwest in the carbonate aquifer.

The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley groundwater basin. The actual subbasin boundaries are poorly defined, as shown in Figure 2.9. Groundwater beneath the eastern part of the NTS is in the Ash Meadows subbasin, defined by discharge through evapotranspiration along a spring line in Ash Meadows (south of the NTS). Most of the western NTS is in the Alkali Flat/ Furnace Creek Ranch subbasin, which discharges by evapotranspiration at Alkali Flat and by spring discharge near Furnace Creek Ranch. Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley subbasin, discharging by evapotranspiration in the Oasis Valley.

Some underflow, past all of the subbasin discharge areas, probably travels to springs in Death Valley. Recharge for all of the subbasins most likely occurs by precipitation at higher elevations and infiltration along stream courses and in playas. Regional groundwater flow is from the upland recharge areas in the north and east towards discharge areas at Ash Meadows and Death Valley, southwest of the Site. Due to the large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions can be radically different from the regional trend.

Groundwater is the only local source of drinking water in the NTS area. Drinking and industrial water supply wells for the NTS produce from the lower and upper carbonate, the volcanic, and the valley-fill aquifers. Though a few springs emerge from perched groundwater lenses at the NTS, discharge rates are low, and spring water is not currently used for DOE activities. Wildlife use the springs for drinking water. South of the NTS, private and public supply wells are completed in a valley-fill aquifer.

The hydrogeology of the underground nuclear testing areas on the NTS (Figure 2.9) has been summarized by the Desert Research Institute, University of Nevada System, in its report on the groundwater monitoring program for the NTS (Russell 1990).

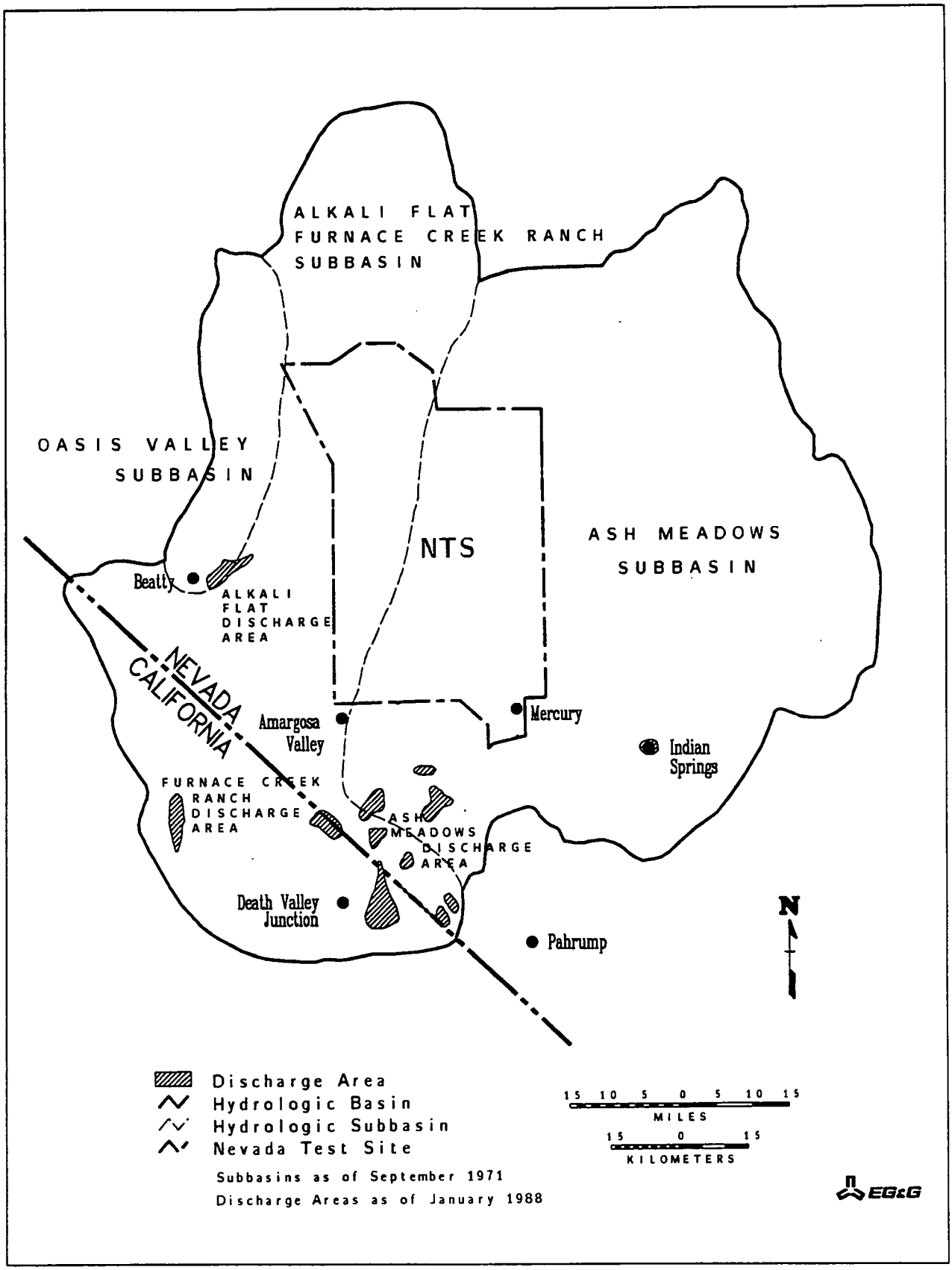


Figure 2.9 Groundwater Hydrologic Units of the NTS and Vicinity

Yucca Flat is situated within the Ash Meadows groundwater subbasin. Groundwater occurs within the valley fill, volcanic, and lower carbonate aquifers and in the volcanic, upper clastic, and lower clastic aquitards. The depth to water generally ranges from 525 feet (160 meters) to about 1900 feet (580 meters) below the ground surface. The tuff aquitard forms the principal Cenozoic hydrostratigraphic unit beneath the water table in the eastern two thirds of the valley and is unconfined over most of its extent. The welded tuff and bedded tuff aquifers are saturated beneath the central and northern parts of the valley and occur under both confined and unconfined conditions. The valley fill aquifer is saturated in the central part of the valley and is unconfined (Winograd and Thordarson 1975).

Frenchman Flat is also within the Ash Meadows subbasin. Regional groundwater flow in this valley occurs within the major Cenozoic and Paleozoic hydrostratigraphic units at depths ranging from 515 to 1180 feet (157 to 360 meters) below the ground surface. Perched water is found as shallow as 65.6 feet (20 meters) within the tuff and lava flow aquitards in the southwestern part of the valley. In general, the depth to water is least beneath Frenchman playa (515 feet [157 meters]) and depths increase to nearly 1180 feet (360 meters) near the margins of the valley (Winograd and Thordarson 1975). The water table beneath Frenchman Flat is considerably shallower (and stratigraphically higher) than beneath Yucca Flat. Consequently, the areal extent of saturation in the valley fill and volcanic aquifers is correspondingly greater.

Winograd and Thordarson (1975) hypothesized that groundwater within the Cenozoic units of Yucca and Frenchman Flats probably cannot leave these basins without passing through the underlying and surrounding lower carbonate aquifer. In addition, lateral gradients within the saturated volcanic units exist and may indicate groundwater flow toward the central areas of Yucca and Frenchman Flats prior to vertical drainage.

The only hydrostratigraphic units encountered at Pahute Mesa are the volcanic aquifers and aquitards. Pahute Mesa is thought to be a part of both the Oasis Valley and Alkali Flat/Furnace Creek Ranch subbasins. The location of the inter-basin boundary is uncertain. Groundwater is thought to move towards the south and southwest, through Oasis Valley, Crater Flat and western Jackass Flats (Blankennagel and Weir 1973). Points of discharge are thought to include the springs in Oasis Valley, Alkali Flat, and Furnace Creek. The amount of recharge to Pahute Mesa and the amount of underflow which moves to the various points of discharge are not accurately known. Vertical gradients within Pahute Mesa suggest that flow may be downward in the eastern portion of the mesa but upward in the western part (Blankennagel and Weir 1973).

The hydrostratigraphic units beneath Rainier Mesa consist of the welded and bedded tuff aquifer, zeolitized tuff aquitard, the lower carbonate aquifer, and the tuffaceous and lower clastic aquitards. The volcanic aquifer and aquitards support a semiperched groundwater lens. Nuclear testing at Rainier Mesa is conducted within the tuff aquitard. Work by Thordarson (1965) indicates that the perched groundwater is moving downward into the underlying regional aquifer. Depending on the location of the subbasin boundary, Rainier Mesa groundwater may be part of either the Ash Meadows or the Alkali Flat/Furnace Creek Ranch subbasin. The regional flow from the mesa may be directed either towards Yucca Flat or, because of the intervening upper clastic aquitard, towards the Alkali Flat discharge area in the south. The nature of the regional flow system beneath Rainier Mesa has not been defined and requires further investigation.

2.1.7 CLIMATE AND METEOROLOGY

Precipitation levels on the NTS are low, runoff is intermittent, and the majority of the

active testing areas on the NTS drain into closed basins on the Site. Annual precipitation in Southern Nevada is very light and depends largely upon elevation. A characteristic of desert climates is the temporal and spatial variability of precipitation. Topography contributes to this variability. For example, on the NTS the mesas receive an average annual precipitation of nine inches (22.9 cm), which includes wintertime snow accumulations. The lower elevations receive approximately six inches (15.2 cm) of precipitation annually, with occasional snow accumulations lasting only a matter of days (Quiring 1968).

Precipitation usually falls in isolated showers with large variations in precipitation amounts within a shower area. Summer precipitation occurs mainly in July and August when intense heating of the ground below moist air masses (transported northward from the tropical Pacific Ocean through the Gulf of California and into the desert southwest) triggers thunderstorm development. On occasion a tropical storm will move northeastward from the west coast of Mexico, bringing widespread heavy precipitation to Southern Nevada during September and/or October.

Elevation also influences temperatures on the NTS. At an elevation of 6560 feet (2000 meters) above MSL in Area 20 on Pahute Mesa, the average daily maximum/minimum temperatures are 40°/28°F (4.4°/-2.2°C) in January and 80°/62°F (26.7°/16.7°C) in July. In Area 6 (Yucca Flat, 3920 feet [1200 meters] MSL), the average daily maximum/minimum temperatures are 51°/21°F (10.6°/-6.1°C) in January and 96°/57°F (35.6°/13.9°C) in July. The extreme temperatures at Mercury are 69°/12°F (20.6°/-11.1°C) in January and 109°/59°F (42.8°/15°C) in July.

Wind direction and speed are important aspects of the environment at the NTS. These are major factors in planning and conducting nuclear tests, where atmospheric transport is the primary potential route of contamination transport to onsite workers and offsite populations.

The movements of large-scale pressure systems control the seasonal changes in the wind direction frequencies. Predominating winds are southerly during summer and northerly during winter. The general downward slope in the terrain from north to south results in an intermediate scenario that is reflected in the characteristic diurnal wind reversal from southerly winds during the day to northerly winds at night. This north to south reversal is strongest in the summer and, on occasion, becomes intense enough to override the wind regime associated with large-scale pressure systems. This scenario is very sensitive to the orientation of the mountain slopes and valleys.

At higher elevations in Area 20, the average annual wind speed is 10.5 miles per hour (mph; 16.9 kilometers per hour [km/h]). The prevailing wind direction during winter months is from north-northeast, and, during summer months, winds prevail from the south. In Yucca Flat the average annual wind speed is 7 mph (11.3 km/h). The prevailing wind direction during winter months is north-northwest and during summer months is south-southwest. At Mercury the average annual wind speed is 8 mph (12.9 km/h), with a prevailing wind direction of northwest during the winter months and southwest during the summer months. The 1990 ten-meter wind roses for the NTS are shown in Figure 2.10.

2.1.8 FLORA AND FAUNA

The greater part of the NTS is vegetated by various associations of desert shrubs typical of the Mojave or Great Basin Deserts or the zone of transition desert between these two. There are areas of desert woodland (piñon, juniper) at higher elevations. Even there, typical Great Basin shrubs, principally sagebrushes, are a conspicuous component of the vegetation. Although shrubs (or shrubs and small trees) are the dominant forms, herbaceous plants are well

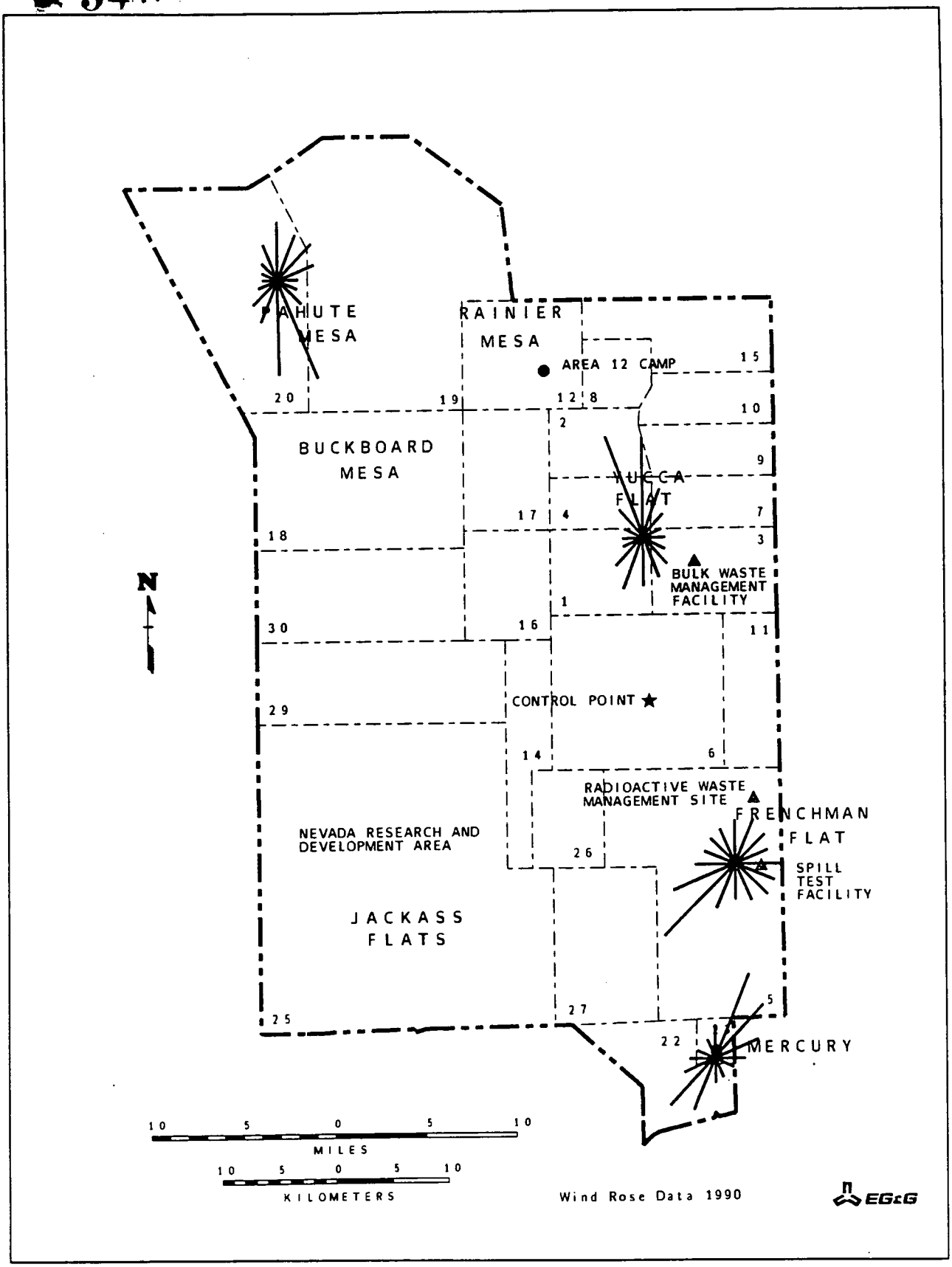


Figure 2.10 1990 Wind Rose Patterns for the NTS (Courtesy of Weather Services Nuclear Support Office, NOAA)

represented in the flora and play an important role in supporting animal life.

Extensive floral collection has yielded 711 taxa of vascular plants within or near the boundaries of the NTS (O'Farrell and Emery 1976). Associations of creosote bush, *Larrea tridentata*, which are characteristic of the Mojave Desert, dominate the vegetation mosaic on the bajadas of the southern NTS. Between 4000 and 5000 feet (1220 and 1520 meters) in elevation in Yucca Flat, transitional associations are dominated by *Grayia spinosa-Lycium andersonii* (hopsage/desert thorn) associations, while the upper bajadas support *Coleogyne* types. Above 5000 feet (1520 meters) the vegetation mosaic is dominated by sagebrush associations of *Artemisia tridentata* and *Artemisia arbuscula* ssp. *nova*. Above 6000 feet (1830 meters) piñon pine and juniper mix with the sagebrush associations where there is suitable moisture for these trees. No plant species located on the NTS is currently on the federal endangered species list; however, the state of Nevada has placed *Astragalus beatleyae* on its critically endangered species list.

Most mammals on the NTS are small and secretive (often nocturnal in habitat), hence not often seen by casual observers; larger mammals include feral horses, burros, deer, mountain lions, bobcats, coyote, kit foxes, and rabbits. Reptiles include four species of venomous snakes; bird species are mostly migrants or seasonal residents. Rodents are, in terms of distribution and relative abundance, the most important group of mammals on the NTS. Most nonrodent mammals have been placed in the "protected" classification by the state of Nevada.

In 1989 the desert tortoise, *Gopherus agassizii*, was placed on the endangered species list by the U.S. Department of Interior and was relisted as threatened in 1990. Tortoise habitats on the NTS are found in the southern third of the NTS outside the current areas of nuclear test activities in Yucca Flat, Rainier Mesa, and Pahute Mesa.

2.1.9 ARCHAEOLOGICAL AND HISTORICAL VALUES

Human habitation of the NTS area ranges from as early as 10,000 B.C. to the present. Various aboriginal cultures occupied the NTS area over this extended period as evidenced by the presence of artifacts at many surface sites and more substantial deposits of cultural material in several rock shelters. This period of aboriginal occupation was sustained primarily by a hunting and gathering economy based on using temporary campsites and shelters. The area was occupied by Paiute Indians at the time of the first known outside contact in 1849.

Because readily available surface water was the most important single determinant governing the location of human occupation, historic sites are often associated with prehistoric ones, both being situated near springs. As a consequence of this superposition of historic occupation, disturbance of certain aboriginal sites by modern man occurred long before use of the area as a nuclear testing facility began. The larger valleys show little or no evidence of occupation. Together these areas comprise almost the entire floors of Yucca, Frenchman, and Jackass Flats. Thus, testing and associated operational activities have generally been most intense in those parts of the NTS where archaeological and historic sites are absent.

In addition to the archaeological sites, there are also some sites of historical interest on the NTS. The principal sites include the remains of primitive stone cabins with nearby corrals at three springs, a natural cave containing prospector's paraphernalia in Area 30, and crude remains of early mining and smelting activities. Even sites on the periphery of Yucca Flat, close to the area of repeated underground testing, seem to have been little affected by ground motion from tests. The stone cabin at Tippipah Spring,

less than ten miles from numerous tests, was found to be essentially unchanged in spite of testing over an eight-year period (Norman 1969).

2.1.10 DEMOGRAPHY

Figure 2.11 shows the current population of counties surrounding the NTS, based on 1990 Bureau of Census estimates (DOC 1990). Excluding Clark County, the major population center (approximately 741,000 in 1990), the population density within a 150-kilometer radius of the NTS is about 0.5 persons per square kilometer. In comparison, the 48 contiguous states (1980 census) had a population density of approximately 29 persons per square kilometer. The estimated average population density for Nevada in 1980 was 2.8 persons per square kilometer.

The offsite area within 80 kilometers of the NTS Control Point is predominantly rural. CP-1 (a building at the Control Point) is the primary point from which the dose commitment was determined for the purpose of this report. Several small communities are located in the area, the largest being in the Pahrump Valley. This growing rural community, with an estimated population of 7400, is located 80 kilometers south of CP-1. The Amargosa Farm area, which has a population of about 950, is located about 50 kilometers southwest of CP-1. The largest town in the near offsite area is Beatty, which has a population of about 1500 and is located approximately 65 kilometers to the west of CP-1.

The Mojave Desert of California, which includes Death Valley National Monument, lies along the southwestern border of Nevada. The National Park Service (NPS 1990) estimated that the population within the Monument boundaries ranges from a minimum of 200 permanent residents during the summer months to as many as 5000 tourists and campers on any particular day during the major holiday periods in the winter months. As many as 30,000 are in the area during "Death Valley Days" in the month of November. The next largest town and contiguously populated area (about 40 square miles) in the Mojave Desert is Barstow, California, located 265 kilometers south-southwest of the NTS, with a 1990 population of about 21,000. The largest populated area is the Ridgecrest-China Lake area, which has a current population of 28,000 and is located 190 kilometers southwest of the NTS. The Owens Valley, where numerous small towns are located, lies 50 kilometers west of Death Valley. The largest town in the Owens Valley is Bishop, located 225 kilometers west-northwest of the NTS, with a population of 3500.

The extreme southwestern region of Utah is more developed than the adjacent portion of Nevada. The largest community is St. George, located 220 kilometers east of the NTS, with a 1990 population of 29,000. The next largest town, Cedar City, with a population of 13,000, is located 280 kilometers east-northeast of the NTS.

The extreme northwestern region of Arizona is mostly range land except for that portion in the Lake Mead Recreation Area. In addition, several small communities lie along the Colorado River. The largest towns in the area are Bullhead City, 165 kilometers south-southeast of the NTS, with a 1990 population estimate of 22,000, and Kingman, located 280 kilometers southeast of the NTS, with a population of about 13,000.

2.1.11 SURROUNDING LAND USE

Figure 2.12 is a map of the offsite area showing a wide variety of land uses such as farming, mining, grazing, camping, fishing, and hunting within a 190-mile (300-kilometer) radius of the CP-1. West of the NTS elevations range from 280 feet (85 meters) below MSL in Death Valley to 14,500 feet (4400 meters) above MSL in the Sierra Nevada Range, including parts of two major agricultural valleys (the Owens and San Joaquin). The areas south of the NTS are more uniform since the Mojave Desert

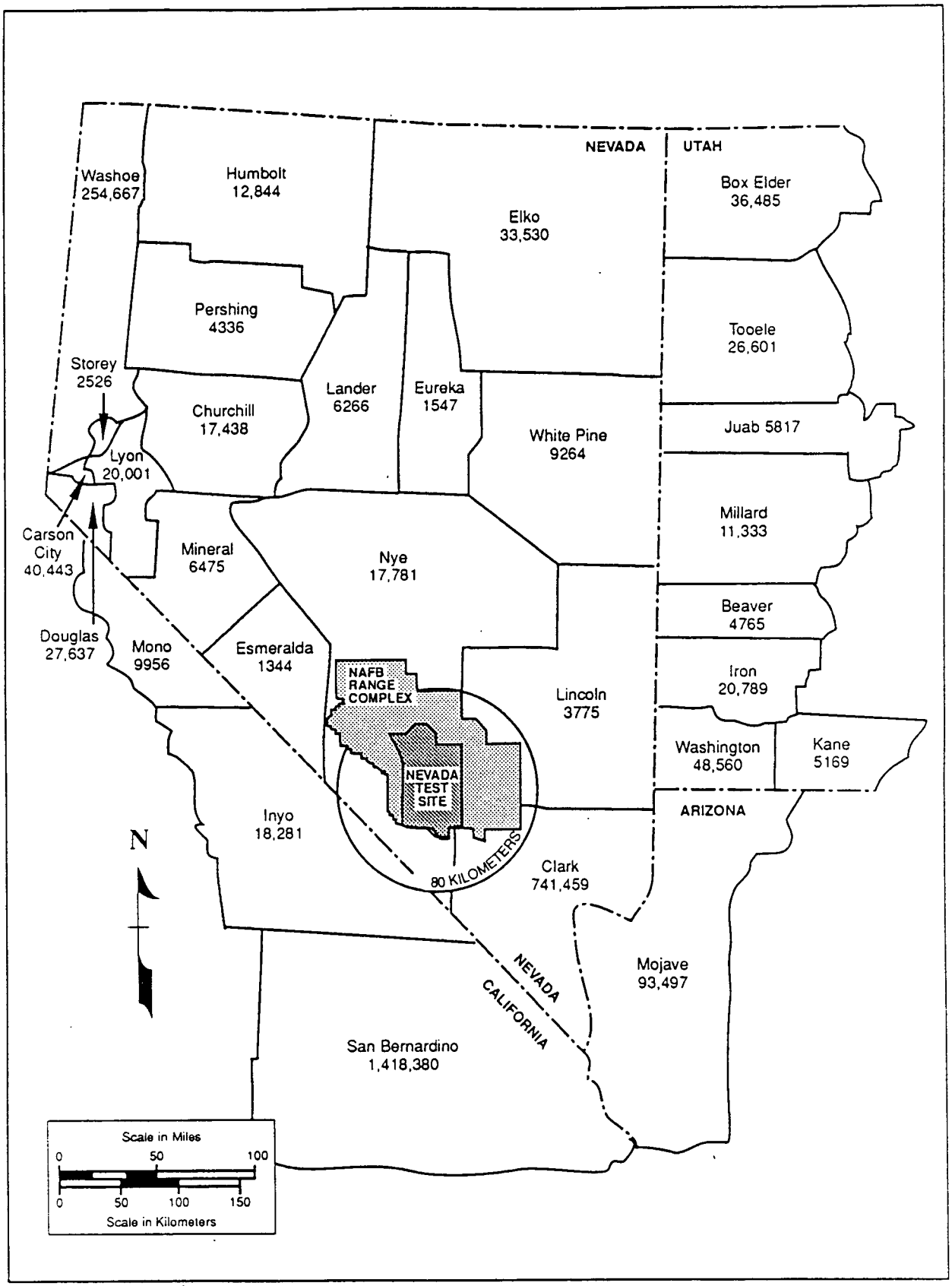


Figure 2.11 Population Distribution in Counties Surrounding the NTS (based on 1990 Census estimates)

054

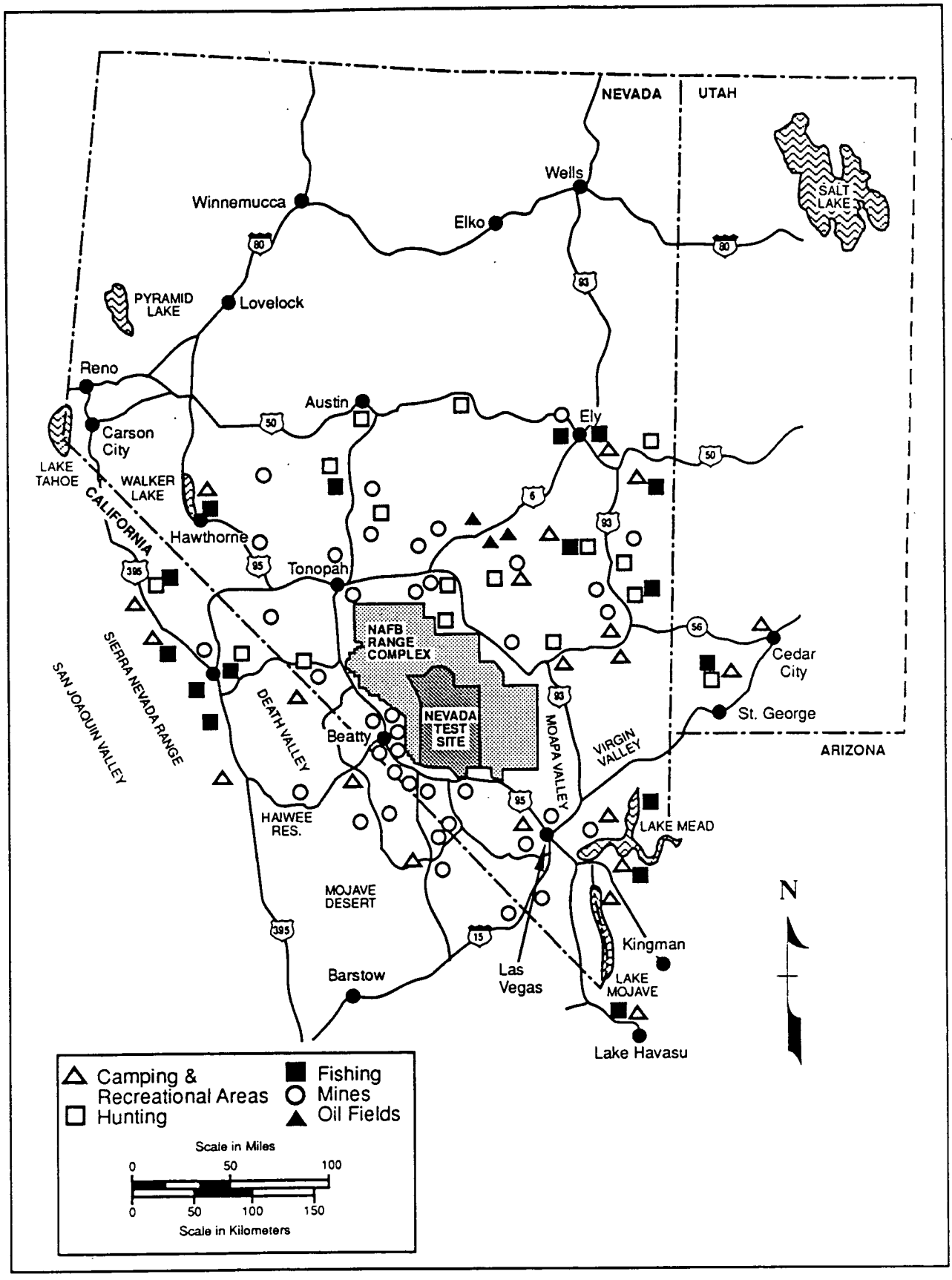


Figure 2.12 Land Use Around the NTS

ecosystem (mid-latitude desert) comprises most of this portion of Nevada, California, and Arizona. The areas east of the NTS are primarily mid-latitude steppe with some of the older river valleys, such as the Virgin River Valley and Moapa Valley, supporting irrigation for small-scale but intensive farming of a variety of crops. Grazing is also common in this area, particularly towards the northeast. The area north of the NTS is also mid-latitude steppe where the major agricultural activity is grazing of cattle and sheep. Minor agriculture, primarily the growing of alfalfa hay, is found in this portion of the state within 190 miles (300 kilometers) of CP-1. Many of the residents have access to locally grown fruits and vegetables.

Recreational areas lie in all directions around the NTS and are used for such activities as hunting, fishing, and camping. In general the camping and fishing sites to the northwest, north, and northeast of the NTS are utilized throughout the year except for the winter months. Camping and fishing locations to the southeast, south, and southwest are utilized throughout the entire year. The peak hunting season is from September through January.

2.2 NON-NTS FACILITIES

EG&G/EM operates several offsite facilities in support of activities at the NTS under a contract with the DOE/NV. These facilities include the Amador Valley Operations (AVO), Pleasanton, California; Kirtland Operations (KO), Kirtland Air Force Base (KAFB), Albuquerque, New Mexico; Las Vegas Area Operations's (LVAO's) Remote Sensing Laboratory at the NAFB and North Las Vegas Complex in North Las Vegas, Nevada; Los Alamos Operations (LAO), Los Alamos, New Mexico; Santa Barbara Operations (SBO), Goleta, California; Special Technologies Laboratory (STL), Santa Barbara, California; Washington Aerial Measurements Department (WAMD), Andrews Air Force Base, Maryland; and Woburn Cathode Ray Tube Operations (WCO), Woburn, Massachusetts. These locations are shown in Figure 2.13. Each of these facilities is located in a metropolitan area. City, county, and state regulations govern emissions, waste disposal, and sewage. No independent systems exist for supplying drinking water or sewage disposal, and hazardous waste is moved off the facility sites for disposal. No raw materials are stored such that precipitation causes a hazardous runoff. Radiation sources are sealed, and no radiological emissions are possible during normal facility operations.

2.2.1 AMADOR VALLEY OPERATIONS

The AVO facility in Pleasanton, California, occupies a 100,000 square-foot (9290 square-meter) facility consisting of two large combination office/laboratory buildings, one two-story and one single-story. The facility is located near the Lawrence Livermore National Laboratory (LLNL) in Livermore, California, to simplify logistics and communications associated with EG&G/EM support of LLNL programs. Most of the work is in support of NTS underground weapons testing. AVO also supports LLNL with optical alignment systems, fast-streak camera fabrication, and a variety of mechanical and electrical engineering activities associated with energy research and development programs. Fields of specialized experience represented at AVO include the design and fabrication of cathode-ray tubes for use in the weapons test program. Areas of environmental interest include several localized exhaust hoods and small chemical cleaning operations.

2.2.2 KIRTLAND OPERATIONS

KO at KAFB and in Albuquerque, New Mexico, consists of a 56,000 square-foot (5200 square-meter) complex of prefabricated metal buildings located on 39.5 acres (1.60 hectares) at KAFB, and a 35,000 square-foot (3250 square-meter) industrial facility, called the Craddock Facility, located near the Albuquerque International Airport. KO provides technical support to

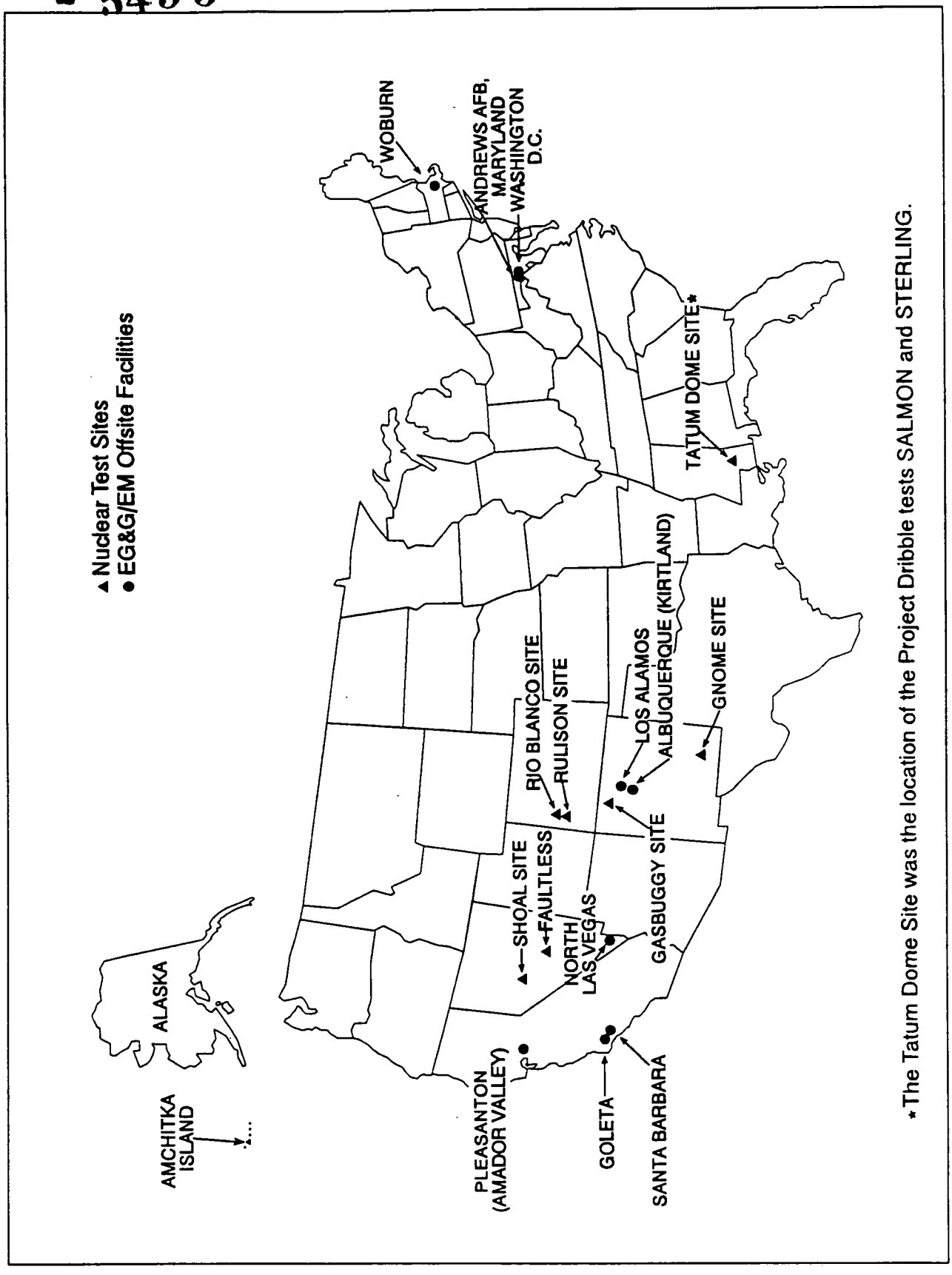


Figure 2.13 Locations of Non-NTS Facilities and Underground Event Sites

SNL, the DOE, the Department of Defense (DOD), and other federal agencies. In conjunction with DOE work, KO provides significant support to a variety of ongoing safeguards and security programs. KO is also responsible for operation of the System Control and Receiving Station (SCARS), a part of the DOE Remote Seismic Test Network (RSTN). Areas of environmental interest include small solvent cleaning operations and a small metal finishing shop.

2.2.3 LAS VEGAS AREA OPERATIONS

The LVAO includes the North Las Vegas facility at 2621 Losee Road and the Remote Sensing Laboratory on the NAFB in North Las Vegas, Nevada. These facilities provide technical support for the DOE/NV test program.

The North Las Vegas facility includes multiple structures totaling about 400,000 square feet (37,200 square meters). At the facility there are numerous areas of environmental interest, including electroplating and metal finishing operations, a radiation source range, an X-ray laboratory, solvent and chemical cleaning operations, small amounts of pesticide and herbicide application, photo laboratories, and hazardous waste generation and accumulation.

The Remote Sensing Laboratory is a 118,000 square-foot (11,000 square-meter) facility located on a 35-acre (140 hectares) site within the confines of the NAFB. The facility includes space for aircraft maintenance and operations, mechanical and electronics assembly, computer operations, photo processing, a light laboratory, and warehousing. Areas of environmental interest are photo processing and aircraft maintenance and operations.

2.2.4 LOS ALAMOS OPERATIONS

The LAO resides in a facility of approximately 65,000 square feet (6040 square meters). It is a two-story combination engineering/laboratory/office complex located near the LANL facility to provide local support for LANL's programs. The work performed includes direct support of the LANL testing program, the DOE Research and Development (R&D) Program, and miscellaneous DOE cash-order work. LAO's primary activities are twofold: (1) the design, fabrication, and fielding of data acquisition systems used in underground nuclear testing diagnostics and (2) the analysis of data from underground and high-altitude experiments. In addition, two LAO operations build and field CORRTEX III recorders. Areas of environmental interest include small solvent cleaning, metal machining operations, and a small photo laboratory.

2.2.5 SANTA BARBARA OPERATIONS

The SBO facility consists of a combination office/laboratory building of approximately 38,000 square feet (3530 square meters), including a specialized radiation research building that houses the DOE-EG&G/EM linear accelerator (LINAC) and accompanying laboratories. Several small machine shops, laboratory buildings, and a source range are located on county property. In support of the DOE/NV, the SBO was established for R&D work in nuclear instrumentation and measurements with emphasis on radiation detectors, data acquisition systems, and fast pulse electronics. Through the years its facilities have been adapted to a wide range of R&D tasks. The SBO also describes and assesses the potential ecological impacts of various R&D projects on ecological systems of interest. Activities of environmental interest include a mercuric iodide laboratory (where mercuric iodide crystals are grown), minor solvent operations, and several fume hoods.

2.2.6 SPECIAL TECHNOLOGIES LABORATORY

The STL located in Santa Barbara, California, consists of approximately 36,000

square feet (3340 square meters) of secure combination office/laboratory area used primarily for engineering and electronic research. The research is conducted to develop a suite of sensor systems for testing and field deployment in support of DOE Headquarters and DOE/NV. Areas of environmental interest include a small printed circuit board operation and limited solvent cleaning operations. STL also supports LLNL with optical alignment systems, fast-streak camera fabrication, and a variety of mechanical and electrical engineering activities associated with energy R&D programs. Fields of specialized experience represented at STL include the design and fabrication of cathode-ray tubes for use in the weapons test program. Areas of environmental interest include several localized exhaust hoods and small chemical cleaning operations.

2.2.7 WASHINGTON AERIAL MEASUREMENTS DEPARTMENT

The WAMD, located at Andrews Air Force Base, consists of a 2000 square-foot (186 square-meter) Butler building used as office space; a 12,000 square-foot (1110 square-meter) combination electronics laboratory, aircraft maintenance, and office complex; and a portion of a large aircraft hangar. WAMD operations provides an effective East Coast Nuclear Emergency Search Team (NEST) response capability and provides an eastern aerial survey capacity to the DOE/NV. Areas of environmental interest include small solvent cleaning operations and used fuels and oils.

2.2.8 WOBURN CATHODE RAY TUBE OPERATIONS

The WCO in Woburn, Massachusetts, is comprised of a 14,000 square-foot (1300 square-meter) facility which is used to develop and manufacture advanced cathode-ray tubes and oscilloscopes in support of the DOE/NV LANL Test Program for use in the weapons test program. Areas of environmental interest include small solvent cleaning operations and several laboratory hoods.

2.3 NON-NTS UNDERGROUND EVENT SITES

Non-NTS tests were conducted in eight locations in the continental U.S. These events and their locations appear in Figure 2.13 and Table 2.2. Activities at these locations are limited to sampling at 217 wells, springs, and other sources at locations near sites where nuclear explosive tests were conducted. Sampling results for these sites appear in Section 9 of this volume. (Sampling at the Amchitka Island sites occurs biannually; no sampling was performed in 1990.)

Table 2.2 Non-NTS Nuclear Explosive Test Sites Studied in 1990

Event Name	Location	Date of Test
GNOME	Malaga, New Mexico	12/10/61
SHOAL	Fallon, Nevada	10/26/63
SALMON (Dribble)	Baxterville, Mississippi	10/22/64
LONG SHOT	Amchitka Island, Alaska	10/29/65
STERLING (Dribble)	Baxterville, Mississippi	12/03/66
GASBUGGY	Gobernador, New Mexico	12/10/67
FAULTLESS	Blue Jay, Nevada	01/19/68
RULISON	Grand Valley, Colorado	09/10/69
MILROW	Amchitka Island, Alaska	10/02/69
CANNIKIN	Amchitka Island, Alaska	11/06/71
RIO BLANCO	Rio Blanco, Colorado	05/17/73

3.0 COMPLIANCE SUMMARY

Dean L. Cox, H. Bruce Gillen, Steve J. Nacht, Scott E. Patton, Carlton S. Soong, and Scott A. Wade

In addition to conducting the nuclear testing programs in compliance with radiation protection guides and standards, the predominant environmental compliance activities at the NTS during 1990 involved hazardous waste management associated with Resource Conservation and Recovery Act (RCRA) requirements. Clean Air Act compliance involved sampling and reporting of asbestos renovation projects and state of Nevada air quality permit renewals and reporting. Toxic Substances Control Act (TSCA) compliance activities were concerned with polychlorinated biphenyl (PCB) management practices on the NTS. Compliance actions also included pre-operational surveys to protect and preserve archaeological and cultural history sites on the NTS. Endangered Species Act compliance actions involved accommodating regulations related to the April 1990 listing of the Mojave desert tortoise as a threatened species.

During 1990, 12 environmental compliance corrective actions identified in the 1987 NTS environmental survey conducted by the DOE were completed. Issues addressed in the DOE "Tiger Team" assessment of environmental compliance and program management, conducted in October 1989, continued to prompt corrective action.

Throughout 1990 the NTS was subject to two formal compliance agreements with federal or state regulatory agencies; the American Indian Religious Freedom Act compliance program and the *Astragalus beatleyae* Conservation Agreement. No lawsuits have been identified that affect the DOE/NV's program obligations. A notice of violation was received from the state of Nevada that potentially may affect storage of mixed transuranic (TRU) waste. Waste minimization efforts at the NTS were expanded in 1990.

Operations at the DOE/NV non-NTS facilities operated by EG&G/Energy Measurements, Inc. (EG&G/EM), involved compliance with the permitting and monitoring requirements of (1) the Clean Air Act for airborne emissions, (2) the Clean Water Act for wastewater, (2) state Safe Drinking Water Act (SDWA) regulations, (4) RCRA disposal of hazardous wastes, and (5) hazardous substance reporting. Waste minimization efforts extended to many EG&G/EM facilities.

3.1 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA)

NEPA related activities included 1 approved and 10 pending Environmental Assessments (EAs), 121 approved and 16 pending Categorical Exclusions (CXs), and 5 Memoranda to File approved. Two EAs begun in 1989 were discontinued. Use of the Memoranda to File was discontinued in September 1990.

061

3.1.1 ENVIRONMENTAL ASSESSMENTS

3.1.1.1 COMPLETED ENVIRONMENTAL ASSESSMENTS

Liquified Gaseous Fuels Spill Test Facility (LGFSTF)

An EA was approved on February 5, 1990, for the LGFSTF addressing the environmental consequences of spill testing hazardous materials in the Frenchman Flat basin. This EA was addressed in detail in the Nevada Test Site Annual Site Environmental Report - 1989 (Wruble and McDowell 1990).

3.1.1.2 IN-PROCESS ENVIRONMENTAL ASSESSMENTS

NTS Groundwater Characterization

An EA for NTS groundwater characterization activities is pending. This groundwater program was designed to characterize the hydrogeology of the NTS through the drilling of up to 99 wells across the NTS.

New Decontamination Pond, Area 6

An EA for construction of a new decontamination pond in Area 6 was drafted and is being reviewed at the end of 1990. This pond will replace an existing decontamination pond system which is scheduled for closure. A required action description memorandum was written before beginning EA development.

Rainier Mesa Power Loop, Area 12

An EA for construction of the Rainier Mesa power loop in Area 12 is being reviewed. This will cover a power system upgrade allowing for selective power interruption.

U.S./U.S.S.R. Onsite Inspection Team Housing, NTS

An EA for the construction and occupation of a housing facility for the U.S.S.R. onsite inspection team is being reviewed. This facility will provide housing for Soviet personnel functioning as part of the U.S./U.S.S.R. Joint Verification Experiment.

Mixed Waste Management Unit (MWMU)

An EA covering planned mixed waste disposal operations at the Area 5 Radioactive Waste Management Site (RWMS) was submitted to DOE Headquarters (DOE/HQ) for concurrence.

Liquified Gaseous Fuels Spill Test Facility

Work began in December 1990 on a EA covering programmatic testing at the LGFSTF.

U.S. Army Depleted Uranium Tests

An EA for the Ballistic Research Laboratory in Area 25 was sent to DOE/HQ for approval and forwarding to the state of Nevada for review. The quantities of depleted uranium used in these experiments are minimal, and no significant radiation exposure to onsite or offsite personnel is expected.

Device Assembly Facility

An EA for operation of the Device Assembly Facility in Area 6 was initiated. A draft Action Description Memorandum has been reviewed.

SCYLLA Facility

An EA for the Los Alamos Explosive Pulsed Power SCYLLA Facility has been prepared and reviewed by the state of Nevada.

Integrated Demonstration Project for Removal of Plutonium Substances from Soils

An EA for the plutonium-removal Integrated Demonstration Project was initiated in December 1990. This is a project to research ways of removing contaminated soil

and reducing the volume of the contaminated waste before disposal.

3.1.1.3 WITHDRAWN ENVIRONMENTAL ASSESSMENTS

Waste Examination Building (WEB), Area 5 RWMS

The EA was withdrawn for the Waste Examination Building as a separate facility. A new EA will be resubmitted for the Waste Examination Complex, which will include the previously planned examination facility and a real-time radiography building.

Bulk Waste Management Site (BWMS), Area 3

An EA for the BWMS in Area 3 involving the burial of radioactive waste was canceled as the subject facility will be included in a Site-wide environmental restoration and waste management Environmental Impact Statement to be scheduled at a later date.

3.1.2 CATEGORICAL EXCLUSIONS

CXs for 121 NTS projects were approved by the DOE/NV. This included many building modifications, sewage lagoon improvements, fire protection system additions, underground storage tank removals, and building constructions, among others. These are listed in Table 3.1.

3.1.3 MEMORANDA TO FILE

The five projects listed in Table 3.2 were authorized through Memoranda to File on the dates listed. Use of the Memoranda to File was discontinued in September 1990.

3.2 CLEAN AIR ACT

NTS activities conducted for compliance with the Clean Air Act included National Emissions Standards for Hazardous Air Pollutants (NESHAP) asbestos abatement projects and radiological reporting and monitoring for compliance with ambient air quality standards, as well as air quality permit issues which were addressed both at non-NTS sites (EG&G/EM facilities) and onsite.

3.2.1 NTS OPERATIONS

Clean Air Act compliance requirements were limited to asbestos abatement (projects involving friable asbestos in quantities greater than or equal to 160 square feet [14.9 square meters] or 260 linear feet [79.2 meters]) and radionuclide monitoring and reporting under NESHAP. Compliance with asbestos regulations, radioactive emissions, and air quality permits are discussed below. Although there are no criteria pollutant or prevention of significant deterioration monitoring requirements for NTS operations, a one-month survey was conducted to assess NTS air quality. This study is described in Section 3.2.1.3 below.

3.2.1.1 NESHAP ASBESTOS COMPLIANCE

In January 1990 the state of Nevada, Division of Occupational Safety and Health, issued regulations (Nevada Revised Statutes [NRS] 618.760-805) requiring that all contractors intending to engage in asbestos abatement projects (involving friable asbestos in quantities greater than or equal to three square feet or three linear feet) in Nevada submit a Notification Form. This form was required by the Division ten days before beginning any work at an asbestos abatement project site. Notifications were also made to the EPA Region 9 in accordance with 40 CFR 61.145-146.

During 1990 one NESHAP notification was made to EPA Region 9 and seven state of Nevada notifications were made. These notifications were for asbestos renovation and abatement projects in accordance with the requirements of 40 CFR 61.145-146 and NRS 618.760-805. Reynolds Electrical & Engineering Co., Inc. (REECo), collected and analyzed bulk, occupational, environmental,

Table 3.1 Categorical Exclusions Approved and In Progress - 1990

Project	Date Approved
Fleet Operations, Area 12	04/02/90
EVERGREEN event site, Area 25	04/02/90
Water distribution system, Area 6	04/10/90
SNL cable facility and office modification, Area 6	04/10/90
Tweezer sewage disposal system, Area 11	04/10/90
DOE Bldg. 111 modifications, Area 23	04/10/90
Addition to Bldg. 5-7, Area 5	04/10/90
SNL Assembly Building, Area 6	04/10/90
REECo Environmental Compliance Office trailer, Area 23	04/10/90
U.S. Geological Survey Core Storage Facility, Area 23	04/10/90
RWMS, Area 5, TRU Storage Pad, security fence	04/10/90
Loading Dock, SNL Recording Facility, Area 23	04/10/90
Radiological posting and fencing, Area 12	04/19/90
Warehouse 12 fire protection system, Area 23	05/01/90
Warehouse 160 fire protection system, Area 23	05/01/90
Bldg. 1010 fire protection system, Area 23	05/01/90
Bldg. 701 fire protection system, Area 23	05/01/90
Well C1 housing modification, Area 6	05/01/90
Bldg. 101 fire protection system, Area 23	05/01/90
Warehouse 4 and 5 fire protection system, Area 6	05/01/90
Bldg. 4215 modification, Area 25	05/01/90
Munitions Magazine Bldg., Area 23	05/01/90
Modifications of Bldg. 600, Area 23	05/01/90
Bldg. 725 uninterruptable power system, Area 23	05/01/90
Coal Tar Epoxy Plant modification, Area 1	05/01/90
Well 5B housing modification, Area 5	05/01/90
Sewage lagoon modification, Test Cell C, Area 25	05/01/90
UST modification, Bldg. 4838, Area 25 (550 gal.)	05/01/90
UST removal, Test Cell A, Area 25	05/01/90
UST removal, Test Cell C, Area 25	05/01/90
UST removal, MX yard, Area 25	05/01/90
UST modification, Bldg. 4838, Area 25 (2/10,000 gal.)	05/01/90
Modifications to Technical Security Area, Bldg. 600, Area 23	05/01/90
UST modification, Bldg. 1216, Area 12	05/01/90
Sewage lagoon modification, Engine Test Stand 1, Area 25	05/01/90
Sewage lagoon modification, Bldg. 6-72, Area 6	05/01/90
Potable water/anti-siphon system	05/01/90
Sewage lagoon modification, sewage facility, Area 2	05/01/90
Sewage lagoon modification, Reactor Control Point, Area 25	05/01/90
Sewage lagoon modification, Central Support Area, Area 25	05/01/90
Fleet Operations/steam cleaning, Area 23	05/01/90
Indoor pistol range, Area 23	05/09/90
Bldg. 114 fire protection system, Area 23	05/10/90

Table 3.1 (Categorical Exclusions Approved and In Progress - 1990, cont.)

Project	Date Approved
Security gates, Bldg. 300, Area 23	05/14/90
Bldg. 3127 renovation, Area 25	05/14/90
Rest room addition, Warehouse 777, Area 23	05/14/90
Security gate, Bldg. 12-30, Area 12	05/14/90
Electrical modifications, Quonsets 27 and 28, Area 23	05/14/90
Track Etch Laboratory, Bldg. 650, Area 23	05/14/90
Neutron Dosimetry, Bldg. 610, Area 23	05/14/90
Defense Waste Management Department Office Bldg., Area 23	05/21/90
Electrical Equipment Maintenance Bldg., Area 2	05/25/90
Lawrence Livermore National Laboratory Field Operations Bldg., Area 2	05/25/90
Bldg. CP-50 modification, Area 6	05/25/90
Bldg. 117 heating, ventilation, and air conditioning upgrade, Area 23	05/25/90
Oil containment berms, Mercury Switch Yard, Area 23	05/25/90
Bldg. 6-605 fire protection system, Area 6	05/25/90
Modification to Bldg. 102, Area 1	05/25/90
Nevada Intelligence Center	06/05/90
Air and power hookup to storage boxcar, Area 23	06/08/90
Parking traffic control, cafeteria parking lot, Area 12	06/08/90
Bldg. 1-102 modifications, Area 1	06/08/90
UST removal, Area 12	06/08/90
Gate 100 sewage lagoon modification, Area 22	06/08/90
Steam cleaning pad, Drilling Support Yard, Area 6	06/08/90
Fire stations, apparatus exhaust vents; Areas 6, 12, and 23	06/20/90
Bldg. demolition and removal, Area 25	06/20/90
DNA Valve Shop, Bldg. 12-01, Area 12	06/20/90
Trailer complex removal, Area 12	06/20/90
Bldg. 1010 addition, Area 23	06/20/90
Concrete pads, sewage disposal sites; Areas 6, 12, and 23	06/20/90
Asbestos removal; Bldgs. 2203, 2204, and 2205, Area 6	06/20/90
Diesel tank replacement, P Tunnel portal, Area 12	06/20/90
Oil/water separator, N Tunnel, Area 12	06/20/90
Camp sewage facility modification, Area 3	06/20/90
Fiber optic relay station decommissioning	06/20/90
Environmental monitoring support; E, N, & T Tunnels, Area 12	06/20/90
Sand/oil separator, Drilling Support Yard, Area 6	06/20/90
Air conditioning for SNL Recording Facility, Bldg. 12-909, Area 12	07/10/90
UST abandonment, Area 23	07/10/90
Personnel Support Bldg., gate/fence, Area 5	07/11/90
Backfill and cap of tony holes, Area 6	07/13/90
Army well water line check valve, Area 22	08/08/90
Bldgs. 6-618 & 12-2 asbestos flex connections, Areas 6 and 12	08/09/90
SCADA system communication; Areas 2, 3, 5, 12, and 25	08/09/90
Warehouse A turbine installation, Area 23	08/09/90

Table 3.1 (Categorical Exclusions Approved and In Progress - 1990, cont.)

Project	Date Approved
CP-65 fume hood, Area 6	08/09/90
Sewage lagoon closure fill, Area 12	08/14/90
Diesel tank replacement, T Tunnel portal, Area 12	08/14/90
P Tunnel 34.5 KVA line relocation, Area 12	08/14/90
Bldg. 4221 trim saw exhaust, Area 25	08/90/90
RWMS, Exhibit Shelter, Area 5	09/12/90
New power line, Areas 2 and 8	09/20/90
Power line relocation, Area 23	09/25/90
Hazardous/Industrial Waste Accumulation Facility expansion, NLV	10/03/90
Bldg. B-1 chemical neutralization/precipitation unit, NLV	10/03/90
Expansion of the Hazardous Waste Accumulation Facility	10/03/90
EG&G/EM facility Service Bldg., NLV	10/03/90
High Intensity Source Laboratory, NLV	10/03/90
Los Alamos National Laboratory Diagnostic Trailer staging area, NLV	10/03/90
Control Point 1 Compound emergency generator diesel fuel storage tank, NLV	10/03/90
SNL/U.S. Department of Defense Operations Facility, NLV	10/03/90
Protective Coating Facility, NLV	10/03/90
Event Support Bldg., NLV	10/03/90
EG&G/EM Atlas Covered Storage Facility, NLV	10/17/90
Control Point 1 Compound cooling tower pad, NLV	10/17/90
Construction of the Technical Support Facility, Nellis Air Force Base	10/17/90
Construction of the Advanced Technology Laboratory, NLV	10/17/90
Construction of the Verification Facility, NLV	10/17/90
DOE Nevada Test Site Office (NTSO) office bldg., Area 23	10/31/90
Replacement of emergency generator 100-gal. fuel storage tank with 500 gal. tank	11/02/90
Construction of Protective Coating Facility	11/02/90
Installation and operation of a chemical batch treatment module	11/02/90
Construction of Facility Services Bldg.	11/02/90
Construction of the High Intensity Source Laboratory	11/02/90
Expansion of LANL Diagnostic Trailer staging area	11/02/90
Construction of Sandia/U.S. Department of Defense Operations Facility	11/02/90
Construction of an addition to the Event Support Bldg.	11/02/90
Generator and picnic tables, NLV	11/29/90
Reclamation and revegetation trials to support land surface cleanup	12/12/90
Concrete slabs for picnic tables	12/27/90
Upgrade of emergency generator	12/27/90

The following projects have a Categorical Exclusion in progress:

Road 5-01 upgrade, Area 5
Bldg. 143 modification, Area 23
Modification to Bldg. 6, Room 100, Control Point 1 Compound, Area 6
Bldg. 650 leach field closure plan, Area 23

5453

Table 3.1 (Categorical Exclusions Approved and In Progress - 1990, cont.)

Project
The following projects have a Categorical Exclusion in progress (cont.):
Bldg. 114 modifications, Area 23
NTS power distribution
Temporary Monitor Trailer, Able Compound, Area 27
Fleet Operations steam cleaning pad, Area 12
AWC, Inc., soil samples
Truck parking area, RWMS, Area 5
Special Projects Bldg., RWMS, Area 5
Equipment Maintenance Bldg., RWMS, Area 5
Hazardous Waste Support Bldg., RWMS, Area 5
Land Surface Cleanup of Plutonium Project
Pond sediment sampling, E Tunnel, Area 12
Integrated Soil Demonstration Project

and clearance samples for these projects. The seven areas are listed in Table 3.3.

3.2.1.2 RADIOACTIVE EMISSIONS

NTS operations were conducted in compliance with the radioactive air emission standards of NESHAP. On August 7, 1990, EPA Region 9 requested a review of NTS operations with respect to compliance with 40 CFR 61, Subparts H and Q. NTS operations are subject to

Subpart H only. In compliance with reporting requirements, the DOE/NV provides reports to DOE/HQ on radioactive effluents for submission to EPA. Copies of DOE Orders 5400.1 and 5400.5, along with reports submitted to the DOE/HQ, were sent to the Region 9 Air and Toxics Division Director to indicate the requirements the DOE/NV must currently meet.

There are three locations on the NTS where effluents may occur from permanent stacks.

These include air ventilation exhaust stacks (1) on the tunnels in Rainier Mesa, (2) on clothes dryers for the anticontamination clothing laundry facility (although most of the radioactivity removed from this clothing is in the wash water), and (3) for the analytical

Table 3.2 Memoranda to File - 1990

Project	Date Approved
Well 4A, Area 6	01/09/90
Closure Plan, Area 23	02/02/90
Sewage lagoon pipeline, Area 23	06/05/90
PANTEX Radiological Assistance Team, Area 11	06/19/90
Camp Desert Rock Expansion, Area 22	08/08/90

Table 3.3 NESHAP Notifications to the State of Nevada for NTS Asbestos Renovation Projects - 1990

Area	Building	Friable Asbestos	Estimate of Start Date	Completion Date
23	101	45 linear ft of preformed thermal system insulation (TSI)	08/07/90	08/07/90
23	650	40 linear ft of TSI and five pipe elbows	08/01/90	08/02/90
23	300	3 ft^3, including fireproofing debris and 3 linear ft of TSI	09/21/90	09/21/90
23	725	8 ft^2 from 15 pipe elbows	10/23/90	10/24/90
23	725	30 ft^2 from 60 pipe elbows	11/28/90	11/30/90
23	725	33 linear ft of TSI	01/08/91	01/15/91
26	2203, 2204, 2205	1770 linear ft of TSI, 300 ft^2 of acoustic tile and 600 ft^2 of vinyl asbestos tile (EPA Region 9 notified)	11/05/90	Job suspended on 11/13/90 due to a lack of funds

laboratory hoods in Mercury. Based on the amount of material handled, the exhaust from the laundry and the analytical laboratory are considered negligible compared to other sources on the NTS. Sources that are difficult to monitor include increases in seepage of noble gases through the ground caused by meteorological changes and evaporation of tritiated water from containment ponds. Other emissions occur from operational activities such as drill-backs into test cavities (to obtain diagnostic and other data) and purging of tunnel systems after nuclear tests (to facilitate re-entry activities). The NTS user laboratories that conduct these nuclear tests have developed effluent monitoring procedures that are accurate within a factor of two for such operational activities. Considering the low levels of maximum offsite exposures that have been reported in the recent past, this accuracy has been considered acceptable. For example, using best estimates of air emissions in 1990 as input to AIRDOS-PC, the maximum individual effective dose equivalent was only 5×10^{-3} mrem, much less that the 10 mrem specified in 40 CFR 61.

Exposures to offsite people, either by monitoring or by AIRDOS calculation, are much less than one percent of the 10 mrem/year limit, so discussions will be undertaken with EPA Region 9 personnel to determine (1) the acceptability of the present effluent monitoring for operational releases or (2) the modifications that may be necessary to achieve full compliance with 40 CFR 60 and 61 requirements.

3.2.1.3 AMBIENT AIR QUALITY STANDARDS

In 1990 the following nonradiological studies were conducted: (1) an ambient air quality study, (2) air pollution source testing of selected sources, and (3) an emissions inventory at the NTS. Ambient monitoring was conducted in three areas; Area 23, Area 6, and Area 12. A monitoring station was operated at each site to determine the levels of carbon monoxide, nitrogen dioxide, sulfur

dioxide, and particulate matter. Concurrent with the ambient monitoring program, surface meteorological data were collected by the National Oceanic and Atmospheric Administration's Weather Service Nuclear Support Office at weather stations operated near each ambient monitoring station. During the monitoring period, no violations of the current federal primary and state secondary air quality standards were recorded. Testing of selected point sources was also conducted at the NTS to determine compliance status with various operating permits. Among the sources tested were a boiler, paint spray booth, incinerator, and tunnel exhaust. No violation, as specified in permits granted by the state of Nevada, Department of Conservation and Natural Resources, was found for the sources tested. Based on the data collected during this study, the NTS air quality was well within all applicable local, state, and federal regulations (Engineering-Science 1990).

Although sampling and analysis lasted only one month, considering the concentrations found, it appears unlikely that violations of air quality standards will occur during normal operations.

3.2.1.4 AIR QUALITY PERMITS

NTS air quality regulatory compliance activities for 1990 also involved state of Nevada air quality permit reporting and renewals. (See Table 4.1, Section 4.3.1 for a listing of permit renewals.) Common air pollution sources at the NTS included aggregate production, stemming activities, surface disturbances, fugitive dust from unpaved roads, fuel burning equipment, open burning, and fuel storage facilities. Emission tests on some permitted sources indicated no permit violations (as indicated in Section 3.2.1.3, above).

The 1989 annual report for state of Nevada air quality permits was submitted to the state on March 21, 1990. This report included the production, operating hours, and a report of all surface disturbances of five acres or greater. The report listed all permitted activities and indicated that no permit conditions were exceeded.

3.2.2 NON-NTS FACILITIES

3.2.2.1 RADIOLOGICAL REPORTING

As all radiation sources used at EG&G/EM facilities are sealed, Clean Air Act issues affect only the nonradiological emissions covered by state and local permit requirements.

3.2.2.2 AIR QUALITY PERMITS

Air quality permits were required in two of the eight non-NTS facilities although there were no monitoring requirements associated with these permits and only one county required an annual report. Specific compliance issues are discussed below.

The EG&G/EM Las Vegas Area Operations (LVAO) Atlas facility in North Las Vegas (NLV), Nevada, was required to maintain air quality permits issued by Clark County, Nevada. Several emission units regulated by Clark County were discovered to be operating without permits. These were shut down and permit applications were filed. These unpermitted emission units remained out of service at the end of 1990 awaiting issuance of the applicable operating permits.

Although the Amador Valley Operations facility was not required to obtain permits, local regulations in Amador Valley, California, required businesses to discontinue use of aerosol spray paints containing more than 67 percent organics. Compliance has been maintained although no routine monitoring activities were mandated to verify compliance with this regulation.

In Woburn, Massachusetts, local regulations required that no more than one ton per year of 1,1,1-trichloroethane be used in vapor degreasers. Compliance has been maintained although no routine monitoring or

reports were mandated to verify this requirement.

3.3 CLEAN WATER ACT

There are no National Pollutant Discharge Elimination System (NPDES) permits for DOE/NV facilities as there are no wastewater discharges to onsite or offsite surface waters. Monitoring and reporting were limited to the requirements of state and local permits. A complete listing of these permits appears in Section 4.3.

3.3.1 NTS OPERATIONS

Water monitoring at the NTS was limited to sampling wastewater influents to lagoons and ponds under a series of state of Nevada permits. The results of this sampling are summarized in Section 7.1.2 of this volume. Other compliance issues are discussed below.

In January 1990 a discharge permit application was submitted to the state of Nevada for two shallow injection wells in Area 1. These wells received nonhazardous wastewater from steam cleaning of drill pipe. However, in November a decision was made to pursue other disposal methods, so a closure plan for the wells will be prepared and submitted to the state.

State approval was received in January 1990 to construct an evapotranspiration bed serving the Airborne Response Team Hanger in Area 6. Original submittals to the state in 1989 were for a leach field, but results of percolation tests caused the state to reject the leach field. The project was completed in May 1990.

In February 1990 the state was contacted concerning a septic tank/leach field system in Area 3 that had become overloaded, causing the effluent to percolate to the surface, and thus creating an unpermitted sewage lagoon. The septic tank was pumped on a regular basis to temporarily alleviate the problem. A proposal to correct the problem was made to the state based on construction of a new above-ground primary/secondary evaporative lagoon system. Engineering design for this project was initiated, the area affected was fenced, and the appropriate warning signs were posted. However, the change house for the miners performing U1a shaft tunneling operations was moved to Area 6, and there was a significant reduction in effluent by the end of the summer. Since this construction yard is being moved to new facilities in Area 6 in 1991, no new sewage system will be installed. The line to the existing septic tank and leach field will be capped and the tank filled with sand per Nevada Administrative Code (NAC) 444.818-11.

On April 24, 1990, the DOE/NV responded to a state request for additional information concerning proposed modifications to several NTS sewage lagoon systems. Information was provided, and the state conditionally approved the modifications in May 1990.

At the Area 6 Yucca Lake facility, the flow rates for November and December 1990 were 0.0126 million gallons per day (MGD) and 0.0104 MGD, respectively. These rates exceeded the state of Nevada limit for the lagoon system of 0.01 MGD. These results were reported to the state, and a request to increase the permitted flow rate will be submitted during 1991.

3.3.2 NON-NTS FACILITIES

Permits for wastewater discharge were held for five of the eight non-NTS, EG&G/EM-operated DOE/NV facilities, and monitoring and reporting were accomplished according to the dictates of state and local governments. No wastewater permits were held for the Los Alamos Operations, Kirtland Operations, or Washington (D.C.) Aerial Measurements Department in 1990. No noncompliance level of any regulated substance was reported to any permitting agency.

It was discovered in May 1990 that a process discharging wastewater to the publicly owned treatment works located at the Craddock Facility (Kirtland Operations, Kirtland Air Force Base, Albuquerque) may require a city permit. A letter was sent to the city requesting guidance in July 1990. The city informed EG&G/EM that a permit application would be needed, including an analysis of potential pollutants. Samples were taken and analyzed in November and reported to the city in December. At the end of 1990 no further action had been taken by the city.

3.4 SAFE DRINKING WATER ACT

Safe Drinking Water Act regulations apply to onsite potable water sources at the NTS and an injection well at the EG&G/EM facility in Woburn, Massachusetts. Permit information and the associated required monitoring are discussed in Section 4.3.

3.4.1 NTS OPERATIONS

Potable water systems were sampled based on the population served as stipulated by the SDWA and state of Nevada regulations. As all water systems served less than 1000 nontransient persons, sampling was required only once monthly. Figure 3.1 shows the percentage of state and federal standards calculated from the individual sampling results of regulated constituents in NTS potable water. Sampling results in tabular form are shown in Section 7.1.1.

Four individual samples had levels exceeding the National Primary Drinking Water Standard.

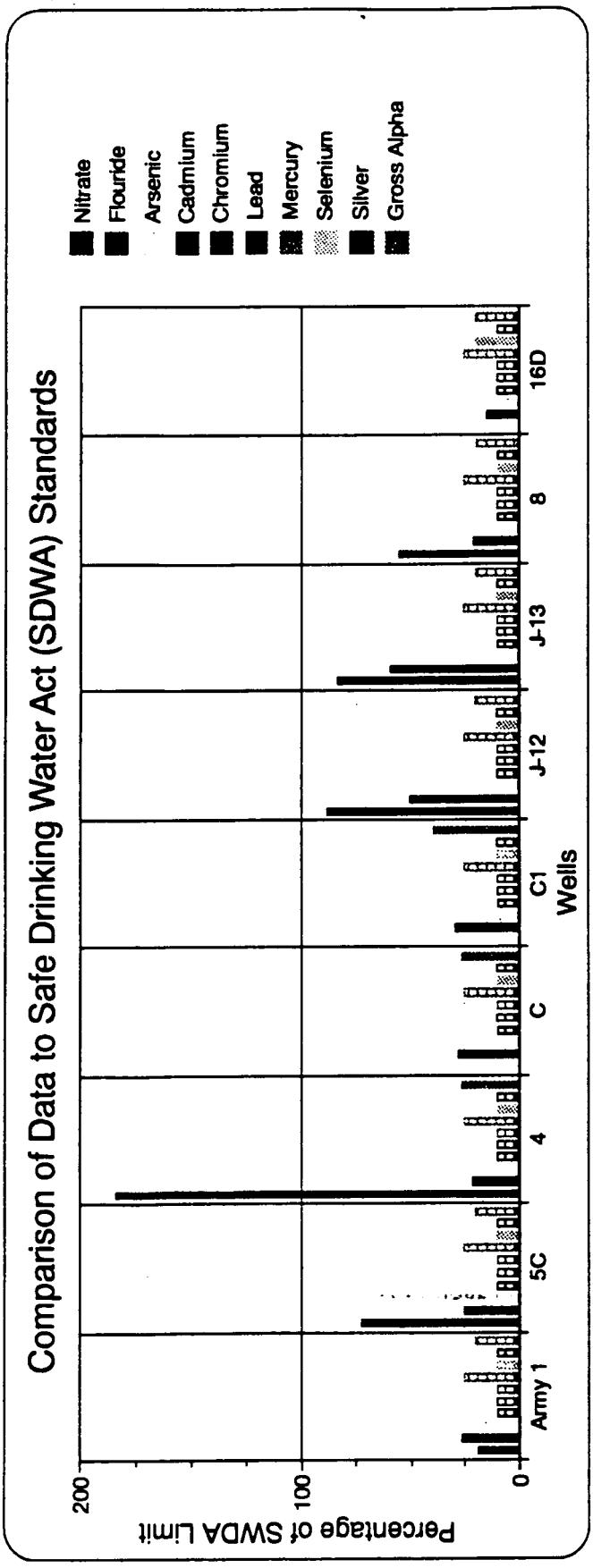
- Well 4 in Area 6 had a nitrate level of 18 parts per million (ppm), 8.2 ppm above the National Primary Drinking Water Standard. Additional samples were collected which confirmed standard violations. Since the Area 6 Control Point complex was supplied by this well and Well C-1, samples were taken to establish the levels at the supply points. A sample from a Building CP-2 use point source was taken each of the two days a replicate well sample was taken. The results from the use point source samples reflected levels of 0.6 ppm and 1.2 ppm in Building CP-2. These were well below the 10 ppm standard. The reduction in nitrate level resulted from mixing Well 4 and Well C-1 waters.

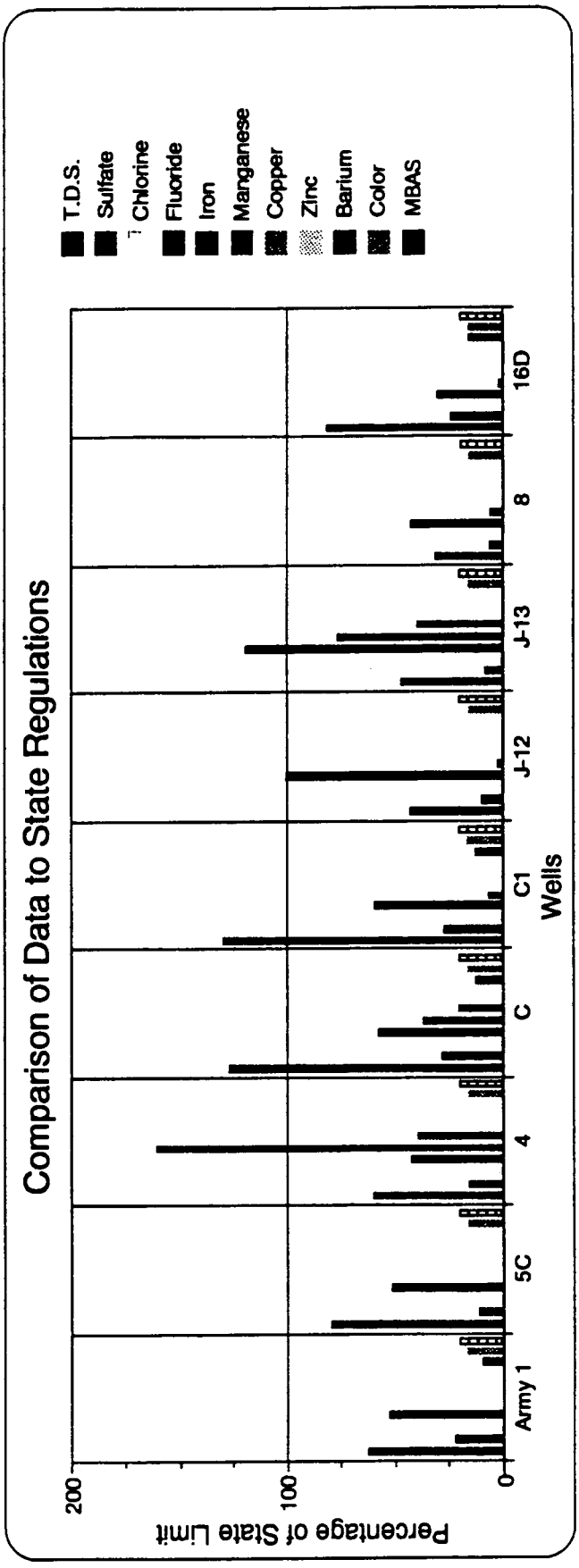
- Two wells in Area 25 had fluoride levels of 2.1 ppm and 2.3 ppm, respectively, both of which exceed the state of Nevada Secondary Standard of 2.0 ppm. Additional samples were collected which confirmed standard violations. Use points of water from these wells were posted as having elevated fluoride levels.

- Wells C and C-1 in Area 6 had total dissolved solids levels of 640 ppm and 650 ppm, respectively, both of which exceeded the state of Nevada Secondary Standard of 500 ppm. Additional samples taken from one well confirmed the standard violations. Additional samples will be collected on the second well in 1991.

- Well 5C in Area 5 had a pH of 8.9, which exceeded the state of Nevada Secondary Standard of a pH between 6.5 and 8.5. Three additional samples for pH were collected at the well which confirmed the standard violation.

Notices entitled "Elevated pH in Mercury Water Supply," "Elevated Nitrate Concentration in Area 6 Water Supply," "Elevated TDS Concentration in Area 6 Water Supply," and "Elevated Fluoride Concentration in Area 25 Water Supply" were posted at the drinking water outlets for each standard violation. These notices identified the (1) violations, (2) areas affected, and (3) potential health effects. The state of Nevada will be contacted to determine the required corrective actions.





Note: Striped bars signify samples that were at the lower limit of detection

Figure 3.1 Comparison of Individual Water Sampling Results to Regulation Limits

3.4.2 NON-NTS FACILITIES

The EG&G/EM facility in Woburn, Massachusetts, has an injection well for returning uncontaminated, noncontact cooling water to the underground aquifer. The state of Massachusetts was authorized by EPA to administer the Underground Injection Control Program. Through an internal environmental compliance appraisal in November 1990, it was determined that this injection well might not be in compliance with state regulations. Efforts have been initiated to secure the appropriate notification forms and permit applications from the state.

No other noncompliance issue was reported for any other non-NTS facility.

3.5 RESOURCE CONSERVATION AND RECOVERY ACT

In addition to routine environmental sampling (discussed in Section 7.1), significant RCRA activities for 1990 included (1) state of Nevada RCRA actions involving the Area 5 RWMS and Area 12 tunnels, (2) submission of the EPA biennial hazardous waste report for the NTS, (3) internal revisions to the draft RCRA Part A Permit Application, (4) responses to state of Nevada comments concerning the Area 6 Decontamination Facility evaporation pond, (5) underground storage tank movement/closure, and (6) completion of waste minimization and pollution prevention awareness plans. These items are discussed in detail in the paragraphs following.

3.5.1 STATE OF NEVADA/RCRA ACTIVITIES

On April 16, 1990, the Nevada Division of Environmental Protection (NDEP) provided a Completeness Review of the RCRA Part B Application for the Mixed Waste Management Facility (MWMF) at the RWMS in Area 5. Several general comments were submitted. These are discussed in Section 3.5.1.1 below.

On March 6 to 8, 1990, NDEP staff visited the DNA tunnels and the Area 5 MWMF. Four issues were identified in a letter to the DOE/NV on April 16, 1990. A listing of these issues appears in Section 3.5.1.2.

On August 19, 1990, NDEP staff returned to perform an inspection of the Area 5 RWMS. Several potential violations were noted. Section 3.5.1.3 is a discussion of these potential violations.

REECo and DNA responses to the issues raised during these inspections were submitted to the DOE/NV, but no formal response has been made to the NDEP by the DOE/NV since these and other issues are being negotiated as part of the Agreement in Principle with the state of Nevada.

3.5.1.1 COMMENTS ON THE RCRA PART B APPLICATION

The NDEP review of the DOE/NV MWMF Part B Application found the application to be either incomplete or deficient in the areas listed below. Modification of the permit is required as stated below:

- Floodplain - Records or sources utilized in verifying the location of the nearest 100-year floodplain boundary are to be submitted in accordance with 40 CFR 265.18(b) and 40 CFR 270.14(b)(11).

- Storage Containers - Information on all containers used for storing or disposing of waste (i.e., drums, metal boxes, metal cargo carriers, etc.), must be outlined as described in 40 CFR 264.171. This must include the number and a complete description of the containers. It must be demonstrated how emissions are prevented or controlled for wastes capable of generating gases. In containers certified adequate for at least 20 years from the date of Waste Isolation

Pilot Plan (WIPP) certification, if the date of WIPP certification is known, it should be specified. Documentation also needs to be provided for (1) the basis by which wastes are characterized as mixed TRU wastes and (2) what provisions in the waste analysis plan will be made to adequately characterize a hazardous waste component in future wastes accepted for storage at the Waste Storage Cell facility.

- Run-on/Run-off Control - The effectiveness of installing a storm run-off collection system that would prevent the surface accumulation of precipitation on the pad must be discussed in accordance with 40 CFR 270.15(a)(2) and 40 CFR 264.175(b)(2).

- Life of Permit - Because the effective life of a permit is not to exceed five years (NRS 459.520) and permits for land disposal facilities are reviewed by the Director, NDEP, before reissuance, the permitted capacity will not be significantly greater than the expected capacity needed for the life of the permit. The state recommends that the proposed 96 landfill cells (each with an approximate operating life of five years) be reduced to no more than five cells. This volume represents more than adequate capacity for the effective life of the permit. This modification should also be reflected in the closure and post-closure plan as stated in 40 CFR 270.50.

- Waste Analysis Plan - The waste analysis plan must specify sampling methods and frequency in accordance with 40 CFR 264.13(b) and Part 261, Appendix I, for each waste stream listed in the Part A application and Exhibit F of Volume I of the Part B application. A rationale must be given for selecting the chosen method for each waste stream.

- Groundwater Monitoring - Based on 40 CFR 265.90, further site characterization was recommended on the unsaturated zone characteristics (i.e., geologic materials, physical properties, and depth to groundwater). Most of the groundwater studies cited in the application addressed the NTS or the Frenchman Flat region of the NTS in general. The nearest existing well appeared to be at about three miles from the RWMS. The 800 to 900 feet depth to groundwater, as cited in the application (Volume II, p. 5-1), is according to a study by Winograd and Thordarson published in 1975. An acceptable evaluation will require the installation of groundwater monitoring pilot wells adjacent to the MWMF.

- Landfill Liner and Leachate Collection System - A request had been made to waive the double-liner system requirement made in 40 CFR 264.301. The state deferred a decision on the request for the double-liner system waiver pending the results of further study at the RWMS. The additional evaluation requested for the groundwater monitoring waiver will provide needed information in determining the need for a liner and leachate collection system.

- Subsurface Exploration Data - Sections of 40 CFR 264.301(a)(1)(ii) and 40 CFR 270.21(b)(1) need to be addressed. Specifically, the results of the bearing capacity analysis performed must be included to assess potential causes of the observed pile toppling and pile slope of up to 45 degrees. Estimates must be provided of the total and differential settlement including immediate settlement, primary consolidation, and secondary consolidation.

- Closure and Post-Closure Care - A description must be provided on how the unsaturated zone monitoring system will be utilized and maintained during post-closure of the facility in accordance with 40 CFR 264.310.

3.5.1.2 RCRA ISSUES RESULTING FROM NDEP VISIT OF MARCH 6 TO 8, 1990

Area 5 RWMS Contingency Plan

During the March 6 to 8 state inspection of the Area 5 RWMS Mixed Waste Disposal Facility, it was noted that there was some confusion as to whether there was an Area 5 contingency plan specifically for the Area 5 Mixed Waste Disposal Facility and whether staff at the Area 5 complex had received training in implementation of that plan. Although 40 CFR 265 only requires a contingency plan for the "facility," and facility may be broadly defined to encompass the entire 1350 square-mile (3500 square-kilometer) NTS, it was suggested that "it may be prudent to develop a contingency plan unique to the Area 5 complex." It was further suggested "that staff at Area 5 also be given specific training in the implementation of that plan."

The NDEP requested a copy of the existing contingency plan and records documenting training in that plan for staff located at the Area 5 RWMS. Information on any DOE/NV plans to develop a site-specific contingency plan for the Area 5 RWMS was also requested.

Receipt of Mixed Wastes

At the exit meeting on March 8, 1990, NTS representatives stated no mixed waste from Rocky Flats would be received after May 8, 1990, the anticipated date of the final ruling for the Land Disposal Regulations (LDR). DOE/NV staff indicated that this was based on the concern that Rocky Flats was sending wastes with insufficient characterization for the DOE/NV staff to determine if the waste could be placed in the RWMS mixed waste cells in accordance with the LDR. They also indicated that a more complete characterization of the wastes would be completed in July 1990, and at that time waste shipments could resume under the conditions of the LDR[a]. The NDEP requested a report outlining the DOE's plans for complying with the LDR after the final rule is adopted. Also, the report is to include documentation that all wastes placed in the Area 5 RWMS hazardous waste facility have met the criteria for those portions of the LDR in effect on the date wastes were placed in the units.

Disposal of Wastes from NTS Tunnels

On March 6, 1990, the Chief, Technical Compliance Division, Defense Nuclear Agency (DNA), conducted a tour of the active tunnel complexes, namely N, P, and T. The tour and subsequent meeting focused on the possible regulatory approaches which could be used to address the environmental impacts from three primary activities at the tunnels. Those three activities were (1) mining the reentry drifts, (2) disposal of waste onto the portal muck piles, and (3) discharges of water from the tunnels to the tunnel ponds.

The NDEP requested that the DOE/NV present a report which outlines the approach the DOE wishes to use on evaluation, permitting, and, where necessary, mitigating the environmental impacts from each of these three types of activities. The report is to document in detail the reasoning behind the DOE's approach and should also establish a schedule for implementing each task.

3.5.1.3 POTENTIAL VIOLATIONS - INSPECTION OF AUGUST 19, 1990

The following comments were made as a result of the Area 5 RWMS inspection by NDEP:

(a) Rocky Flats must apply to DOE/NV as a generator shipping under the conditions of the LDR prior to being allowed to resume shipment of mixed waste to the NTS. As of this report writing, Rocky Flats has not submitted an application for this purpose.

- RWMS staff receiving hazardous wastes do not compare the manifest to the hazardous waste label on the containers. This is necessary to verify that the waste received matches the manifest in accordance with 40 CFR 265.13(a)(4).

- The training plan does not include a requirement to train personnel on implementation of the contingency plan in accordance with 40 CFR 265.16(a)(2).

- The training program does not specifically list any training in procedures for using, inspecting, repairing, and replacing facility emergency and monitoring equipment. Since the training plan does not provide a written description of each course content, it could not be determined if the program included training in the use of communications, alarm systems, and shutdown of operations in accordance with 40 CFR 265.16(a)(3).

- The personnel training records list the name, course, and date attended but do not list the job title and description in accordance with 40 CFR 265.16(d).

- No aisle space is provided between drums stored in the metal carriers located on the TRU pad in accordance with 40 CFR 265.35.

- Arrangements to familiarize police, fire department, hospitals, and emergency response teams are not documented. If support from offsite emergency support teams is not thought to be needed, this should be documented and explained in accordance with 40 CFR 265.37(a)(1-4), 40 CFR 265.52(c), and 40 CFR 265.53(b).

- The Emergency Management Plan (EMP, also known as the contingency plan) fails to clearly define the role of the Emergency Coordinator in monitoring equipment, recovering contaminated material, and overseeing decontamination procedures in accordance with 40 CFR 265.56(f)(g)(h).

- The EMP should expressly require that the Administrator, NDEP, be notified before resuming operations in affected areas in accordance with 40 CFR 265.56(i).

- Waste shipments should be checked for discrepancies against the uniform manifest in accordance with 40 CFR 265.71(a)(2) (e.g., hazardous waste codes from labels on containers versus the manifest, number of containers, volumes, etc.). This check should not rely solely upon other internal documents or shipping papers.

- The drums stored on the TRU mixed waste storage pad are not inspected weekly as required in 40 CFR 265.17 and 265.15(a).

- Each drum of mixed waste should have been labeled prior to receipt by the NTS. Labels should be placed on each drum in accordance with 40 CFR 262.31-32.

- The facility does not test the waste or an extract of the waste to assure that the wastes are in compliance with the applicable treatment standards set forth in Subpart D of 40 CFR 268, nor is the testing frequency specified in the facility's waste analysis plan in accordance with 40 CFR 268.7(c)(2).

- The TRU mixed waste pad was constructed prior to submitting a Part A Permit and receiving approval of the state of Nevada Administrator, Division of Environmental Protection. This is not in compliance with 40 CFR 270.72(a)(3).

3.5.2 HAZARDOUS WASTE REPORTING

DOE/NV has been allowed to dispose of waste under the EPA Generator Identification

(ID) Number NV3890090001 which has been assigned to REECo, the primary contractor for the NTS. The required hazardous waste generator annual report was sent to the state of Nevada on March 30, 1990. EG&G/EM sent a 1989 hazardous waste generator annual report to the state of Nevada in 1990 for the LVAO waste associated with EPA Generator ID Number NVD097868731.

3.5.3 RCRA PART A PERMIT APPLICATION

A modification to the Part A Permit application was received from REECo on April 30, 1990, to include two steam cleaning effluent ponds located in Area 6. These ponds are unlined and are suspected to have received RCRA wastes in the form of chlorinated solvents. A closure plan, which should be completed early in 1991, is being prepared for these ponds. The modified application has not been transmitted to the state pending negotiations of the Agreement in Principle.

3.5.4 AREA 6 DECONTAMINATION FACILITY EVAPORATION POND

In March 1990 responses were provided to state comments made in October 1989 regarding the Area 6 Decontamination Facility Evaporation Pond Closure Plan. These are listed below.

Comment: The closure plan does not address site-specific characterization of the local hydrology.

Response: Possible impacts to shallow water aquifers are not a consideration since historical information does not indicate any shallow aquifers beneath the Yucca Lake playa. Well logs from Wells B and C, located at the northern and southern edges of the playa, indicate the static water level to be at more than 1500 feet (Garber and Thordarson 1962, Moore and Barber 1962). Schlumberger soundings at several locations in the playa revealed no underlying shallow aquifers (Zohdy and Bisdorf 1979). In the unlikely event that a shallow or perched water groundwater system is penetrated, the DOE/NV will immediately notify the NDEP. At this time, further site investigation activities will be modified with full concurrence of the NDEP.

Comment: The state is concerned that the indicator constituents identified in the site investigation plan do not address the full complement of contamination which may be present.

Response: The state's observation concerning indicator constituents was well taken and the site investigation was changed accordingly. Phase 1 water, sediment, and soil sample data will be reported and the data will be screened for suitable indicator constituents. Analytical methods already specified in the site investigation will cover volatile organic compounds and basic/neutral/acid organics along with EPTox metals. An additional analysis of soil will be run for total metal (the inductively coupled plasma test) to estimate the movement of metals in the plume. Indicator constituents which will be used in Phase 2 will be agreed to by both the DOE/NV and NDEP and will comprise the analytes to be used for the Phase 2 sampling effort.

Comment: The site investigation calls for boreholes at the edge of the pond. Without boreholes within the perimeter of the existing pond, the vertical extent of the contamination may be missed.

Response: The DOE/NV intends to address the vertical extent of contamination at the Decontamination Facility evaporation pond. Borings will be made within the bermed area of the pond subsequent to draining the pond. Liquids will be removed or evaporated prior to boring operations.

Comment: References in the closure plan to change and nonconformance/corrective action control do not include state review. Any changes to the approved closure plan will require state review.

Response: This section of the quality assurance part of the plan was not intended to bypass NDEP concurrence of project changes, only to assure that any changes are recorded in a consistent and prescribed manner.

3.5.5 UNDERGROUND STORAGE TANKS

Sixteen underground storage tanks (USTs) containing petroleum products were removed, closed in place, or temporarily closed in 1990 (see Table 3.4) in accordance with state statutes. Five tanks were removed from service and closed in place. Three other tanks were removed from the ground and disposed of in a landfill. Eight more tanks were temporarily closed by removing all petroleum products to no more than one inch in the tanks. Soil samples were taken on the outside ends of the tanks closed in place or removed, and two of the sites were found to have concentrations of hydrocarbons above the 100 mg/kg action level. The Building 111 tank site is being remediated using native soil microbes and nutrients. The second tank site at P Tunnel in Area 12 will be remediated using a similar approach.

All tanks were rinsed with water and made inert using nitrogen gas and/or dry ice prior to performing closure activities. One fiberglass tank was sent to the Area 6 equipment yard for reuse. Tanks that were closed in place were filled with cement grout.

The state was notified in January 1990 of five USTs which were installed at the Area 5 Device Assembly Facility. Further notification was made in February to confirm the final disposition of USTs removed in 1989.

3.5.6 WASTE MINIMIZATION

3.5.6.1 NTS OPERATIONS

The DOE/NV Waste Minimization Plan was published on May 9, 1990. On November 1, 1990, the REECo plan was completed. (REECo is the primary construction and support contractor on the NTS.) These plans apply to hazardous, radioactive, mixed, and solid wastes. The DOE/NV plan contains a waste minimization policy statement and created a Waste Minimization Task Force with representatives from all NTS contractor and user groups. The REECo plan contains both the waste minimization and the pollution prevention awareness plans.

The REECo plan established waste minimization operations and management committees. Waste streams and associated waste generation processes were identified, and quantitative waste minimization goals with completion schedules were established. Goals included establishing baselines for waste generation and reducing hazardous waste generation by 20 percent of the fiscal year 1989 level during 1991. A procurement and product issuing control procedure was established that requires REECo Environmental Compliance Office approval and user documentation on the final disposition of all products categorized as "controlled." The plan also calls for adoption of nonhazardous waste producing products and processes.

Several nonhazardous, biodegradable products with various uses were made stock items. Several new waste minimization technologies were established.

Automatic parts washers that use biodegradable solvent were put into use at two locations. A cutting oil recycling machine was placed at the machine and welding shop. Freon gas recovery and recycling units were placed in all refrigeration mechanics' shops. Special spray gun cleaning and condensing units were put in place in all paint shops. These units were

5453

Table 3.4 Underground Storage Tank Activities - 1990

Area/Facility	Size (Gallons)	Tank Number	Contents	Disposal
Closed in Place				
23/Bldg. 116	500	23-116-4	Diesel	N/A
23/Bldg. 116	500	23-116-5	Diesel	N/A
23/Bldg. 119	2500	23-119-1	Used Oil	N/A
23/Bldg. 210	5000	23-210-4	Gasoline	N/A
23/Bldg. 210	5000	23-210-5	Gasoline	N/A
Temporarily Closed for Upgrade[a]				
25/Bldg. 4838	10,000	25-4838-1	Gasoline	N/A
25/Bldg. 4838	10,000	25-4838-2	Diesel	N/A
23/Bldg. 752	10,000	23-752-1	Gasoline	N/A
23/Bldg. 752	10,000	23-752-2	Gasoline	N/A
23/Bldg. 752	10,000	23-752-3	Diesel	N/A
Temporarily Closed (will be replaced with above-ground tanks)				
25/Bldg. 4838	550	25-4838-3	Used Oil	N/A
23/Bldg. 750	2000	23-750-1	Used Oil	N/A
23/Bldg. 751	2000	23-751-1	Used Oil	N/A
Removed				
12/P Tunnel	550	12-P-2 Landfill	Diesel	U10c Sanitary
12/N Tunnel	4380	12-N-1 Landfill	Diesel	U10c Sanitary
12/T Tunnel	4380	12-T-1 Landfill	Diesel	U10c Sanitary

(a) Upgrades consist of replacement of existing piping with dual wall fiberglass piping and installation of piping leak detectors, containment manholes, and float bulbs (for overfill prevention) and/or vapor monitors.

used to capture chlorinated compounds that would otherwise escape to the atmosphere.

Employee training and awareness efforts and goals are referenced in the REECo plan. These include the use of training films and other pollution prevention awareness media as well as incorporation of waste minimization suggestions into the REECo suggestion award system.

3.5.6.2 NON-NTS FACILITIES

Hazardous waste minimization efforts at LVAO were focused on the machine shop in Building B-1 at the Atlas facility in North Las Vegas, Nevada. This included material

079

substitution and the installation of a coolant recycling machine. Consumption of 1,1,1-trichloroethane was reduced 75 percent by eliminating the vapor degreaser and switching to a parts washer using biodegradable soap. Cutting fluids containing 1,1,1-trichloroethane were replaced with a cutting fluid that did not contain this solvent. This reduced the volume of the waste cutting oils that were required to be treated as hazardous waste. A coolant recycling machine purchased for the machine shop reduced waste volume by 80 percent.

Waste volume from spray paint cans was reduced by puncturing the cans and allowing the paint wastes to drain and be absorbed in a drum. The paint waste was managed as a hazardous waste, but the punctured cans were only empty containers and disposed of as ordinary trash. This resulted in a 90 percent reduction in spray paint can waste.

At the EG&G/EM Amador Valley facility, one oil-free pump was substituted for an oil-sealed pump in a vacuum system.

During 1990 a significant effort at EG&G/EM Santa Barbara Operations facility in Goleta, California, focused on wastewater treatment, recycling, and segregation of wastes. The wastewater treatment and recycling of liquid containing mercury resulted in the complete elimination of this waste stream which would typically generate 28 barrels each year. Efforts to segregate solid from mercury-contaminated waste resulted in a reduction of two to three waste drums per year.

The EG&G/EM Special Technologies Laboratory in Santa Barbara, California, modified its wastewater treatment to remove copper from printed circuit board rinse water. This effort resulted in a reduction of 1320 gallons of waste per year.

3.6 COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, AND LIABILITY ACT (CERCLA)/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT (SARA)

3.6.1 NTS OPERATIONS

In 1987 a DOE/HQ task force determined that underground nuclear device testing areas are CERCLA sites. Under CERCLA all releases of hazardous or extremely hazardous substances that exceed reportable quantities must be reported to the National Response Center (NRC). Following further review of the issue and reporting procedures by the DOE and EPA, the DOE/NV began reporting nuclear tests to the NRC in 1989. This reporting is in accordance with Section 103 of CERCLA and Section 304 of SARA. Following a test the NRC is notified of the test and of which typical test profile to reference. During 1990 the DOE/NV continued reporting underground tests to the state of Nevada, Emergency Management Division, as part of this reporting procedure.

Preliminary Assessment/Site Investigation reports required by CERCLA were prepared for the NTS and for formerly used sites and provided to the EPA in 1988. Not all data needed to determine a revised Hazard Ranking Score reflecting changes in the NTS water production well system have been collected, so a new Hazard Ranking Score has not been assigned. The EPA will use the new assessments to determine if the sites are to be included on the National Priorities List (NPL).

The possibility of listing the NTS on the NPL of hazardous waste sites under the auspices of CERCLA carries potential for extensive budget and operational impacts. During 1990 environmental restoration planning for environmental contamination mitigation and environmental restoration actions was continued.

5453

A SARA Tier II report was filed with the DOE/NV on February 28, 1990, for the NTS.

3.6.2 NON-NTS FACILITIES

A Tier II report was filed with the DOE/NV on February 27, 1990, for the LVAO Atlas Facility (a Form R report was not required), and four Tier II reports were filed for fuel storage facilities managed by the Remote Sensing Laboratory. A Tier II report was prepared and submitted for the Woburn Operations facility on March 13, 1990. A Form R report was prepared for Woburn Operations and submitted to the DOE/NV on June 28, 1990.

3.7 TOXIC SUBSTANCES CONTROL ACT

On January 26, 1989, EPA Region 9 personnel conducted an inspection of the NTS for compliance with PCB regulations, including a review of sampling procedures and associated analyses. The final inspection report was transmitted to the DOE/NV on July 30, 1990, and contained twenty violations. Sixteen of these violations were from NTS noncompliant activities during the period of 1978 to 1983; the remaining four violations were from noncompliant activities at the time of the inspection. The inspection report required response from the DOE/NV within thirty days. The response was made on August 28, 1990, and specifically addressed each violation. Pending further investigations by the EPA, this inspection and the resultant compliance status report are considered closed.

TSCA requires submission of an annual report describing PCB control activities. The NTS PCB annual report was submitted to the EPA in June 1990. The report included the quantity and status of PCB and PCB-contaminated transformers and electrical equipment at the NTS. Also reported were the number of shipments of PCBs and PCB-contaminated items from the NTS to an EPA-approved disposal facility.

No activities relating to TSCA occurred at non-NTS facilities during 1990.

3.8 FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT (FIFRA)

During 1990 REECo was responsible for the application of pesticides at the NTS. The program was operated under the supervision of a company sanitarian who was certified as a pesticide applicator with the state of Nevada. The program consisted of application, training, record maintenance, and scheduling. No unusual environmental activities occurred in 1990 at the NTS relating to FIFRA.

Pesticides were stored in an approved storage facility located in Area 23. Pesticide usage included insecticides, herbicides, and rodenticides. Insecticides were applied twice a month at the food service and storage areas, herbicides were applied once or twice a year, and all other pesticide applications were applied on an as-requested basis. General-use pesticides were used for most applications, although restricted-use herbicides and rodenticides were used upon occasion.

Records were maintained on all pesticides used, both general and restricted. These records will be held for at least three years. Training activities include at least two safety meetings covering pesticide use, and all applicators are provided the opportunity to receive state-sponsored training materials.

Contract companies applied pesticides at all non-NTS facilities in 1990.

3.9 SOLID/SANITARY WASTE

Permission to operate sanitary landfills at the NTS is given by the state of Nevada (no permits are required). All operation and maintenance manuals for the sanitary landfills at the NTS have been approved by the state of Nevada. On March 15, 1990, a

081

NDEP representative conducted an inspection of the landfills located at the NTS. This was done prior to upgrading three of the landfills (in Areas 23, 10, and 6) to Class I sanitary landfills and the remaining landfills (Area 25, 20 and 3) to Class III construction landfills.

The following draft documents were submitted by REECo to the Solid Waste Section of NDEP for review:

- Operation and Maintenance Plan, Class I Sanitary Landfills, NTS.
- Operation and Maintenance Plan, Class III Area 3 Construction Landfill.
- Operation and Maintenance Plan, Class III Area 20 Construction Landfill.
- Operation and Maintenance Plan, Class III Area 25 Construction Landfill.
- Industrial Hygiene Department Standard Operating Procedures, including: "Solid Waste Recycling Program"; "Collection, Transportation, and Disposal of Medical Waste"; "Rabies Control"; and "Dead Animal Disposal."

Subsequent to the onsite inspection and review of the applicable documentation, on May 2, 1990, the NDEP issued a letter of authorization to operate each landfill in accordance with the Operation and Maintenance Plans as submitted.

3.10 ARCHAEOLOGICAL AND CULTURAL HISTORY PRESERVATION

The National Historic Preservation Act requires federal agencies to take into account any impact their actions might have upon historic sites listed in the National Register of Historic Places. In compliance with this law, the DOE/NV contracted pre-activity surveys and other studies to assess any impacts NTS operations may have on historical and archaeological sites found on the NTS. From the findings of the surveys, plans can be written for the recovery of data to mitigate the effects of operations on these sites. When the plans have been finalized, recovery programs may be initiated for the collection of archaeological data. The data recovery programs culminate in technical reports on the scientific findings of the programs. The responsibility for conducting these studies belongs to a group (Task 5 - Compliance with Environmental Regulations/Archaeology) within the DOE/NV-sponsored Basic Environmental Compliance and Monitoring Program (BECAMP).

In 1990, 22 pre-activity surveys were conducted for archaeological sites on the NTS, and reports on the findings were prepared. These pre-activity surveys identified 60 sites containing previously unknown archaeological information. Five data recovery plans were prepared, six data recovery programs were initiated, and four technical reports concerning previous data recovery efforts were completed.

Initiation of the American Indian Religious Freedom Act Compliance Program occurred in 1989. The program requires (1) a literature review of baseline documents about Native American concerns on the NTS, (2) development of a study plan on how the DOE/NV is considering the effects of NTS operations on Native American concerns, (3) consultation with Native Americans who have concerns on the NTS, including coordinating field visits, (4) preparation of a draft report on the findings of the study plan and consultations with recommendations for mitigation of adverse effects on Native American concerns, and (5) completion of a final report which has been reviewed by appropriate state of Nevada and federal agencies. A literature review and evaluation of baseline documents about Native American concerns on the NTS were completed in 1990. This information was assembled in a draft baseline document and was used in the preparation of a draft study

plan. The final versions of these documents are scheduled for completion in 1991.

3.11 ENDANGERED SPECIES PROTECTION

The Endangered Species Act (ESA) requires federal agencies to assure that their actions do not (1) jeopardize the continued existence of state of Nevada and federally listed endangered or threatened plant or animal species or (2) result in the destruction or adverse modification of critical habitat for these species. In compliance with this law, the DOE/NV contracts pre-activity surveys and other studies to identify the locations and areas occupied by protected species.

There are currently eight species of concern found on the NTS; seven plant species that are being considered for listing as endangered or threatened and one reptile species that was listed (on an emergency basis) as an endangered species in 1989. This reptile species was relisted as a threatened species in April 1990. The responsibility for conducting these studies belongs to a group (Task 5 - Compliance with Environmental Regulations/Endangered Species) within BECAMP. Efforts in 1990 included identifying locations of the plant *Astragalus beatleyae*, work associated with the *A. beatleyae* conservation agreement (see below), and assessments of NTS activities on the desert tortoise, *Gopherus agassizii.*

During 1990, 34 pre-activity surveys were conducted to determine the presence of threatened or endangered species. Survey results and recommendations were documented in 25 reports. Significant survey findings included two locations of potential habitat of the plant *A. beatleyae* in Area 20 and one population of the plant *Penstemon pahutensis* on Rainier Mesa (Area 12).

A conservation agreement for *A. beatleyae* between the DOE/NV and the U.S. Fish and Wildlife Service (USFWS) was signed in 1989 and is effective until 1991. The agreement includes (1) the preparation of a species management plan; (2) pre-activity surveys to identify and protect populations from disturbance; (3) implementation of field surveys to document species' life history, assess the viability of known populations, and locate new populations;
(4) documentation of known populations on maps filed with the DOE/NV; and (5) fencing of the species' type locality.

A field study plan for monitoring *A. beatleyae* was prepared and implemented in 1989. Field monitoring in 1990 included the collection of monthly microclimate and life history data from 13 *A. beatleyae* populations and habitat characterization data including site descriptions, plant species composition, and vegetative cover. Permanent sampling transects used to measure densities of *A. beatleyae* plants and nearest-neighbor distances were established at each site. All the life history, microclimate, and transect data collected in 1989 were entered into a computer database and analyzed.

The USFWS has listed the Mojave desert tortoise *(Gopherus agassizii)* as a "threatened species" north and west of the Colorado River. The primary reasons for listing the desert tortoise were the continued loss of habitat and the rapid decline in tortoise numbers due to disease, habitat destruction by human activities, and other factors. Thus the Mojave desert tortoise population receives the full protection given to any species listed under the ESA. The desert tortoise distribution on the NTS is patchy and primarily in the southern third of the NTS. Larger numbers of tortoises appear to inhabit the bajadas surrounding Jackass Flats, Frenchman Flat, most of Rock Valley, and Mercury Valley. Densities of tortoises on the NTS are generally low and range from 0 to 45 individuals per square mile, with most habitats probably having densities of 0 to 20 individuals per square mile. A total of 64 free-roaming tortoises have been captured and marked since September 1987.

In 1990 a USFWS permit, required for handling desert tortoises, and a state of Nevada scientific collection permit for the study of desert tortoises on the NTS were received by EG&G/EM. A draft Biological Assessment on the effects of all NTS activities on desert tortoises, as required by the ESA, was initiated and is scheduled for completion in 1991. Reports were prepared on the effects of several projects on NTS desert tortoise populations. These reports included the Biological Assessment for the Ballistic Research Laboratory in Area 25 and an Environmental Assessment for the SCYLLA project, mentioned in Section 3.1.1. In addition, a draft Biological Assessment was completed on the effects of the Area 25 Forty-Mile Wash power-line maintenance project on desert tortoise populations. A draft topical report on the known distribution and abundance of desert tortoises on the NTS was also completed.

To better inform onsite workers on the subject of the Mojave desert tortoise, a notice was included in all REECo paycheck envelopes, and video tape and training sessions were presented to other NTS personnel.

3.12 DOE ENVIRONMENTAL SURVEYS

DOE/NV contractors are routinely audited to identify potential environmental compliance situations. A DOE/HQ inspection of the NTS was conducted in 1987, and a DOE/NV audit was made of the LVAO facilities at both North Las Vegas locations in 1990.

3.12.1 NTS OPERATIONS

The 1987 DOE/HQ environmental survey team review of the NTS prompted an Environmental Survey Action Plan developed in 1988 by the DOE/NV. The Environmental Survey Action Plan was designed to list and describe specified environmental corrective actions, provide scheduling and financial estimates for corrections, and track the corrective action process. At the end of 1990, 85 of 105 action items were certified as completed or closed. This information is summarized in Table 3.5, "Environmental Survey Action Plan Items."

Because several Environmental Survey Action Plan items were also being tracked in the Quarterly Compliance Action Report (used to track "Tiger Team" finding items, see Section 3.13, below), the Environmental Survey Action Plan is considered to be closed as of November 1990. The remaining Environmental Survey Action Plan items are primarily long-term projects assigned to the DOE/NV Environmental Restoration Branch and will be addressed as funding is available.

Table 3.5 Environmental Survey Action Plan Items - 1990

Issues	Closed 1988	Closed 1989	Closed 1990	Remaining Items
Radiation Disposal	6	7	2	0
Wastewater Disposal	3	23	9	13
Air Pollution Permitting	4	2	0	0
RCRA Permitting Actions	1	1	0	1
Storage	3	4	0	0
Solid Waste Disposal	5	9	1	4
Quality Assurance	3	2	0	2
Totals	25	48	12	20

3.12.2 EG&G/EM LAS VEGAS AREA OPERATIONS AUDIT

The DOE/NV Quality Assurance Division audited the EG&G LVAO facilities in 1990 and made 29 findings. Twenty-six of these have been addressed, and three remain outstanding until corrective actions have been fully implemented.

3.13 TIGER TEAM COMPLIANCE ASSESSMENT

The DOE Tiger Team Compliance Assessment of the NTS conducted from October 30 to December 1, 1989, was part of a 10-point initiative by the Secretary of Energy to conduct independent oversight compliance and management assessments of environmental, safety, and health programs at over 100 DOE operating facilities.

The Tiger Team identified 149 deficiencies including 45 environmental "findings" in its assessment of the NTS, none of which reflected situations which presented an immediate risk to public health or the environment. Potential noncompliance findings included 35 irregularities with federal or state of Nevada environmental regulations and/or DOE Orders. Ten findings represented conditions which were judged not to meet "best management practices," i.e., practices which could be improved through application of available or improved methods.

In response to the Tiger Team report, the DOE/NV developed an action plan to address each of the findings. In many cases the planned actions were straightforward and could be readily implemented. Others required or will require substantial funding and years to implement. A schedule for accomplishing all actions was established in 1990, and, assuming funding is made available, all work is planned to be completed by September 30, 1996.

The "most significant findings" identified by the environmental sub-team of the Tiger Team included:

- Incomplete waste characterization for wastes slated for onsite and offsite disposal.
- Radioactive wastes being accepted at the Area 3 and Area 5 radioactive waste disposal sites from generators not approved in accordance with DOE/NV procedures.
- Various wastes generated on the NTS were managed with insufficient knowledge of hazardous waste-related components in the waste streams.

Work continues on responding to these issues. Of the 129 actions required by the Tiger Team assessment that remained to be addressed in 1990, 91 were completed, and work is in progress on the remaining 38.

3.14 RADIATION PROTECTION

3.14.1 NTS OPERATIONS

Results of environmental monitoring on the NTS during 1989 showed full compliance with the radiation exposure guidelines of DOE Order 5480.11, "Radiation Protection for Occupational Workers," DOE Order 5400.5, "Radiation Protection of the Public and the Environment," and the 40 CFR 141 National Primary Drinking Water Regulations. Onsite air monitoring results showed average annual concentrations ranging from 8×10^{-4} percent of the DOE Order 5400.5 guidelines for ^{85}Kr to 0.14 percent of the guidelines for $^{239+240}Pu$ in air. Drinking water supplies on the NTS contained 4×10^{-3} percent of the DOE Order 5400.5 guideline and 0.4 percent of the National Primary Drinking Water Regulation for tritium. Supply wells contained 0.02 percent of the DOE Order 5400.5 guideline for $^{239+240}Pu$. Comparisons

were made to the guidelines for public consumption although the general public does not consume water from these supplies. The guideline concentrations in DOE Order 5480.11 for occupational workers are one hundred to one thousand times higher than those for the public.

3.14.2 NON-NTS FACILITIES

In 1990 the Santa Barbara Operations and LVAO Atlas facilities were the only EG&G/EM facilities with radiation sources, and these were sealed sources. The recorded exposure at the Santa Barbara Operations facility fence line was 75 percent below the allowable levels listed in DOE Order 5400.5. Radiation measured at the Atlas facility perimeter in North Las Vegas was at background levels.

3.15 UNUSUAL OCCURRENCES

Unusual occurrences are environmental, health, and/or safety-related events which are reported in accordance with DOE Order 5000.3A, "Unusual Occurrence Reporting System." A listing of the environmental episodes appears in Table 3.6.

3.16 PERMIT SUMMARY

For facilities used in the operation and maintenance of the NTS, the DOE contractors providing such operation and support activities for the DOE/NV have been granted numerous permits by the appropriate regulatory authorities, both state and federal. In addition to the existing number of permits in 1990 (shown in Table 3.7), five RCRA permits were in various stages of the approval process at the end of 1990.

Table 3.6 Unusual Occurrences - 1990

Date	Description
01/19/90	About 25 gallons (94.6 liters) of diesel fuel spilled from a 100-gallon (378-liter) elevated barrel onto a concrete pad. The fuel was retained by curbing, and no soil contamination occurred.
02/14/90	About 40 gallons (151 liters) of diesel fuel spilled onto the soil at a drill rig onsite at U19bg. The soil was excavated and disposed of in 55-gallon (208-liter) drums.
02/21/90	There was a spill of 50 to 100 gallons (189 to 378 liters) of diesel fuel onto the surface of the highway near Control Point Compound 1. The spill was sanded and allowed to evaporate.
02/27/90	About 35 gallons (132 liters) of an asphalt/diesel mixture spilled onto soil from an asphalt distribution truck. The contaminated soil was excavated and disposed of properly.
03/01/90	A mixture of 2 quarts (1.89 liters) of water-soluble oil containing lead and methylene chloride and 15 gallons (56.8 liters) of water was spilled onto asphalt pavement at Bldg. A-9 in the Waste Storage Area, NLV. Absorbent *(cont.)*

Table 3.6 (Unusual Occurrences - 1990, cont.)

Date	Description
(cont.)	material was used to clean up the spill which was then containerized for proper disposal.
03/14/90	Between 50 and 60 gallons (189 and 227 liters) of diesel fuel spilled to the ground from a supply line leak. Most of the fuel was contained in the berm. The contaminated soil was removed for proper disposal.
03/14/90	About 3.25 curies of noble gases and radioiodines was allowed to release during post-shot drilling at the METROPOLIS event during afternoon and overnight operations. None of the radioactivity was detected offsite.
04/09/90	A tank truck spilled about 40 gallons (151 liters) of diesel fuel through the tank vent onto three different portions of highway along the Pahute Mesa Road, affecting about 150 feet (45.7 meters). Sand was placed over the spill, the spill was allowed to evaporate, and this truck was removed from service.
04/20/90	Fifty gallons (189 liters) of hydraulic fluid leaked from a truck onto the ground in waste disposal Pit #3 at the RWMS facility in Area 5. The fluid and contaminated soil was removed the same day, tested for PCBs, and stored for disposal pending test results. The results showed no PCBs and was subsequently disposed of in a Class I sanitary landfill.
05/31/90	Pinhole leaks were discovered in a 55-gallon (208-liter) drum of trichloroethylene located in Area 2. About one gallon (3.78 liters) of fluid leaked and evaporated. No soil contamination occurred.
06/07/90	A contractor dismantling an oil distribution system in Bldg. A-1, NLV, removed insulation that was suspected of containing asbestos. Air sampling performed on June 8 confirmed the presence of asbestos. The contractor completed removal of the asbestos on June 12. Since asbestos removal was not done by a licensed state contractor, the DOE/NV assessed an appropriate penalty.
08/03/90	During removal of an UST at Bldg. 111 in Mercury, a spill of an unknown quantity of heating oil was detected that had been caused by repeated overfilling of the tank. The contaminated soil was removed for proper disposal.
08/09/90	A fuel pump hose blew off a truck at the onsite Teamsters' Shack in Area 25, spilling about six gallons (22.7 liters) of gasoline onto the pavement. The spill was washed down with water and allowed to evaporate.
08/14/90	A spigot on a 500-gallon (1890-liter) tank being lifted at the salvage yard in Mercury was damaged, resulting in spillage of about 15 gallons (56.8 liters) of an unknown hydrocarbon onto the ground. The contaminated soil was containerized for disposal.

Table 3.6 (Unusual Occurrences - 1990, cont.)

Date	Description
08/16-21/90	About 65 mCi of predominantly ^{133}Xe gas were intentionally released to remove noble gases and toxic or explosive mixtures from the site of the MINERAL QUARRY event. The release was not detectable by either onsite or offsite monitoring.
08/30/90	An operational release of radioactive gas occurred during the changing of a gas sampling valve on the platform of a 1985 test. The release lasted about one minute, and survey meter readings peaked at 0.15 mR/h. No samples were obtained for analysis. The release was not detectable offsite.
09/89-08/90	During this 12-month period, about 47.9 curies (0.012 curies in 1990) of radioactive xenon and krypton were released during re-entry operations associated with the DISKO ELM event. The release was not detectable onsite or offsite.
09/11/90	A natural gas line at the construction site of the Advanced Technology Laboratory in NLV was inadvertently ruptured. Southwest Gas Corporation capped the gas line, air sampling confirmed the capping as no traces of gas were detected in the atmosphere. Future requirements for subcontract personnel will include a "call before you dig" indoctrination.
09/26/90	During removal of an underground storage tank at P Tunnel, a hydrocarbon spill was discovered. The contaminated soil was removed, a sample was collected for analysis, and the soil was placed in drums for proper disposal.
10/01/90	A 20-inch (50.8-cm) drill casing, containing more than 130 gallons (49.2 liters) of used motor oil, spilled in a building previously used for maintenance of drilling equipment. The fluid was sampled and is stored in drums pending results of the analysis.
10/16/90	A line on a backhoe ruptured, spilling about 35 gallons (132 liters) of hydraulic fluid on the ground. The contaminated soil was sampled and containerized for disposal.
10/25/90	Oil was discovered on the surface of the Area 23 sewage lagoons. A faulty oil/water separator was suspected. About 100 gallons (378 liters) of this oil was siphoned off and disposed of.
11/07/90	Less than 100 gallons (378 liters) of tritiated water seeped from a temporary dike at the T Tunnel ponds onto previously contaminated soil. The dike was used to divert tunnel seepage water so that coring samples for characterization could be obtained and monitoring equipment could be installed. Analysis indicated a tritium concentration of 7×10^{-3} µCi/mL in the seepage, a level consistent with the concentration in the tunnel pond water. The tunnel seepage was diverted back to the primary pond. No cleanup was performed as the ground was already contaminated.

Table 3.7 Environmental Permit Summary - 1990

	Air Pollution	Wastewater	Drinking Water	Number of EPA Generator User IDs [a]	State/County Hazardous Waste Disposal	Transportation of Hazardous Waste	Storage of Flammables (City)
NTS	27	5	5	2			
Las Vegas Area Operations Office	22[b]	2		1	1[b]	1[b]	
Amador Valley Operations		1		1			
Kirtland Operations				2			
Los Alamos Operations				1			
Santa Barbara Operations		2[b]		2	2[b]		
Special Technologies Laboratory (Santa Barbara)		1[b]		1	1[b]		
Woburn Cathode Ray Tube Operations		1		1			1[b]
Washington Aerial Measurements Dept.							
TOTAL	49	12	5	11	4	1	1

(a) Biennial report required.
(b) Routine monitoring of emissions is not required.

089

5453

4.0 ENVIRONMENTAL PROGRAM INFORMATION

The environmental monitoring and compliance program for the NTS and offsite EG&G Energy Measurements, Inc. (EG&G/EM), facilities consists of (1) radiological monitoring, (2) nonradiological monitoring, and (3) environmental permits and operations compliance.

4.1 RADIOLOGICAL MONITORING

Daniel A. Gonzalez, Christopher A. Fontana, and Daryl J. Thomé

There are two radiological monitoring programs associated with the NTS, the onsite and offsite programs. The onsite radiological monitoring program is conducted by several organizations. Reynolds Electrical & Engineering Co., Inc. (REECo), the operating contractor at the NTS, is responsible for environmental surveillance and effluent monitoring. Several other organizations, such as the Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory (LANL), Desert Research Institute (DRI), EPA, and participants in the Basic Environmental Compliance and Monitoring Program (BECAMP) also make radiological measurements. The offsite radiological monitoring program is conducted by the EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV).

4.1.1 ONSITE MONITORING

At the NTS radiological effluents may originate from (1) tunnels, (2) underground test event sites (at or near surface ground zeros [SGZs]), and (3) facilities where radioactive isotopes are either used, processed, stored, or discharged. All of these types of sites have the potential or are known to discharge radioactive effluents into the environment.

Air sampling was conducted for radioactive particulates, halogens, noble gases, and tritiated water vapor (see Figure 4.1 for sampling locations). Ambient gamma monitoring was conducted throughout the Site (see Figure 4.2). Potable water (from groundwater wells), spring water, well reservoirs, and waste disposal ponds were sampled for radiological substances (see Figures 4.3 and 4.4). These tasks made up the environmental surveillance program on the NTS. Table 4.1 is a summary of all routine environmental surveillance.

4.1.1.1 CRITERIA

DOE Order 5400.1, "General Environmental Protection Program," published in November of 1988, established the onsite environmental protection program requirements, authorities, and responsibilities for DOE operations. These mandates required compliance with applicable federal, state, and local environmental protection regulations. Other orders applicable to environmental monitoring include DOE Order 5480.11, "Radiation Protection for Occupational Workers"; DOE Order 5480.1B, "Environment, Safety, and Health Program for Department of Energy Operations"; DOE Order 5484.1, "Environmental Protection, Safety, and Health Protection Information

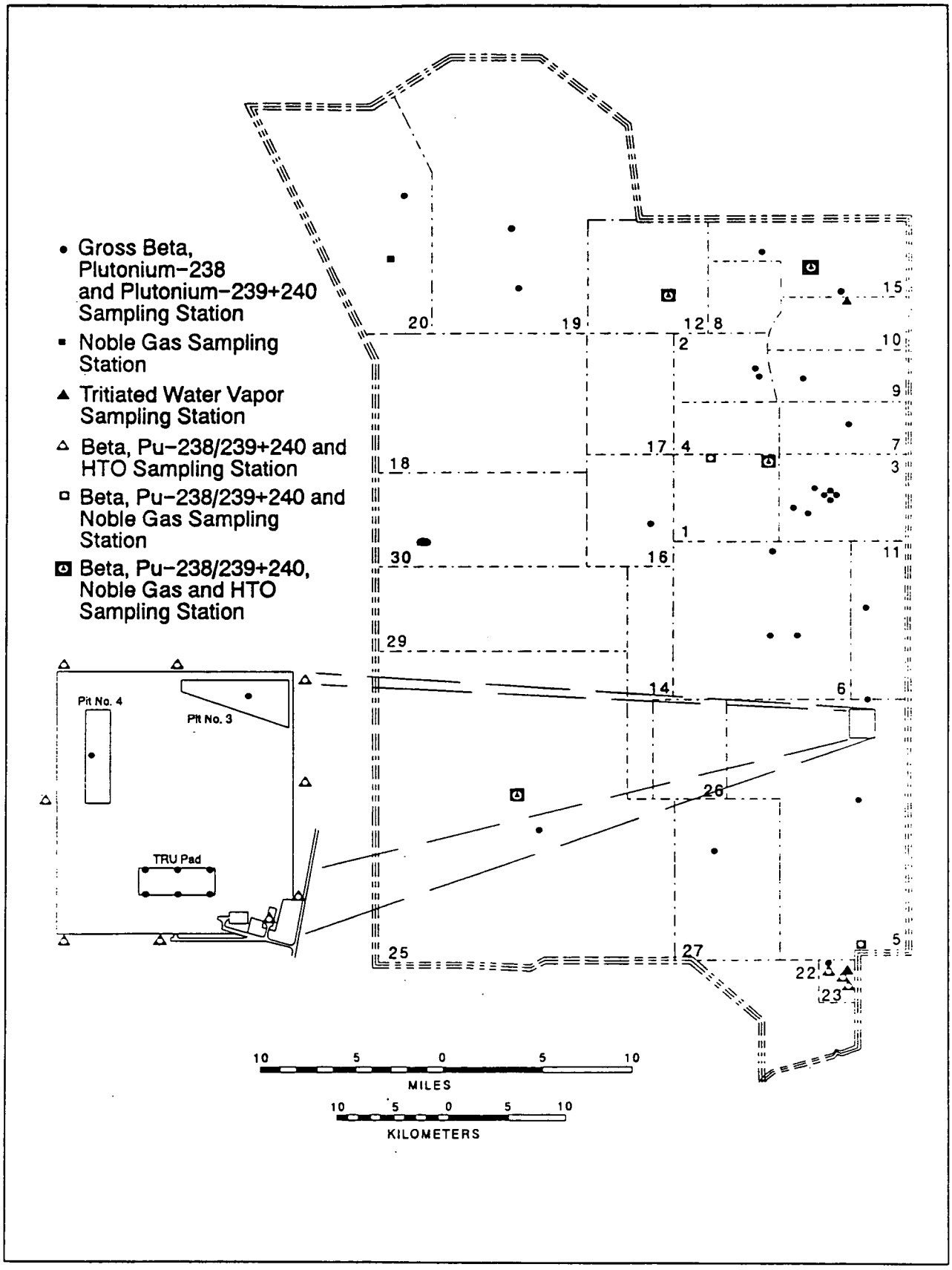


Figure 4.1 Air Sampling Stations on the NTS - 1990

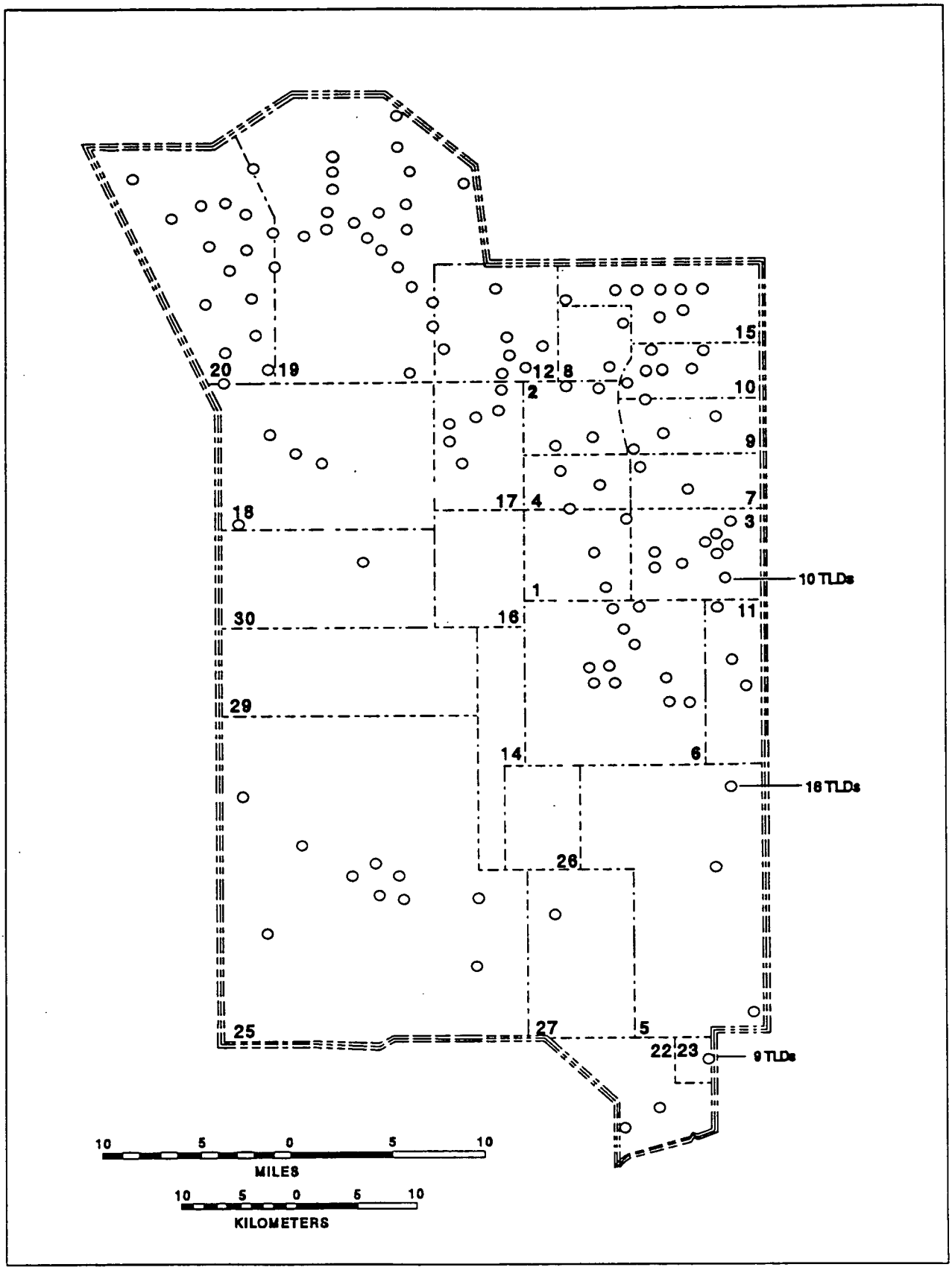


Figure 4.2 Thermoluminescent Dosimeter Stations on the NTS - 1990

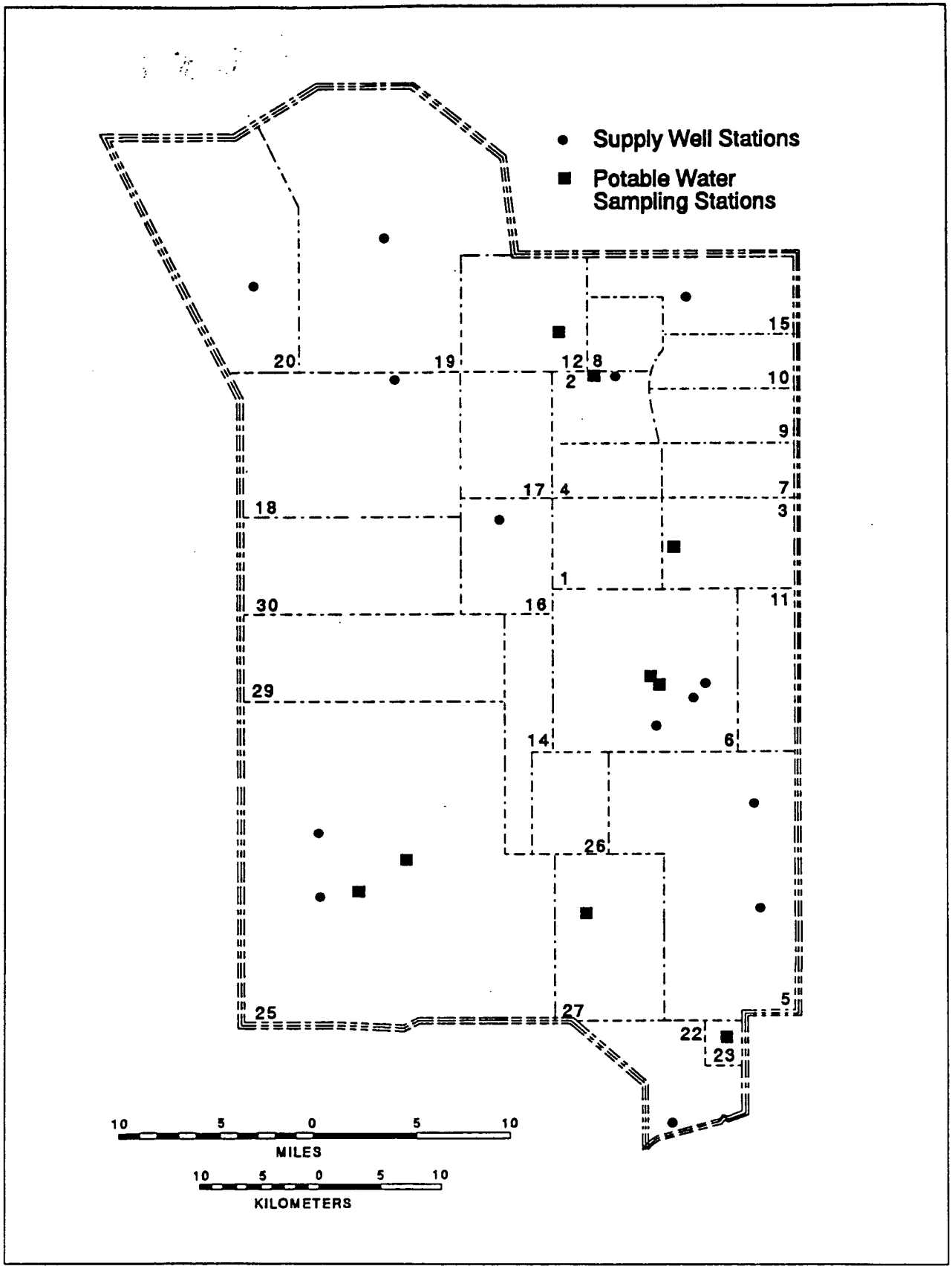


Figure 4.3 Supply Well and Potable Water Sampling Stations on the NTS - 1990

5453

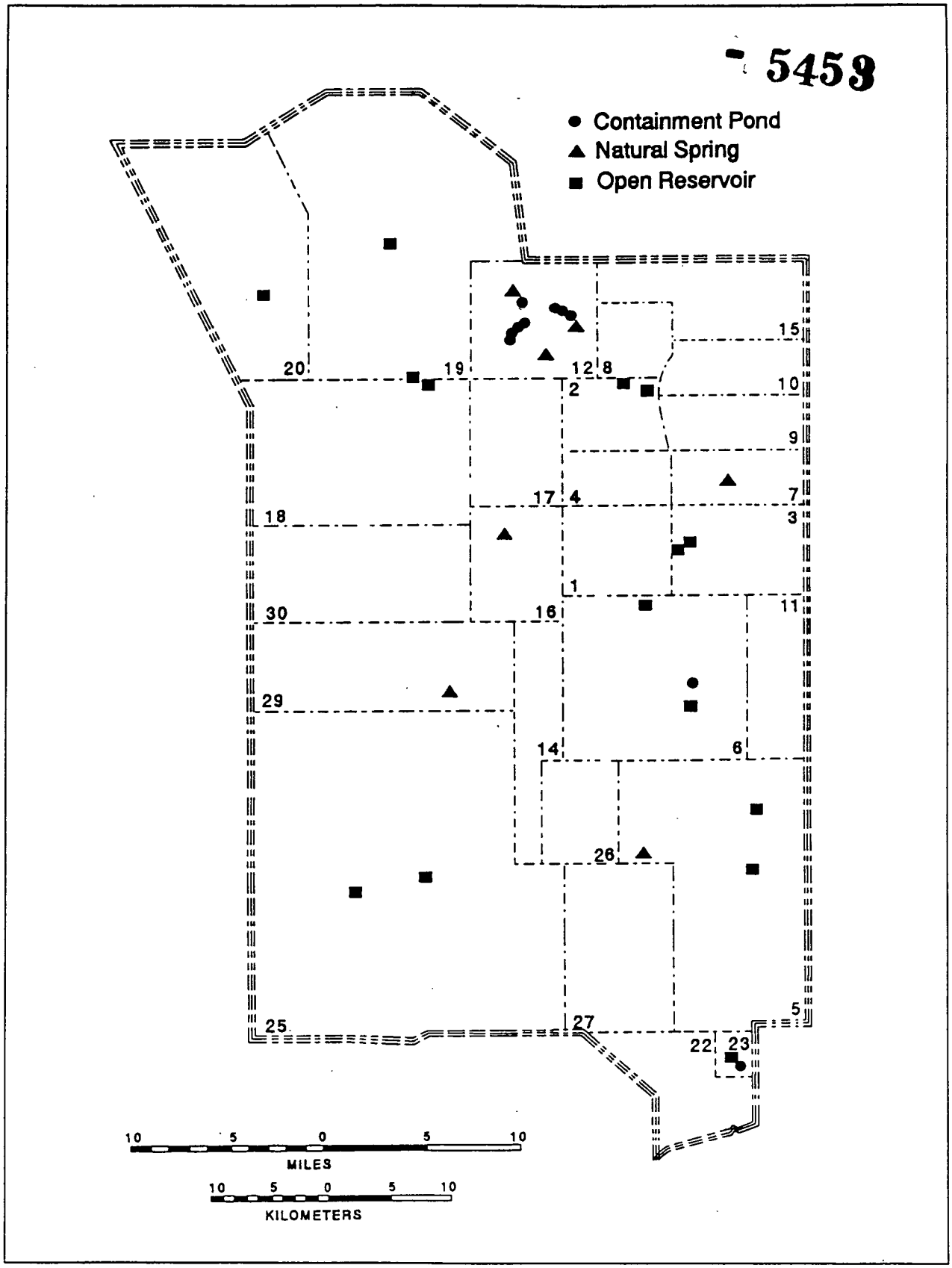


Figure 4.4 Surface Water Sampling Locations on the NTS - 1990

094

Table 4.1 Summary of Onsite Environmental Sampling Program - 1990

Sample Type	Description	Collection Frequency	Number of Sampling Locations[a]	Type of Analysis
Air	Continuous sampling through Whatman GF/A glass filter and a charcoal cartridge	Weekly	52	Gamma spectroscopy, gross beta, $^{238,239+240}Pu$, (monthly composite)
	Low-volume sampling through silica gel	Biweekly	17	HTO (tritium oxide)
	Continuous, low-volume sampling	Weekly	7	^{85}Kr and ^{133}Xe
Potable Water	One-liter grab sample	Weekly	9	Gamma spectroscopy, gross beta, tritium, $^{238,239+240}Pu$ (quarterly)
Supply Wells	One-liter grab sample	Monthly	14	Gamma spectroscopy, gross beta, tritium, $^{238,239+240}Pu$ (quarterly)
Open Reservoirs	One-liter grab sample	Monthly	15	Gamma spectroscopy, gross beta, tritium, $^{238,239+240}Pu$ (quarterly)
Natural Springs	One-liter grab sample	Monthly	7	Gamma spectroscopy, gross beta, tritium, $^{238,239+240}Pu$ (quarterly)
Containment Ponds	One-liter grab sample	Monthly	10	Gamma spectroscopy, gross beta, tritium, $^{238,239+240}Pu$ (quarterly)
Effluent Ponds	Three-liter grab sample	Quarterly	4	Gamma spectroscopy, gross beta, tritium, $^{238,239+240}Pu$
External Gamma Radiation Levels	UD-814AS thermoluminescent dosimeters	Quarterly	184	Total quarterly exposure

(a) Not all of these locations were sampled because of inaccessibility or lack of water.

5453

Reporting Requirements"; DOE Order 5400.5, "Radiation Protection of the Public and the Environment"; and DOE Draft Order 5400.6, "Radiological Effluent Monitoring and Environmental Surveillance."

4.1.1.2 EFFLUENT MONITORING

Effluent monitoring efforts at the NTS focused on monitoring nuclear test event sites, tunnel discharge waters, and the Area 6 radiological Decontamination Facility. During 1990 effluent monitoring was conducted at eight test event sites, three tunnel facilities, one decontamination facility, and one groundwater radionuclide migration research water well.

LIQUID EFFLUENT MONITORING

Radiologically contaminated water was discharged from N, T, and E Tunnels in the Rainier Mesa (Area 12) range. Once each month a grab sample was taken from each tunnel's effluent discharge point and from each tunnel's contaminated water holding pond. These samples were analyzed for tritium (^{3}H), gross beta, and gamma emitters, and a quarterly sample was analyzed for $^{239+240}Pu$ and ^{238}Pu. Tritium was the radionuclide most consistently detected at the tunnel sites. Other radionuclides were detected infrequently.

A conservative estimate of the flow rate from each tunnel was made to quantify the total annual radiological effluent release. The average annual concentration (in curies/gallon) of the isotope of interest in the effluent liquid was multiplied by the estimated total quantity of liquid discharged from the tunnel during a calendar year. This value was reported as the total liquid radiological effluent discharged from the facility.

A similar technique was employed at the Area 6 Decontamination Facility where a flow to the Decontamination Facility holding pond was estimated, then the total quantity of water discharged was multiplied by the concentration of ^{3}H in the water. During 1990 there were no radionuclides other than ^{3}H detected in the pond influent.

At the radionuclide migration research well in Area 5, the flow of water was intentionally discharged to a collecting pond. This flow was maintained with a pump at 600 gallons per minute. The well water was contaminated with measurable amounts of ^{3}H. Therefore, the total discharge of ^{3}H to the environment was determined fairly accurately.

AIRBORNE EFFLUENT MONITORING

Tritiated airborne water vapor was monitored on a continuing basis at the Area 12 G Tunnel complex to determine airborne emissions from tunnel ventilation.

Pahute Mesa events in Area 19 and 20 were monitored for ^{85}Kr and ^{133}Xe. For each event conducted in these areas during 1990, up to three portable noble gas samplers were placed in the vicinity of the SGZ. Noble gas samplers were deployed for any test conducted in an Area 12 tunnel. Portable noble gas samplers were used to detect any seeps of noble gases created from the fission process. The portable noble gas sampling unit used was similar in design to the permanent sampler used for environmental surveillance. The sampling system is described in "Environmental Surveillance" below.

4.1.1.3 ENVIRONMENTAL SURVEILLANCE

Environmental surveillance was conducted onsite throughout the NTS. Equipment at several fixed, continuously sampling stations was used to monitor for radioactive materials in the air, surface water, and groundwater.

AIR MONITORING

The environmental surveillance program maintained samplers designed to detect airborne radioactive particles, radioactive gases (including halogens and noble gases),

096

and radioactive hydrogen (^3H) as water vapor in the form $^3H^3HO$ or ^3HHO.

Air sampling units were located at 52 stations on the NTS to measure radionuclides in the form of particulates and halogens. All placements were chosen primarily to provide monitoring of radioactivity at sites with high worker population density. Geographical coverage, access, and availability of commercial power were also considered in site selection.

An air sampling unit consisted of a positive displacement pump drawing air through a nine-centimeter diameter Whatman GF/A filter for trapping particulates, followed by a charcoal cartridge collecting radioiodines. The filter and cartridge were mounted in a plastic, cone-shaped sample holder. The unit drew approximately 100 L/min of air. A dry-gas meter measured the volume of air displaced over the sampling period (typically seven days). The unit sampled a total volume of approximately 1000 cubic meters.

The filters were held for no less than five days and no more than seven days prior to analysis to allow naturally occurring radon and its daughter products to decay. Gross beta counting was performed with a gas-flow proportional counter for 20 minutes. The lower limit of detection for gross beta, assuming typical counting parameters, was 2 x 10^{-16} µCi/mL. Gamma spectroscopy of the filter and cartridge was accomplished using germanium detectors with an input to a 2000-channel spectrometer, calibrated at 1 kiloelectronvolt (keV) per channel from 0.02 to 2 megaelectronvolts (MeV).

Weekly air samples for a given sampling station were prepared in batches on a monthly basis and radiochemically analyzed for ^{238}Pu and $^{239+240}Pu$. This procedure incorporated an acid dissolution and an ion-exchange recovery on a resin bed. Plutonium was deposited by plating on a stainless steel disk. The chemical yield of the plutonium was determined with an internal ^{236}Pu or ^{241}Pu tracer. Alpha spectroscopy was performed utilizing a solid-state silicon surface barrier detector. The lower limit of detection for ^{238}Pu and $^{239+240}Pu$ was approximately 1 x 10^{-17} µCi/mL.

The radioactive noble gases ^{85}Kr and ^{133}Xe were determined from continuous samples of air taken at seven permanent locations. The noble gas samplers maintained a steady sampling flow rate for one week. Noble gas sampling units were housed in a metal tool box and, with the exception of a few minor differences, were identical to the portable units used to monitor effluents. Three metal air bottles were attached to the sampling units with short hoses. A vacuum was maintained on the first bottle by pumping the sample into the other two bottles. The flow rate was approximately 80 mL/min. The two collection bottles were exchanged weekly and yielded a sample volume of about 400 liters each.

The noble gases were separated and collected from the atmospheric sample by a series of cryogenic gas-distillation techniques. Water and carbon dioxide were removed at room temperature, and the krypton and xenon were collected on charcoal at liquid nitrogen temperatures. These gases were transferred to a molecular sieve where they were separated from any remaining gases and each other. The krypton and xenon were transferred to separate scintillation vials and counted on a liquid scintillation counter. The lower limits of detection for ^{85}Kr and ^{133}Xe were 4 x 10^{-12} and 10 x 10^{-12} µCi/mL, respectively.

Airborne tritiated water vapor was monitored at 17 permanent locations throughout the NTS. Constant air flow over moisture-collecting material was maintained for a two-week period, during which airborne moisture was extracted and, at the end of the sampling period, transferred to the onsite laboratory for analysis. The airborne ^3H sampler was capable of unattended operation for up to two weeks in desert areas. A small electronic pump drew air into the apparatus at approximately 0.5 L/min,

and the tritiated water vapor was removed from the air stream by two silica-gel drying columns. Appropriate aliquots of condensed moisture were obtained by heating the silica gel. Liquid scintillation counting determined the tritiated water vapor activity. The lower limit of detection for tritiated water vapor analysis was 3×10^{-13} µCi/mL.

AMBIENT GAMMA MONITORING

Ambient gamma monitoring was conducted at 184 stations within the NTS through use of thermoluminescent dosimeters (TLDs). A TLD emits light when it is heated after having been exposed to radiation, hence the term "thermoluminescent." The total amount of light given off by the crystal is proportional to the amount of energy absorbed from the radiation; the intensity of light emitted from the TLD crystal is directly proportional to the radiation exposure.

The dosimeters used were UD-814AS environmental dosimeters manufactured by Panasonic. One TLD badge consisted of four elements housed in an air-tight, water-tight, ultraviolet-light-protected case. The first element, made of lithium borate, was only slightly shielded in order to capture low-energy radiation. The other three elements, made of calcium sulfate, were shielded by 1000 mg/cm^2 of lead to screen out low-energy radiation.

Previous research has indicated that only about five to ten percent of the total exposure from natural background is from gamma emitters below 150 keV (Beck 1972). These TLDs were deployed for a period of one calendar quarter. Each TLD holder was placed about one meter above the ground at each monitoring location.

WATER MONITORING

Water samples were collected at various frequencies from selected potable water consumption points, supply wells, natural springs, open reservoirs, final effluent ponds, and containment ponds. The frequency of collection was determined on the basis of a preliminary radiological pathways analysis. Potable water was collected weekly; supply wells were sampled monthly. Samples were collected in one-liter glass containers. All samples were analyzed for gross beta, tritium, and gamma-emitting isotopes. Plutonium analyses were performed on a quarterly basis.

A 500-mL aliquot was taken from the water sample and counted in a Nalgene bottle for gamma activity with a germanium detector. A 5-mL aliquot was used for ^{3}H analysis by liquid scintillation counting. The remainder of the original sample was evaporated to 15 mL, transferred to a stainless steel counting planchet, and evaporated to dryness after the addition of a wetting agent. Beta counting was accomplished as described above in "Air Monitoring," except that the water samples were counted for 100 minutes.

The lower limits of detection for water analyses were:

- Gamma spectroscopy, $\cong 1 \times 10^{-8}$ µCi/mL.
- Tritium, 9×10^{-7} µCi/mL.
- Gross beta, 1×10^{-9} µCi/mL.

For the quarterly plutonium analysis of water samples, an additional one-liter sample was collected. The radiochemical procedure was similar to that previously described in this chapter under "Air Monitoring." Alpha spectroscopy was used to measure any ^{238}Pu and $^{239+240}$Pu. The lower limit of detection for this procedure was 4×10^{-11} µCi/mL.

WASTE MANAGEMENT SITE MONITORING

Environmental surveillance was conducted on the NTS at Radioactive Waste Management Project sites. These sites were used for the disposal of radioactive waste materials as low-level waste (LLW) from the NTS and from other DOE facilities. Shallow

disposal in trenches, pits, augured shafts, and subsidence craters was accomplished at the Area 5 Radioactive Waste Management Site (RWMS) and at the Area 3 Bulk Waste Management Facility (BWMF).

The Area 5 RWMS contains the LLW disposal unit, the transuranic waste storage cell, and the Greater Confinement Disposal Unit. The Area 3 BWMF accepted bulk LLW which could not be packaged. Much of the waste material buried there was contaminated soil and metal remaining from the atmospheric testing of nuclear weapons at the NTS. The materials were deposited in subsidence craters (craters which resulted from surface ground collapse after underground nuclear detonations, see Section 4, Figure 2.5).

Ambient monitoring included 15 permanent air particulate/halogen sampling stations, nine permanent tritiated water vapor sampling stations placed on and around the RWMS in Area 5, and 24 TLD stations.

The BWMF was surrounded by four air particulate/halogen sampling stations, and several TLD stations were located nearby.

RADIONUCLIDE MIGRATION AND UPTAKE STUDIES

A series of studies on the potential of subsurface radionuclide migration were continued on the NTS by the DRI, LANL, and LLNL. These studies included:

- Field research on enhancement of groundwater by surface subsidence craters.
- Study of precipitation recharge effects on Pahute Mesa groundwater recharge.
- Unsaturated zone migration of radionuclides in the vicinity of the CAMBRIC event migration study site ditch (see Section 6.1.2.2).
- Geologic formation fluid pressure studies in Area 3 and Area 4.
- Area 2 hydrogeology characterization and test cavity vicinity plume migration in Area 20.
- Experiments on the role of colloidal transport of radionuclides in groundwater.

4.1.1.4 SPECIAL ENVIRONMENTAL STUDIES

BECAMP was involved in special studies on the NTS that focused on (1) the movement of radionuclides through the environment and (2) the resultant dose to man. BECAMP used the past accomplishments of two former DOE/NV-sponsored programs at the NTS, the Nevada Applied Ecology Group (NAEG) and the Radionuclide Inventory and Distribution Program (RIDP), in ongoing efforts to design effective programs to assess changes over time in the radiological conditions on the NTS, update human dose-assessment models, and provide information to DOE/NV on site restoration projects and compliance with environmental regulations.

The main objective of one group in BECAMP (Task 1 - Movement of Radionuclides On and Around the NTS) has been to determine the rate of movement of surface-deposited radionuclides in four categories: horizontal movement, water-driven erosional transport, vertical migration, and wind-driven resuspension. Efforts in 1990 included three tasks. The first was continuing the development of field monitoring techniques to detect changes in radionuclide concentrations in soil. The second was preparing reports on (1) soil-related sources of variability for *in-situ* methods of radionuclide detection and (2) the influence of local vertical distribution of plutonium in soils on the precision of *in-situ* measurements. The major task in 1990 was the preparation and initiation of a characterization study of resuspension

processes from a plutonium-contaminated site on the Tonopah Test Range.

A second task in the BECAMP program (Task 2 - Human Dose Assessment Models) has been to update the NAEG/NTS dose-assessment model. The NAEG/NTS model estimated the dose, via ingestion and inhalation, to man from $^{239+240}Pu$. The BECAMP dose-assessment model is an expanded version of the NAEG model that has been updated to include all significant radionuclides in the NTS environs and all exposure pathways, including external exposure from gamma-emitting radionuclides. In 1990 the BECAMP dose assessment model was modified to be fully stochastic and capable of calculating the total dose for radionuclides and exposure pathways of interest at the NTS. Work also included (1) codifying the internal and external doses for all radionuclides and (2) analyzing the model for sensitivity of calculated doses to relative variations in levels of radionuclides in soil and for uncertainty in model parameters. A workshop was conducted to review data concerning the differential behavior of similar plutonium isotopes.

Another group within BECAMP (Task 4 - Annual Peer-Reviewed Publications) has been assigned the task of preparing a major yearly thematic, peer-reviewed publication that addresses an important issue related to the potential environmental impacts of past, present, and future activities at the NTS and its environs. Preparations began in 1990 for a paper on the possible differential movement of plutonium isotopes in the NTS environment. Data uncertainty and sensitivity analyses were performed. Work continued on the development of a theme and outline for a major publication that deals with the application of *in-situ* detectors in environmental monitoring and restoration efforts at the NTS. Additional reports completed by BECAMP investigators in 1990 included a draft report on the findings and conclusions from the RIDP program and a publication summarizing radiation-related and environmental monitoring at the NTS (Anspaugh et al. 1990).

5453

4.1.2 OFFSITE MONITORING

The EMSL-LV conducted the offsite radiological monitoring program around the NTS under the terms of an Interagency Agreement with DOE/NV. The radiological safety activities of the EMSL-LV were divided into two areas, both designed to detect environmental radiation; special test support and routine environmental surveillance.

Special test support involved fielding mobile monitoring teams around the NTS prior to and during all nuclear tests. Radiation monitoring technicians, equipped with radiation survey instruments (dosimeters, portable air samplers, and supplies for collecting environmental samples), were prepared to conduct a monitoring program as directed from the NTS Control Point via two-way radio communications. Radiation sampling and tracking aircraft operated by EG&G/EM were flown over the NTS to gather meteorological data, obtain samples, and assess the total volume of the radioactive "cloud" should any airborne radioactive release have occurred. Information from these aircraft could be used in positioning the EMSL-LV mobile radiation monitoring technicians.

The routine surveillance program included pathways monitoring that consisted of air, water, and milk surveillance networks surrounding the NTS and a limited animal and vegetable sampling program. In addition, external and internal exposures of offsite populations were assessed using state-of-the-art dosimetry equipment.

4.1.2.1 AIR MONITORING

The Air Sampling Network (ASN) was designed to monitor the areas within 210 miles (350 kilometers) of the NTS, with some concentration of stations in the prevailing downwind direction. Station location was dependent upon the availability of electrical

power and, at stations distant from the NTS, on a resident willing to operate the equipment. This continuously operating network was supplemented by a standby network which covered the contiguous states west of the Mississippi River.

During 1990 the ASN consisted of 32 continuously operating sampling stations (see Figure 4.5 for these locations) and 78 standby stations (Figure 4.6). Another station was added to the continously operating monitoring network in 1990. The air sampler at each station was equipped to collect particulate radionuclides on filters and gaseous radioiodines in charcoal cartridges. The filters and charcoal cartridge samples from all active stations and the filters from standby stations received complete analyses. The charcoal cartridge samples from standby stations were analyzed only if there was some reason to expect the presence of radioiodines.

Samples of airborne particulates were collected at each active station on 2.1-in (5-cm) diameter, glass-fiber filters at a flow rate of about 2800 ft^3 (80 m^3) per day. Filters were changed after sampler operation periods of one week (approximately 20,000 ft^3 or 560 m^3). Activated charcoal cartridges placed directly behind the filters to collect gaseous radioiodine were changed at the same time as the filters. Seventy-five of the stations in the standby network were activated for one week per quarter. The standby samplers were identical to those used at the active stations and were operated by state and municipal health department personnel or by other local residents. All analytical work was performed at the EMSL-LV.

A second part of the EMSL-LV offsite air network was the Noble Gas and Tritium Surveillance Network (NGTSN). The radionuclides detected were noble gases and tritium emitted from nuclear reactors, reprocessing facilities (non-NTS facilities), and worldwide nuclear testing.

The locations of the NGTSN stations are shown in Figure 4.7. The NGTSN was designed to detect any increase in offsite levels due to possible NTS emissions. Network samplers were typically located in populated areas surrounding the NTS; other samplers were located in communities at some distance from the NTS. In 1990 this network consisted of 16 noble gas samplers and 19 tritium-in-air samplers located in the states of Nevada, Utah, and California. The monitoring network detected only background radioactivity from these sampling locations.

Noble gas samples were collected by compressing air into storage tanks. The equipment continuously sampled air over a seven-day period and stored approximately 21 ft^3 (0.6 m^3) of air in the tanks. The tanks were exchanged weekly and returned to the EMSL-LV for analysis. Analysis started by condensing the samples at liquid nitrogen temperature followed by gas chromatography to separate the gases. The separate fractions of xenon and krypton were dissolved in scintillation cocktails and counted in a liquid scintillation counter.

For ^3H sampling, a molecular sieve column was used to collect water from the air. Up to 350 ft^3 (10 m^3) of air were passed through the column over a seven-day sampling period. Water adsorbed on the molecular sieve was recovered, and the concentration of ^3H in the water was determined by liquid scintillation counting.

4.1.2.2 WATER MONITORING

As part of EMSL-LV's Long-Term Hydrological Monitoring Program, surface water and groundwater sampling and analyses have been performed for many years on water sources on and around the NTS. This monitoring program is discussed in more detail in Section 9, "Groundwater Monitoring."

4.1.2.3 MILK SURVEILLANCE NETWORK

In 1990 the Milk Surveillance Network (MSN) consisted of 26 locations within 180 miles

5453

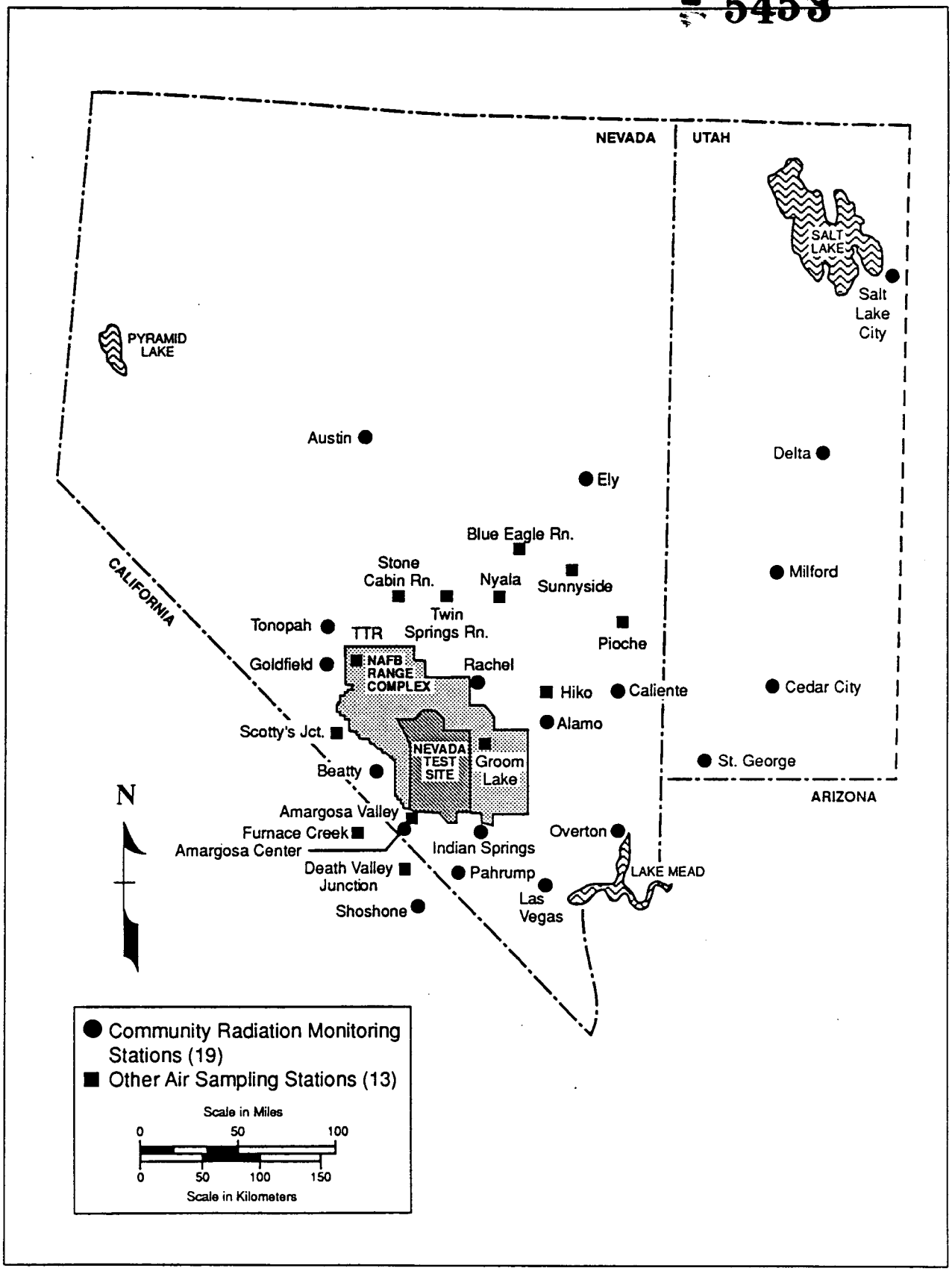


Figure 4.5 Air Surveillance Network Stations - 1990

102

5453

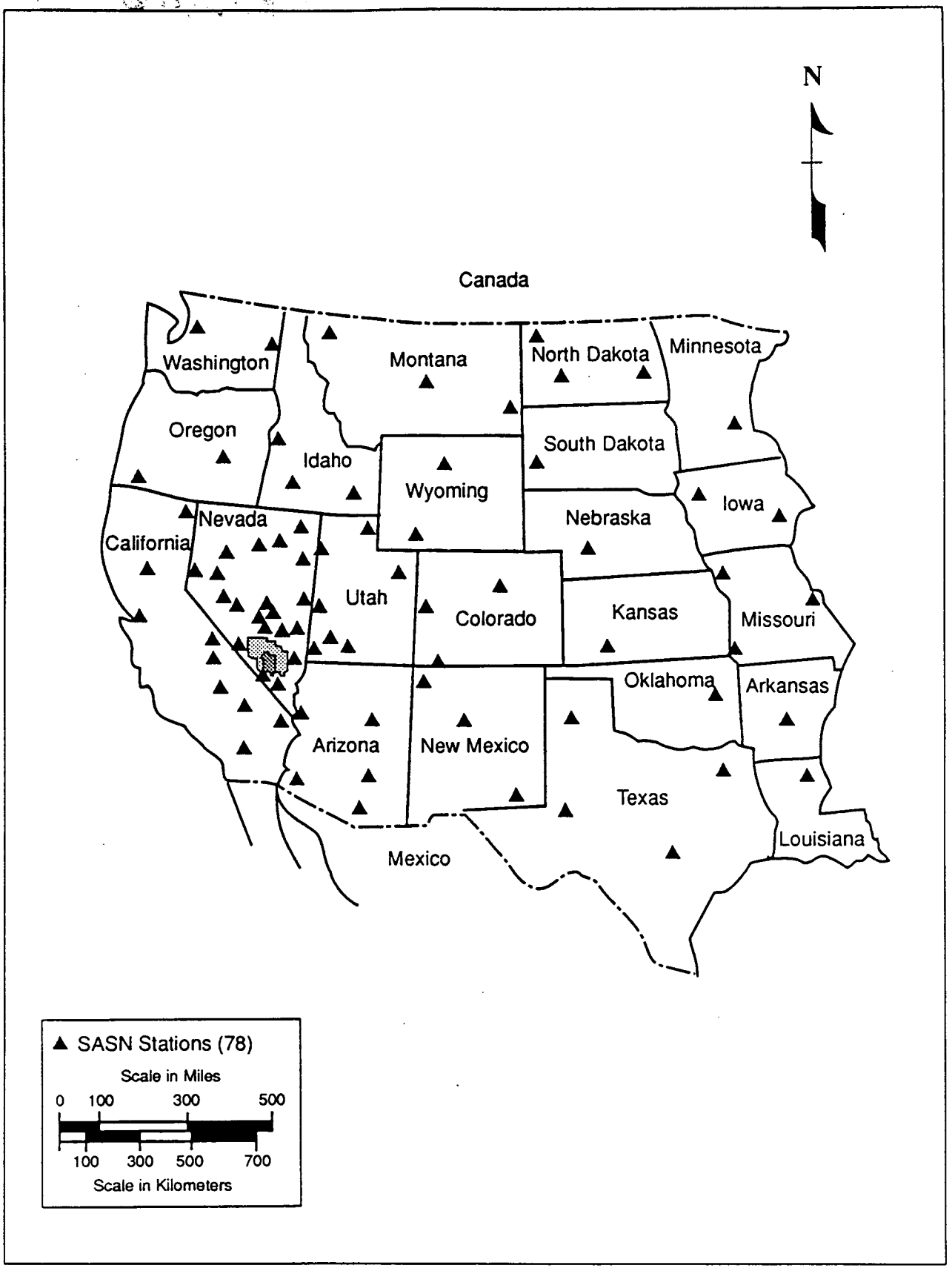


Figure 4.6 Standby Air Surveillance Network Stations - 1990

103

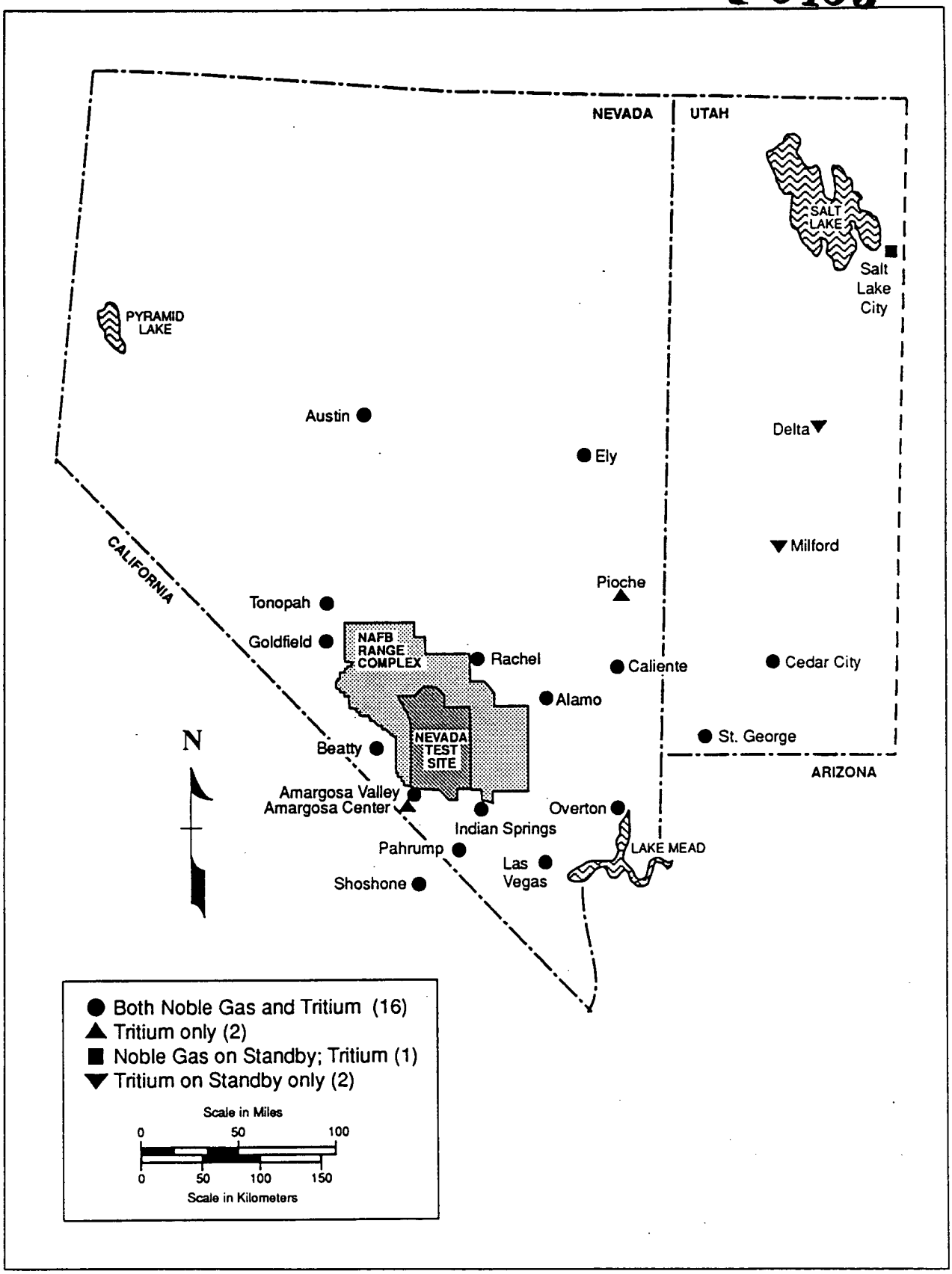


Figure 4.7 Offsite Noble Gas and Tritium Surveillance Network Stations - 1990

(300 kilometers) of the NTS from which samples were scheduled for collection every month. These locations are shown in Figure 4.8. The raw milk was collected in 1-gallon (3.8-liter) Cubitainers and preserved with formaldehyde. In addition, all major milk sheds west of the Mississippi River (represented by 109 locations in 1990) were sampled on an annual basis as part of the Standby Milk Surveillance Network (SMSN). These sampling stations appear in Figure 4.9. One exception was Texas, which sampled the milk sheds in that state. SMSN samples were supplied by cooperating state Food and Drug Administration personnel upon the request of the EPA regional offices. These samples, also preserved with formaldehyde, were mailed to the EMSL-LV. The annual activation of the SMSN helped maintain readiness and highlighted any trends of increasing radionuclide concentrations in western states.

All milk samples were analyzed by high-resolution gamma spectroscopy to detect gamma-emitting radionuclides. One sample per quarter for each location in the MSN and samples from two locations in each western state in the SMSN were subjected to radiochemical analysis for ^{3}H by liquid scintillation counting and for ^{89}Sr and ^{90}Sr by the anion exchange method.

4.1.2.4 BIOMONITORING

Samples of muscle, lung, liver, kidney, blood, and bone were collected periodically from cattle purchased from private herds that graze areas adjacent to the NTS. These sampling locations are shown in Figure 4.10. Soft tissues were analyzed for gamma-emitting radionuclides. Bone and liver were analyzed for strontium and plutonium, and blood and kidney were analyzed for ^{3}H. During 1990 NTS mule deer were collected, sampled, and analyzed similarly. Each November and December, bone and kidney samples have been analyzed for strontium, plutonium, and tritium (kidney only) from desert bighorn sheep killed and donated by licensed hunters in Southern Nevada. These kinds of samples have been collected and analyzed for up to 32 years to determine long-term trends.

During 1990 samples of vegetable produce collected included beets from Rachel, Nevada, and St. George, Utah; carrots from Enterprise, Utah; and potatoes from Hiko, Nevada. The samples were analyzed by gamma spectroscopy, then dissolved in acid for analysis of ^{90}Sr, ^{238}Pu, and $^{239+240}Pu$.

4.1.2.5 EXTERNAL GAMMA EXPOSURE MONITORING

A network of environmental stations and monitored personnel has been established by the EMSL-LV in locations encircling the NTS. Monitoring locations in 1990 are shown in Figure 4.11. This arrangement facilitates estimation of average background exposures as well as detection of any increase due to NTS activities. Monitoring of offsite personnel is accomplished with the Panasonic UD-802 dosimeter. This dosimeter contains two elements of $Li_2B_4O_7$:Cu and two of $CaSO_4$:Tm phosphors. The four elements are behind 14, 300, 300, and 1000 mg/cm^2 filtration, respectively. Monitoring of offsite environmental stations is accomplished with the Panasonic UD-814 dosimeter. This dosimeter contains a single element of $Li_2B_4O_7$:Cu and three replicate $CaSO_4$:Tm elements. The first element is filtered by 14 mg/cm^2 of plastic, and the remaining three are filtered by 1000 mg/cm^2 of plastic and lead. The three replicate phosphors are used to provide improved statistics and extended response range.

The EMSL-LV TLD network was designed primarily to measure total ambient gamma exposures at fixed locations. A secondary function of the network was the measurement of exposures to a number of specific individuals living within and outside estimated fallout zones from past nuclear tests at the NTS (offsite residents). Measurement of exposures to specific individuals involved the multiple uncontrollable variables associated with any

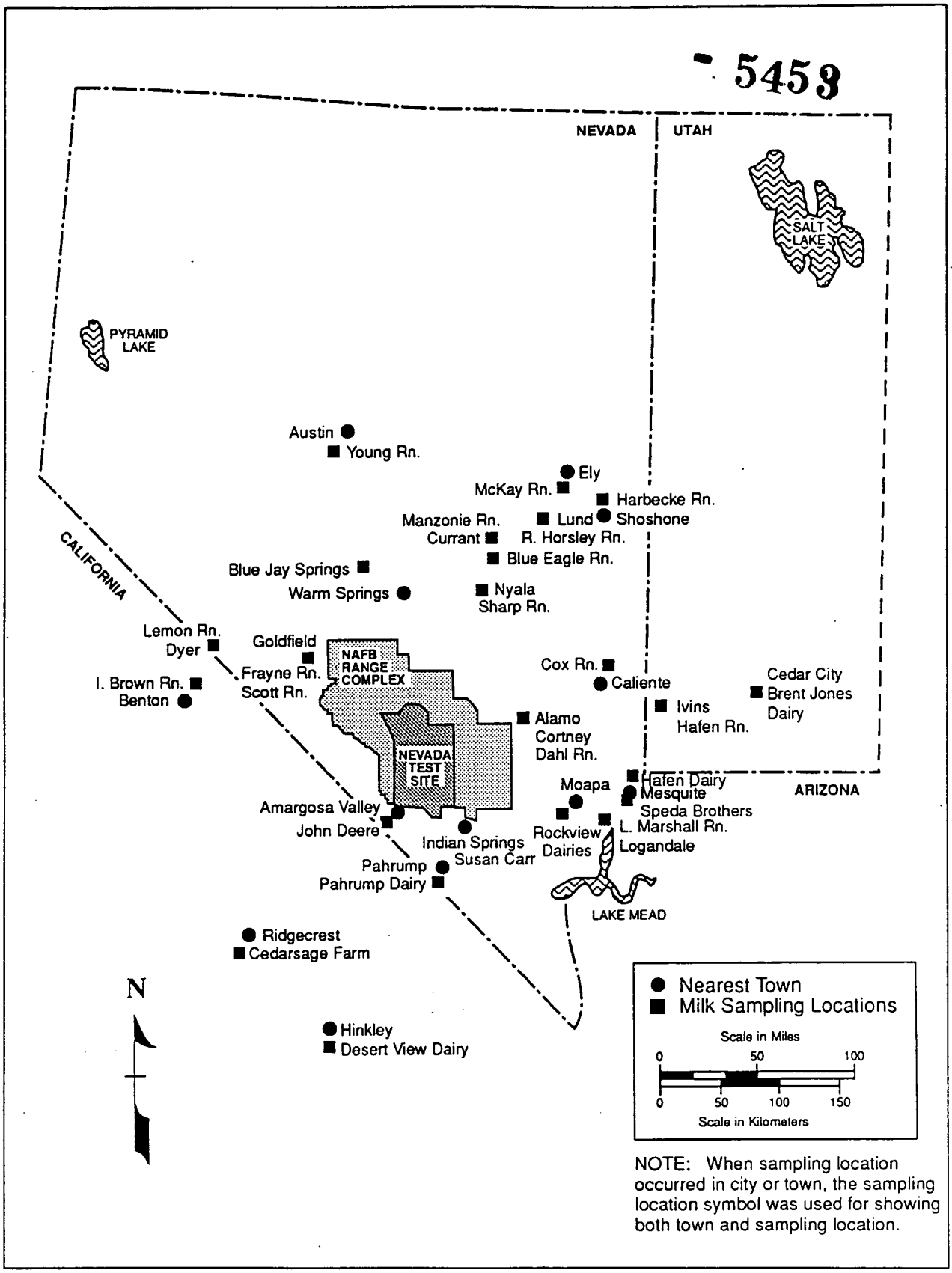


Figure 4.8 Milk Surveillance Network Stations - 1990

- 5453

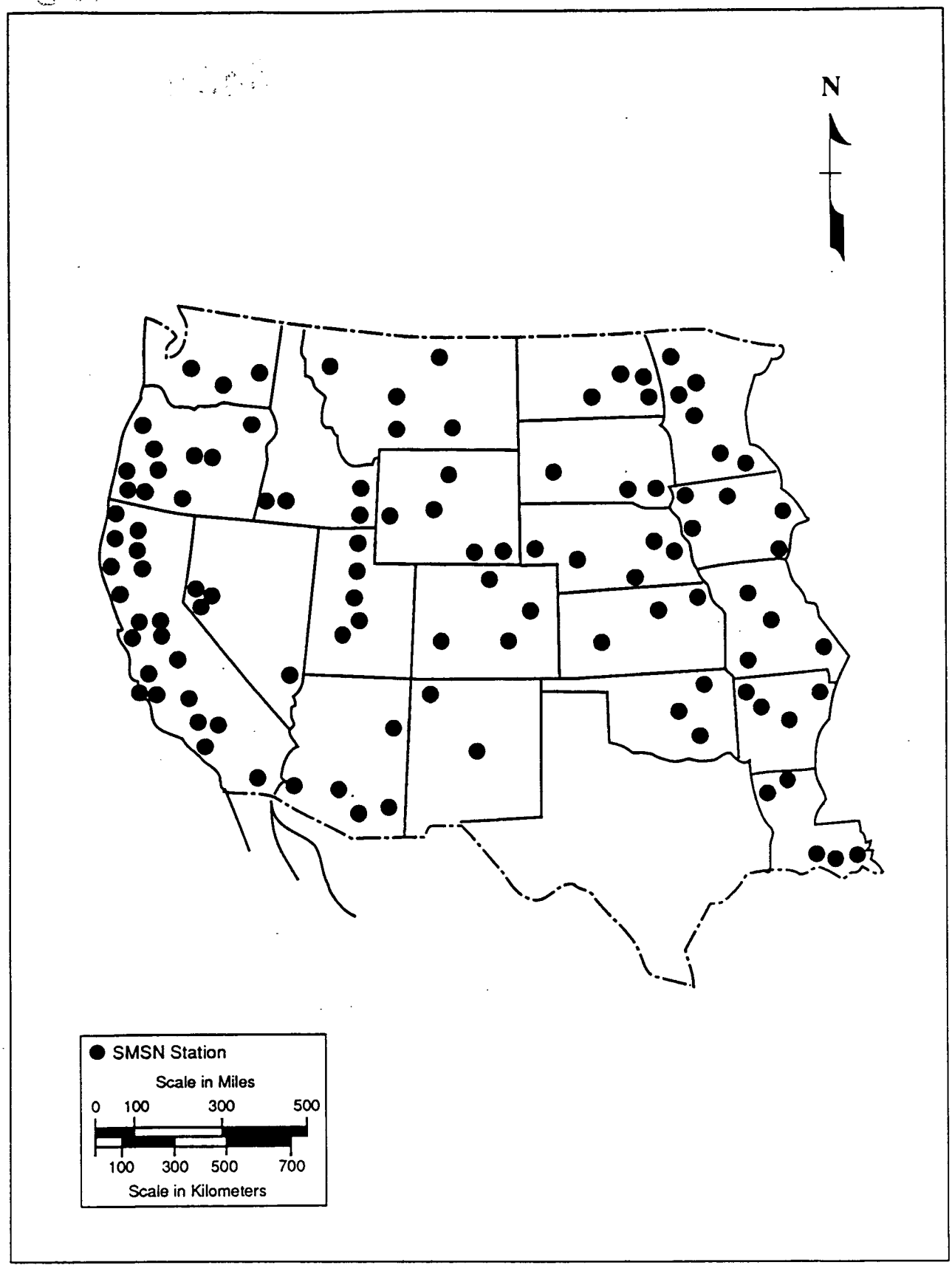


Figure 4.9 Standby Milk Surveillance Network Stations - 1990

107

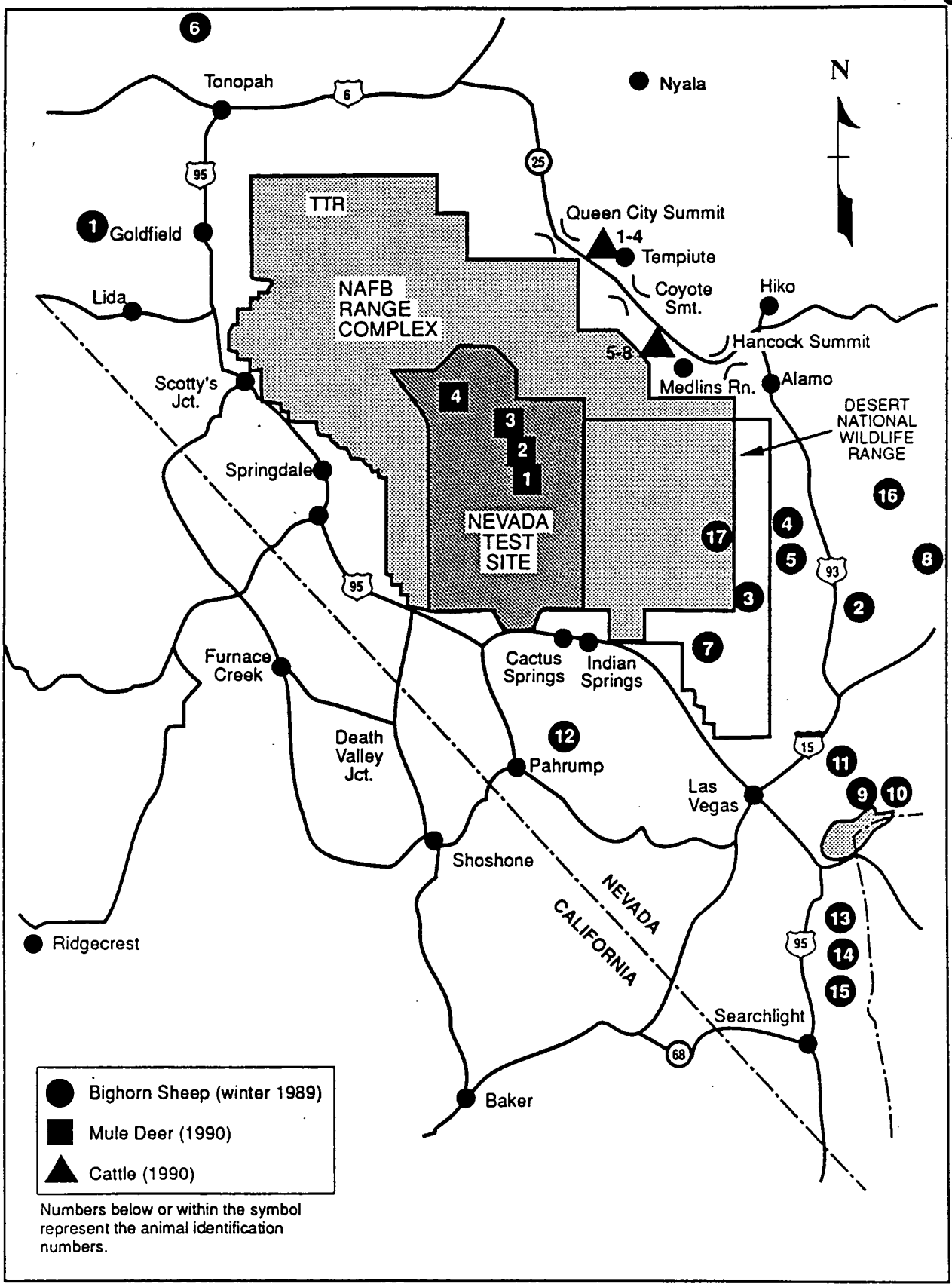


Figure 4.10 Collection Sites for Animals Sampled - 1990

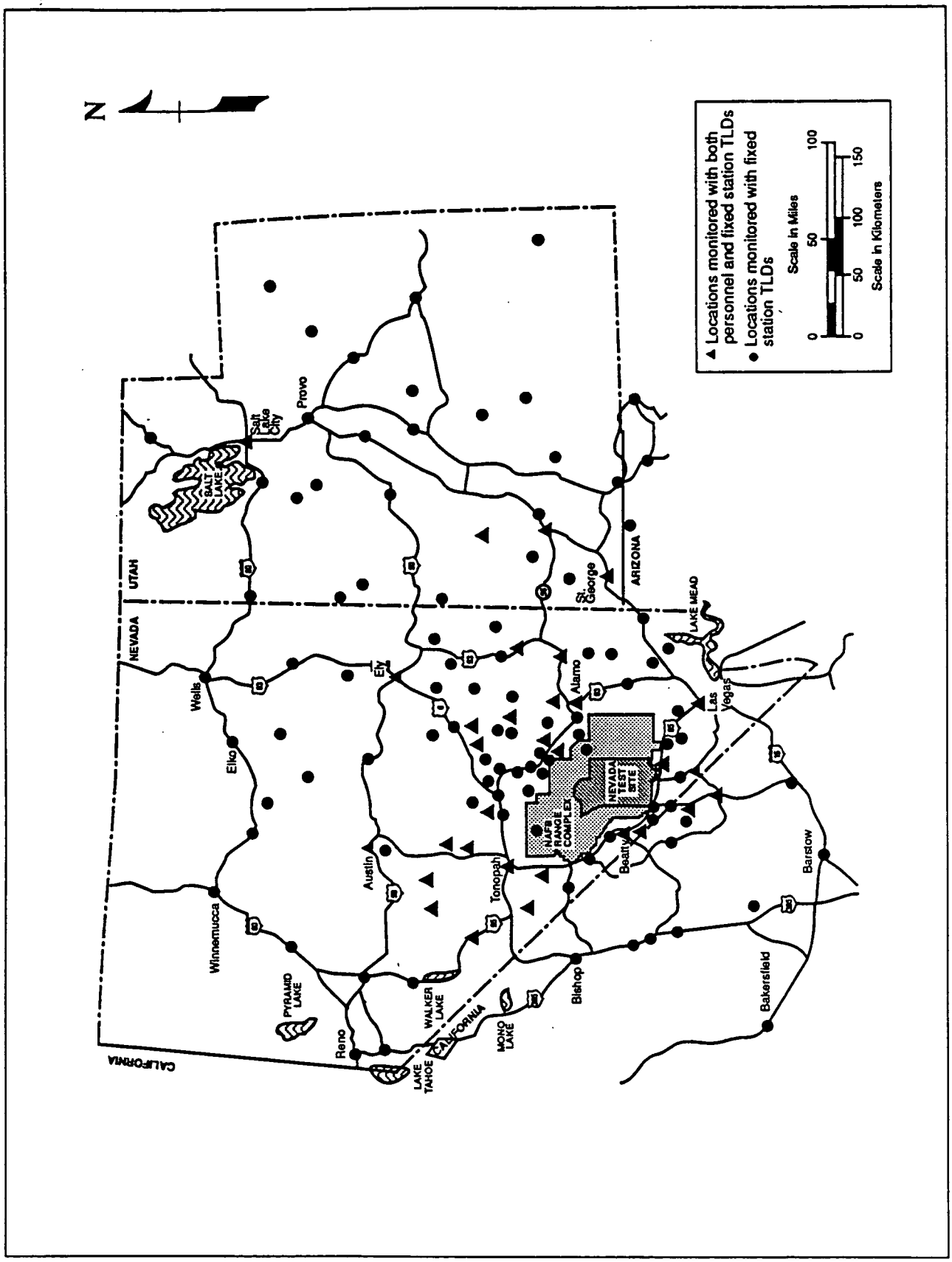


Figure 4.11 Gamma Exposure Monitoring Stations - 1990

5453

personnel monitoring program. Measuring environmental ambient gamma exposures in fixed locations provided a reproducible index which could then be easily correlated to the maximum exposure an individual would have received were he continuously present at that location. Monitoring of individuals made possible an estimate of individual exposures and helped to confirm the validity of correlating fixed-site ambient gamma measurements to projected individual exposures.

During 1990 a total of 71 individuals living in areas surrounding the NTS were provided with personnel TLD dosimeters. The TLDs used to monitor individuals are sensitive to beta, gamma, neutron, and low- and high-energy X radiations. The TLDs used to monitor fixed reference background locations are designed to be sensitive only to gamma and high-energy X radiations. Because personnel dosimeters are cross-referenced to associated fixed reference background TLDs, all personnel exposures are presumed to be due to gamma or high-energy X radiation. Exposures of this type are numerically equivalent to absorbed dose.
TLDs used to monitor individuals are provided in holders which are designed to be worn on the front of an individual's body, between the neck and the waist. When worn in this manner, the TLD may be used to estimate not only ambient gamma radiation exposure but to characterize the absorbed radiation dose an individual wearing the dosimeter may have received.

During 1990 a total of 134 offsite stations were monitored to determine background ambient gamma radiation levels. Each station had a custom-designed holder that could hold from one to four Panasonic TLDs. Normal operations involved packaging two TLDs in a heat-sealed bag (to provide protection from the elements) and placing the dosimeter packet into the fixed station holder. Fixed environmental monitoring TLDs are normally deployed for a period of approximately three months (one calendar quarter).

The annual adjusted ambient gamma exposure (mR in one year) was calculated by multiplying the median daily rate for each station by 365.25. A review of the measurement periods shows that few stations were monitored for exactly 365 days. However, when the results of a "nominal" 365-day year are compared with the results obtained by multiplying the average mR/day by the actual number of days, calculational differences are less than 1 mR/year. This is considered to be an insignificant discrepancy.

4.1.2.6 PRESSURIZED ION CHAMBER NETWORK

The Pressurized Ion Chamber (PIC) network measures ambient gamma radiation exposure rates and, because of its sensitivity, may detect continuous low-level exposures not picked up by other monitoring methods. There are 28 PICs deployed around the NTS as part of this network. The locations of all the EMSL-LV PICs are shown on Figure 4.12. Nineteen of the 28 PICs in the network are deployed at the Community Radiation Monitoring Stations (CRMPs) described in Section 4.1.2.8.

All PIC data are collected via satellite transmissions. In addition to telemetry retrieval, the data are also recorded on both magnetic tapes and strip charts for hard-copy backup. In the unlikely event of an accidental release of radioactivity from the NTS, signals via the satellite telemetry system would provide instantaneous data from all affected PIC locations. At each sampling location, the PIC data are displayed in µR/h on a digital readout display at each location for easy access by the public. Computer analysis of the data is evaluated weekly at EMSL-LV as part of routine quality assurance procedures to note trends and anomalies. Data from calibration check sources are also examined to detect trends or anomalies.

4.1.2.7 OFFSITE DOSIMETRY PROGRAM

The whole-body counting facility has been maintained at the EMSL-LV since 1966. The

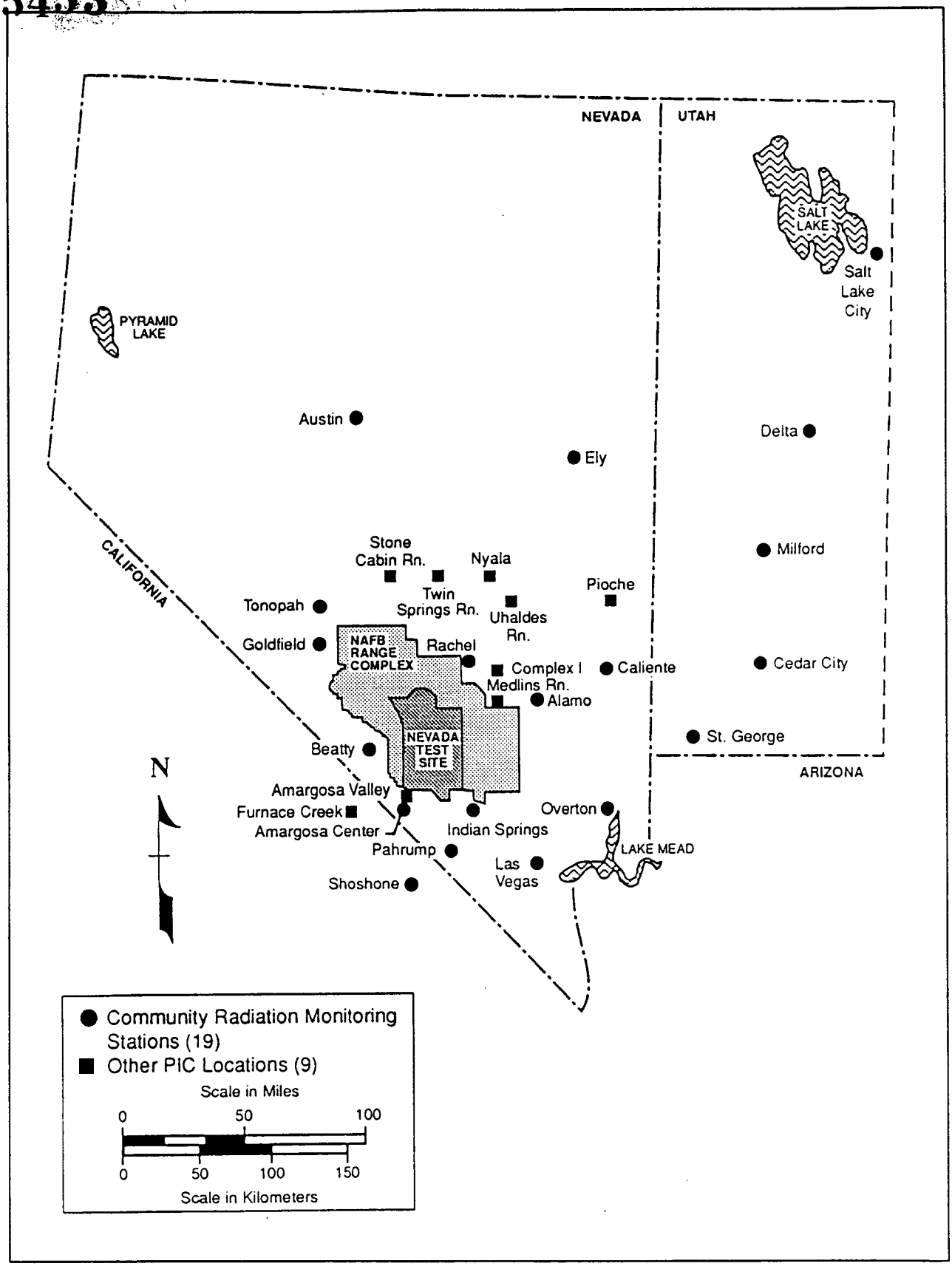


Figure 4.12 Pressurized Ion Chamber Network and Community Radiation Monitoring Stations - 1990

5459

facility is equipped to determine the identity and quantity of gamma-emitting radionuclides which might have been inhaled or ingested by offsite residents and others exposed to 1990 NTS radiation releases. Routine measurement of radionuclides in a person consisted of a 2000-second count with a sensitive radiation detector placed next to a person reclining in one of the two shielded counting rooms. In the other shielded room, a 2000-second count over the lung area is used to determine any plutonium inhalation.

The Offsite Dosimetry Program was initiated in December 1970 to determine levels of radionuclides in some of the families residing in communities and ranches surrounding the NTS. The program consists of radionuclide uptake monitoring, external exposure monitoring, and physical examinations and was designed to estimate exposure to and effects from radioactive emissions from the NTS. The program began with 34 families (142 individuals) residing in general downwind areas from the NTS as well as areas less subject to fallout. Currently there are 38 families (120 individuals) in the program. The locations of the families monitored in 1990 are shown in Figure 4.13. The participants travelled to the EMSL-LV for a biannual whole-body count. A urine sample was also collected for ^{3}H analysis. At 18-month intervals a health history and physical examination, which included a urinalysis, complete blood count, serology, chest x-ray (three-year intervals), sight screening, audiogram, vital capacity, EKG (if over 40 years old), and thyroid panel, were performed. The individual was then examined by a physician.

Radionuclide uptake monitoring was also performed for EPA employees, DOE contractor employees, and other workers who might have been occupationally exposed as well as for concerned members of the general public. Results of measurements on individuals from Las Vegas and other cities were used for comparison.

4.1.2.8 COMMUNITY RADIATION MONITORING PROGRAM STATIONS

Beginning in 1981 the DOE and EMSL-LV established a network of CRMP stations in the offsite areas in order to increase public awareness of radiation monitoring activities. The DOE, through an interagency agreement with the EMSL-LV, sponsored the program and contracted with the (1) DRI to manage the stations and (2) University of Utah to train station managers. Each station was operated by a local resident, in most cases a science teacher, who was trained in radiation monitoring methods by the University of Utah. Samples were analyzed at the EMSL-LV. The DRI provided data interpretation to the communities involved.

During 1990 all of the 19 stations, except for Milford and Delta, Utah, had one of the samplers for the ASN, NGTSN, and dosimetry (TLD) network, plus a PIC and recorder for immediate readout of external gamma exposure, and a recording barograph. The stations at Milford and Delta were complete except for noble gas samplers, which will be added when the equipment becomes available. All of the equipment was mounted on a stand at a prominent location in each community so the residents were aware of the surveillance and, if interested, could have ready access to the data.

Computer-generated reports for each station were issued weekly. These reports indicated the current weekly PIC average, the previous week's and year's averages, and the maximum and minimum backgrounds in the U.S. In addition to being posted at each station, copies were sent to appropriate federal and state personnel in California, Nevada, and Utah.

All of the CRMP stations were equipped with satellite telemetry-transmitting equipment. With this equipment, gamma exposure measurements acquired by the PICs were transmitted via the geostationary operational environmental satellite (GOES) directly to the

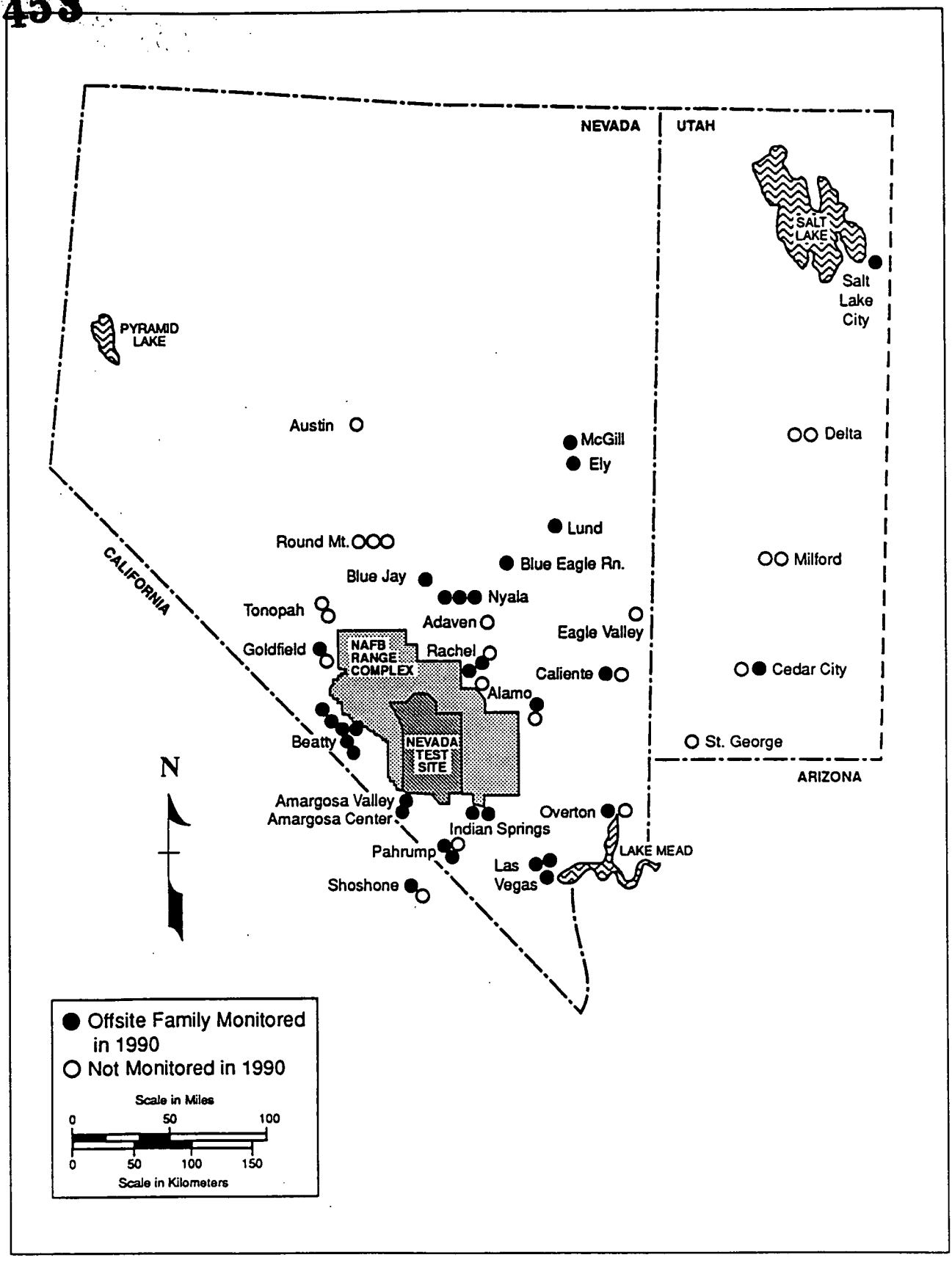


Figure 4.13 Location of Families in the Offsite Dosimetry Program - 1990

5453

NTS and from there to the EMSL-LV by dedicated telephone line.

4.1.3 NON-NTS FACILITY MONITORING

There are two offsite EG&G/EM facilities with radioactive sources. These are located at the Santa Barbara Operations facility in Goleta, California, and the Las Vegas Area Operations facility on Losee Road (the Atlas facility) in North Las Vegas (NLV), Nevada. The sources at these facilities are sealed, and, as no emissions are possible under normal operations, only monitoring at the perimeter fences is performed. EG&G/EM uses Panasonic Type UD-814, three-element CaSO+1LiBO TLDs. At least two TLDs are at the fence line on each side of the facility. TLDs are exchanged on a quarterly basis with an additional TLD rotated from location to location to act as a control. (The locations of these two operations are shown in Section 2, Figure 2.13.)

4.2 NONRADIOLOGICAL MONITORING

Charles W. Burhoe and Scott E. Patton

The 1990 nonradiological monitoring program for the NTS included onsite sampling of various environmental media and substances for compliance with federal and state regulations or permits and ecological studies. BECAMP conducted studies in 1990 that included wildlife surveys and vegetation trend studies in disturbed and undisturbed areas of the Site. Offsite nonradiological monitoring was conducted in 1990 for 129 tests conducted at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF) on the NTS.

Nonradiological monitoring of non-NTS DOE/NV facilities was limited to wastewater discharges in publicly owned treatment works. This occurred at four EG&G/EM facilities.

4.2.1 NTS OPERATIONS MONITORING

4.2.1.1 ROUTINE MONITORING

As there were no industrial-type production facility operations on the NTS, there was no significant production of nonradiological air emissions or liquid discharges to the environment when compared to many other DOE nuclear facility operations. Sources of potential contaminants were limited to construction support and Site operation activities. This included motor pool facilities; large equipment and drilling rig maintenance areas; cleaning, warehousing, and supply facilities; and general worker support facilities (including lodging and administrative offices) in the Mercury Base Camp, Area 12 Camp, and to a lesser extent in Area 20 and the NTS Control Point Complex in Area 6. The LGFSTF in Area 5 is a source of potential release of nonradiological contaminants to the environment, depending on the individual tests conducted. In 1990 there were 129 tests conducted at this facility, and monitoring was performed to assure these contaminants did not move to offsite areas. Since these monitoring functions are performed by the EMSL-LV at the NTS boundary, monitoring functions for the LGFSTF are described below in 4.2.2, "Offsite Monitoring." Routine nonradiological environmental monitoring at the NTS in 1990 was limited to:

- Sampling of drinking water distribution systems for Safe Drinking Water Act and state of Nevada compliance.
- Sewage lagoon influent sampling for Resource Conservation Recovery Act (RCRA) constituents and compliance with state of Nevada operating permits.
- Polychlorinated biphenyl (PCB) sampling of electrical transformer oils, soils, and waste oil for Toxic Substance Control Act compliance.
- Asbestos sampling in conjunction with asbestos removal and renovation projects and in accordance with occupational safety and National Emission Standards for Hazardous Air Pollutants (NESHAP) compliance.
- Sampling of soil, water sediment, waste oil, and other media for RCRA constituents.

4.2.1.2 ECOLOGICAL STUDIES

Ecological studies conducted under the DOE/NV-sponsored BECAMP involved monitoring of the flora and fauna on the NTS

to assess changes over time in the ecological condition of the NTS and to provide information needed for assessing NTS compliance with environmental laws, regulations, and orders. The monitoring effort (conducted by BECAMP Task 3 - Monitoring of the Flora and Fauna on the NTS) has been arranged into three interrelated phases of work: (1) a series of five non-disturbed control study plots in the test-impacted ecosystems that are monitored at one-, two-, three-, four-, or five-year intervals to establish natural baseline conditions; (2) a series of study plots in representative disturbed areas that are monitored at three- to five-year intervals to determine the impact of disturbance, document site recovery, and investigate natural recovery processes; and (3) a series of wildlife observation plots centered around natural-spring and man-made water-source habitats on the NTS.

The monitoring and survey work included (1) soil sampling to determine the fertility status of soil with respect to organic-matter content, available forms of nitrogen, and both macro- and micro-nutrient elements; (2) vegetation sampling for the purpose of determining the health status, recovery, and utilization of vegetation in disturbed and undisturbed areas; (3) trapping of rodents and reptiles to determine the condition of individual specimens and the continuity and stability of resident populations; (4) surveys to obtain information concerning resident populations of desert tortoises, kit foxes, rabbits, deer, and feral horses; and (5) the maintenance and preservation of herbarium and biological data archives.

In 1990 the third full year of flora and fauna monitoring, 14 ecology monitoring sites (38 plots) were surveyed for plants, animals, and reptiles. The 38 plots monitored included (1) 11 for spring ephemeral plants, (2) 9 for perennial plants, (3) 9 for small mammals, and (4) 9 for lizards. Many of these sites contained paired disturbed/undisturbed plots. Monitoring sites surveyed included the control baseline plots in Yucca Flat, Jackass Flats, and Pahute Mesa. Two new plots associated with previous nuclear test ground zeros were established in NTS Areas 2 and 4. Two plots in burned areas of Rock Valley and Yucca Flat were monitored as was a disturbed roadside plot in Frenchman Flat. The plots in Area 5 downwind of the LGFSTF were monitored for mammals, and vegetation was monitored on three plots that had previously been established in 1963 by Dr. Janice Beatley, University of California. To date, a total of 26 BECAMP ecology monitoring sites have been established on the NTS.

Survey work on horses, desert tortoises, deer, and ravens were conducted in 1990. Horse counts were made throughout the summer, one day a month, in regions around springs and well reservoirs, which resulted in a reasonable estimate of the feral horse population on the NTS. Estimates were made of the number of deer and raven on the NTS. Desert tortoises in the Rock Valley/University of California, Los Angeles, study enclosures were surveyed twice in 1990.

4.2.2 OFFSITE MONITORING

The LGFSTF was established in the Frenchman Basin in Area 5 as a basic research tool for studying the dynamics of accidental releases of various hazardous materials and the effectiveness of mitigation procedures. The LGFSTF was designed and equipped to (1) discharge a measured volume of a hazardous fluid at a controlled rate on a specially prepared surface; (2) monitor and record down-wind gaseous concentrations, operating data, and close-in/down-wind meteorological data; and (3) provide a means to control and monitor these functions from a remote location.

DOE/NV provides the facilities, security, and technical support, but all costs are borne by the organization conducting the tests. From April 2 through September 11, 1990, a total of 129 spill tests were conducted on 32 different days. These tests involved

controlled spilling of eight different chemicals under various conditions, including some tests of mitigation techniques. The plans for each test series were examined by an Advisory Panel that consisted of DOE/NV and EMSL-LV professional personnel augmented by personnel from the organization performing the tests.

For each test the EMSL-LV provided an advisor on offsite public health and safety for the Operations Controller's Test Safety Review Panel. At the beginning of each test series (and at other tests depending on projected need), a field monitoring technician from the EPA with appropriate air sampling equipment was deployed downwind of the test at the NTS boundary to measure chemical concentrations that may have reached the offsite area. Based on wind direction and speed, the boundary monitor was instructed to collect samples at the time of projected maximum concentration. Samples were collected with a hand-operated Dräger pump and sampling tube appropriate for the chemical being tested. These results are reported in Section 7.1.7. Not all tests were monitored by EPA if professional judgement indicated that, based on previous experience with the chemical and the proposed test parameters, NTS boundary monitoring was unnecessary.

The EPA monitors at the NTS boundary, in contact by two-way radio, were always placed at the projected cloud center line at the time when the cloud was expected at the boundary, so the air samples would be collected at the time and place of maximum concentration. The exact location of the boundary monitor was adjusted during the test by use of two-way radio to ensure that monitoring was performed at the projected cloud center line.

4.2.3 NON-NTS FACILITY MONITORING

Although permits for the eight EG&G/EM non-NTS facilities included 23 air pollution, 7 wastewater, 9 RCRA, and 5 state and local hazardous waste permits, sampling by facility personnel was required at only two sites (see below). The location of each EG&G/EM facility was in a well-developed metropolitan area, and environmental impact was reviewed by extensive federal, state, and local permitting requirements. Reports on the quantities of hazardous materials used in production or disposed of were required by some of the various permits, but these quantities were gleaned from internal records on operating times or use rate, not from any specific routine monitoring effort. A description involving any unexpected emission was required for some permits, but again, monitoring was not required. All results from routine monitoring were within the permit limits, and monitoring activities were limited to the following:

- One grab sample per month was required to be gathered for analysis by the Dublin/San Ramon Sanitation District for Amador Valley Operations. Analysis for pH, chemical oxygen demand, cyanide, metals, and phenols was made on this sample. One yearly grab sample was analyzed by the sanitation district for total toxic organics.
- Grab samples for the pH of effluent flowing from the sinks into the sewer system were required to be taken semi-annually at the Woburn Cathode Ray Tube Operations facility in Massachusetts and reported to the Massachusetts Water Resources Authority.
- Samples of wastewater discharges at the Santa Barbara Operations facility in California were collected by a state-certified laboratory. Discharges were not to exceed 10 ppm of mercury.
- Effluent monitoring has been conducted approximately once per year by the Goleta Sanitary District. Rinse water for printed circuit board production may contain detectable levels of copper and lead. There was no direct discharge to the sewer from the photographic, circuit board, or degreasing operations.

5453

There is a wastewater discharge from the Kirtland Operations' Craddock facility, located near the Albuquerque International Airport, that enters Albuquerque's publicly owned treatment works. This discharge included wastewater from the anodizing shop rinse tanks that may require regulation under National Pollutant Discharge Elimination System or city regulations. Samples of the discharge were analyzed for eight toxic inorganics in November and the results were reported in December. No action had been taken by the city at the end of 1990.

4.3 ENVIRONMENTAL PERMITS

Carlton S. Soong

NTS environmental permits included 27 state of Nevada air quality permits involving emissions from construction operation facilities, boilers, storage tanks, and open burning. Five permits for onsite drinking water systems and five for sewage discharges to onsite lagoons or septic tank fields have been issued by the state of Nevada. A permit application for two shallow injection wells, submitted to the state in 1989, was withdrawn in 1990. Underground injection will not be used as a form of disposal at the NTS. The RCRA Part A permit application was updated in 1990 to include additional onsite disposal units which will be subject to RCRA closure in the future. The RCRA Part B permit application for mixed waste was approved by the state in 1990.

Non-NTS permits included 22 air pollution control permits and 7 sewage discharge permits. Nine EPA Generator Identification (ID) numbers were issued to seven EG&G/EM facilities, and six state and local RCRA-related permits were required at four facilities.

4.3.1 AIR QUALITY PERMITS

Air quality permits were required for numerous locations at the NTS and at two non-NTS facilities.

4.3.1.1 NTS AIR QUALITY PERMITS

Table 4.2 is a listing of state of Nevada air quality operating permits renewed in 1990. Pursuant to the requirements for boiler permits (OP-1035 and OP-1036) at the NTS, annual fuel analysis of diesel fuel No. 2 (DF #2) was submitted to the state in September 1990. The data provided included the sulfur content and BTU content of the DF #2 delivered to the NTS.

For OP 90-14, the Nevada Air Quality Officer must be notified of each burn no later than five days following the burn, either by telephone or written communication. During 1990 three open burns of explosives-contaminated debris in Area 27 were reported for this permit.

For OP 91-10 the Air Quality Officer must be notified by telephone at least two working days in advance of each training exercise for Class A flammables, and a written summary of each exercise must be submitted within 15 days following the exercise. This summary must include the date, time, duration, exact location, and amount of flammables burned. During 1990 seven burns were conducted for radiological emergency response training and ten training burns were conducted by onsite fire protection services. A summary of all burns was included in an annual report submitted to the state in September 1990.

A new air quality operating permit (OP 2154) was issued by the state of Nevada on October 1, 1990, for an incinerator in Area 23. This operating permit replaced an air quality permit to construct (PTC 2332) issued in 1989. The incinerator will be used by Wackenhut Security, Inc., for the destruction of classified materials. Table 4.3 is a listing of all permits active in 1990.

The LGFSTF conducted tests under Air Quality Operating Permit No. 1505 issued by the Division of Environmental Protection, state of Nevada, as amended on November 9, 1989.

Table 4.2 Nevada Air Quality Operating Permits Renewed in 1990

Location	Permit	Replaces	Expiration Date
Area 27, Explosive Ordnance Disposal	90-14	OP 89-19	02/28/91
All Areas, NTS	91-10	OP 90-6	11/06/91
Area 6, Decontamination Facility	2187	OP 1036	11/01/95
Area 23, Mercury	2154	PTC 2332	10/01/95

Table 4.3 NTS Active Air Quality Permits - 1990

Permit No.	Facility or Operation	Expiration Date
OP 90-14[a]	Open burning, Area 27	02/28/91
OP 91-10[a]	Open burning fire rescue	11/06/91
OP 2187[a]	York-Shipley boiler	11/01/95
OP 1082	Rex LO-GO Concrete Batch Plant	01/30/91
OP 1085	Storage tank, DF #2	02/25/91
OP 1086	Storage tank, unleaded fuel	02/25/91
OP 1087	Storage tank, DF #2	02/25/91
OP 1089	Portable stemming facility, Area 3	02/25/91
OP 1090	Storage tank, unleaded fuel	02/25/91
OP 1287	Aggregate Plant	02/12/92
OP 1304	Portable cement bins, Area 6	03/06/92
OP 1366	Portable cement bins, Area 6	04/01/92
OP 1505	LGFSTF	11/02/92
OP 1583	Cafeteria boiler, Ajax boiler	03/23/93
OP 1584	Cafeteria boiler, Ajax boiler	03/23/93
OP 1585	Area 12 Cafeteria boiler, Ajax boiler	03/23/93
OP 1591	Surface area disturbances	03/23/93
OP 1966	Cement storage equipment, Area 6	11/21/94
OP 1972	Shaker Plant	12/04/94
OP 1973	CMI rotary dryer	12/04/94
OP 1974	Cedarapids crusher	12/04/94
OP 1975	Stemming Facility	12/04/94
OP 1976	Stemming Facility	12/04/94
OP 1977	Concrete Batch Plant	12/04/94
OP 1978	Ajax boiler WOFD-6500	12/04/94
OP 1979	Aggregate Mixing/Hopper Plant	12/04/94
OP 2154[a]	Incinerator	10/01/95

(a) New or reissued permits in 1990.

4.3.1.2 NON-NTS AIR QUALITY PERMITS

Twenty-two air pollution control permits have been issued to the Las Vegas Area Operations facilities, and one permit has been obtained by the Woburn Cathode Ray Tube Operations facility. The permits issued by Clark County for Las Vegas Area Operations are issued for an indefinite period, and are amended and revised only if the situation changes under which the permit has been issued. For the other non-NTS facilities, no other permits have been required or the facilities have been exempted. Table 4.4 lists each of the required permits.

4.3.2 DRINKING WATER SYSTEM PERMITS

The NTS drinking water permits issued by Nye County as shown in Table 4.5 were renewed with new expiration dates as shown. No drinking water systems were maintained by any non-NTS facility.

Table 4.4 Active Air Quality Permits, Non-NTS Facilities - 1990

Permit No.[a]	Facility or Operation
Las Vegas Area Operations	
A06501	Process Equipment, Metal Sanding - Cyclone, Losee Road, NLV
A06502	Process Equipment, Anodizing, Losee Road, NLV
A06504	Diesel Power Generator, Losee Road, NLV
A06506	Process Equipment, Welding, Losee Road, NLV
A06507	Process Equipment, Spray Painting, Losee Road, NLV
A06509	Process Equipment, PC Board Plating, Losee Road, NLV
A06510	Process Equipment, Material Processing, Losee Road, NLV
A06511	Process Equipment, Chemical Processing, Losee Road, NLV
A06512	Cyclone and Stack, Abrasive Blast Facility, Losee Road, NLV
A38701	Emergency Generator, C-1 Complex, Losee Road, NLV
A38702	Process Equipment, Surface Coating, Paint Spraying Facilities, NLV
A38703	Exhaust, Soldering, Building C-1, Losee Road, NLV
A38704	Exhausts, Photo Processing, Building C-1, Losee Road, NLV
A34801	Fuel Burning Equipment, Boiler, NAFB
A34802	Fuel Burning Equipment, Boiler, NAFB
A34803	Fuel Burning Equipment, Boiler, NAFB
A34804	Fuel Burning Equipment, Water Heater, NAFB
A34805	Fuel Burning Equipment, Water Heater, NAFB
A34806	Emergency Generator, NAFB
A34807	Fume Hood, Battery Charging Equipment, NAFB
A34808	Photochemical Mixing & Photo Processing w/Vents, NAFB
A34809	Process Equipment, Paint Spray Booths, NAFB
Woburn Cathode Ray Tube Operations	
MBR-88-IND-188	Vapor Degreaser

(a) An annual fee is paid on these permits; there are no expiration dates.

Table 4.5 NTS Drinking Water Supply System Permits - 1990

Permit No.	Area(s)	Expiration Date
NY-5024-12NC	Area 1	09/30/91
NY-4009-12C	Area 2 & 12	09/30/91
NY-360-12C	Area 23	09/30/91
NY-4098-12NC	Area 25	09/30/91
NY-5000-12NC	Area 6	09/30/91

4.3.3 SEWAGE DISCHARGE PERMITS

Sewage discharge permits from the state of Nevada are listed in Table 4.6. Permit restrictions require quarterly discharge monitoring reports to be submitted to the state. There were no permit violations during 1990. Seven permits were required by EG&G/EM non-NTS facilities. These are listed in Table 4.7.

4.3.3.1 NTS SEWAGE HAULING INSPECTION

New permit applications were submitted to the state of Nevada for sewage hauling trucks for the NTS on February 2, 1990. The state conducted a prerequisite inspection of these trucks in February 1990 to determine the cleanliness of the operation, maintenance of the trucks, and disposal procedures. The inspection team visited the disposal sites around NTS and witnessed the trucks and operators in action. Deficiencies found are listed below.

SEPTIC TANK CLEANUP PAD

A sloped concrete pad needed to be constructed which would surround the manhole areas and ease in cleaning up spillage where trucks connect to dispose of septic tank waste.

Corrective Action

The prescribed concrete pads were constructed around all manhole areas, eliminating the possibility of waste spills on the surrounding ground surface.

Table 4.6 NTS Sewage Discharge Permits - 1990

Permit No./Area	Date Issued	Expiration Date
NEV87069/2&6	02/28/89	02/28/94
NEV87076/22&23	02/28/89	02/28/94
NEV87060/25&6	03/31/88	03/31/93
NEV87059/12	02/28/89	02/28/94
NEV20001/TTR	09/19/87	08/20/92

Table 4.7 Non-NTS Sewage Discharge Permits - 1990

Permit No./Location	Date Issued	Expiration Date
Las Vegas Area Operations		
87-2/Losee Road, NLV	08/08/89	08/09/91
CCSD-032/NAFB, NLV	10/26/89	10/23/91
Amador Valley Operations		
3672-101/Pleasanton, California	10/01/90	10/01/92
Santa Barbara Operations		
II-202/Goleta, California	12/26/89	12/31/90
II-204/Goleta, California	12/26/89	12/31/90
Special Technologies Laboratory		
II-225/Santa Barbara, California	12/26/89	12/31/90
Woburn Cathode Ray Tube Operations		
43 005 732-0	05/18/90	12/31/89[a]

(a) An extension was given on May 18, 1990, for the old permit until a new one could be issued.

UNPERMITTED VEHICLE

One truck which required a permit was not on the list filed with the state.

Corrective Action

A permit application for the new truck was submitted to the state.

EROSION ON LAGOON CONCRETE APRONS

The piping into all the lagoons needed to be extended further into the lagoon to eliminate erosion around the concrete aprons at the lagoon inlets.

Corrective Action

End piping in all lagoons was extended to the lagoon bottom to prevent erosion.
All corrective actions were completed during fiscal year 1990. Permits were issued by the state as listed in Table 4.6.

4.3.3.2 NTS TWEEZER FACILITY EVAPOTRANSPIRATION BED VARIANCE

A proposed variance for an evapotranspiration bed at the Tweezer Facility was submitted to the state in 1989 and approved in 1990. The project was completed and became operational in September 1990.

4.3.3.3 NTS SEWAGE LAGOON OPERATIONS AND MAINTENANCE (O&M) MANUALS

In December 1990 the state commented on the revised O&M manual for the Area 23 sewage lagoon which was submitted in September 1989. Once the state comments have been incorporated into the Area 23 O&M manual, the state has agreed that the remaining O&M manuals for NTS can be completed using the approved Area 23 manual as the model.

4.3.3.4 NON-NTS SEWAGE PERMITS

Sewage permits were required in five of the eight non-NTS facilities. This included two permits at the Las Vegas Area Operations facilities, one at the Amador Valley Operations facility, two at the Santa Barbara Operations facility, one at the Special Technologies Laboratory, and one at the Woburn Cathode Ray Tube Operations facility. These are listed in Table 4.7. Each was issued by the county or community in which the facility was located.

4.3.4 INJECTION WELL PERMITS

Subsequent to the October 1989 submittal of the discharge permit application for the Area 1 injection wells, it was decided in 1990 that underground injection would not be pursued as a viable disposal option for wastewater at the NTS. Also, one injection well at the EG&G/EM facility in Woburn, Massachusetts, is subject to state overview; however, no permit is required.

4.3.5 RCRA PERMITS

A listing of all RCRA and hazardous waste permits issued for operations in 1990 appears in Table 4.8.

4.3.5.1 NTS OPERATIONS

REECo continues to operate under EPA ID Number NV3890090001 as the operator for the NTS. No hazardous waste is generated under the currently existing EPA Generator ID Number NV28890010521, and a petition to the state for closure of this number will be made in 1991.

The RCRA Part A permit application was revised in April 1990 to include two steam cleaning effluent ponds in Area 6, and is being reviewed internally at the time of this writing. This revision has not yet been submitted to the state.

RCRA Part A closure plans completed in 1990 included the U2bu subsidence crater, U3fi injection well, Area 2 bit-cutter injection well, and the LLNL post-shot injection well. Closure plans for the Area 6 steam cleaning effluent ponds and the Area 27 Explosive Ordnance Disposal (EOD) area, not included in the Part A Application, will be completed in 1991.

In November 1990 the RCRA closure plan submittals to the state were prioritized based on the degree of anticipated contamination, existing hazard, and probability of approval of the closure plan by the state. The priority of these closures is as follows:

- Area 23 Landfill (amended plan).
- Area 6 Decontamination Pond.
- U3fi Injection Well.
- Area 6 Steam Cleaning Effluent Ponds.
- Area 2 Injection Wells.
- Area 23 Building 650 Leach Field.
- Area 27 EOD.
- U2bu Subsidence Crater.

The closure plan for the Area 23 Landfill was approved by the state in May 1990 and closure activities were started in June. However, further investigation of historical information indicated that the locations of the

Table 4.8 RCRA Hazardous Waste Permits - 1990

Type of Permit	Permit Numbers	Reporting Requirements
Nevada Test Site		
EPA Generator ID	NV3890090001	Biennial Report
EPA Generator ID	NV2890010521	Biennial Report
Las Vegas Area Operations		
EPA Generator ID	NVD097868731	Biennial Report
State of California Extremely Hazardous Waste Disposal Permit	4-90022708	None
Clark County Transportation of Hazardous Materials	None	None
Amador Valley		
EPA Generator ID	CAD056196900	Biennial Report
Kirtland Operations		
EPA Generator ID	NMD047986896	Biennial Report
EPA Generator ID	NMI890132300	Biennial Report
Los Alamos Operations		
EPA Generator ID	NMD986670340	Biennial Report
Santa Barbara Operations		
EPA Generator ID	CAD980813224	Biennial Report
EPA Generator ID	CAL000044172	Biennial Report
County of Santa Barbara Health Permit	G1700	Annual Report
County of Santa Barbara Health Permit	G1734	Annual Report
Special Technologies Laboratory		
EPA Generator ID	CAL000027394	Biennial Report
County of Santa Barbara Health Permit	G2288	Annual Report
Woburn Cathode Ray Tube Operations		
EPA Generator ID	MAD980578983	Biennial Report
Woburn City Fire Department Flammable Solvent Storage Permit	89-301	None

5453

hazardous waste trenches in the landfill were erroneous. A site investigation of the suspect areas was conducted that revealed no hazardous waste disposal other than that previously identified. The plan was further amended to change the configuration of the post-closure monitoring boreholes. As of January 1991 the amended closure plan does not have state approval.

Two closure plans previously submitted to the state (Area 6 Decontamination Pond and the Building 650 Leach Field) were recalled for modifications in the risk assessment area to make them more consistent with the plans currently being prepared.

In March 1990 a permit application was submitted to the state for the Area 12 Fleet Operations wash-down lagoon. This lagoon will receive steam cleaning effluent from a steam cleaning pad at Building 12-16. No hazardous (RCRA) materials are used at this pad. Additional information was requested by the state and provided in August and November.

4.3.5.2 NON-NTS FACILITIES

Nine EPA Generator ID numbers have been issued to seven EG&G/EM facilities. In addition, six state and local permits were required at three facilities. These permits and the locations with which they are associated are listed in Table 4.8. Hazardous waste is managed at these locations using onsite or satellite accumulation areas and a 90-day waste accumulation area. All hazardous and industrial chemical wastes are transported to RCRA-permitted facilities for approved treatment and/or disposal.

4.3.6 ENDANGERED SPECIES ACT PERMITS

Federal and state permits have been issued to NTS entities for study of endangered species. (All EG&G/EM non-NTS facilities are located in existing metropolitan areas and are not subject to the Endangered Species Act.) These biological studies include ongoing research on the desert tortoise. Reports are filed with the state of Nevada as stipulated by the permits.

In order to continue desert tortoise studies at the NTS, REECo applied for an endangered species permit from the U.S. Fish and Wildlife Service in 1989 and received the new permit in 1990.

5453

5.0 RADIOLOGICAL MONITORING RESULTS

Radiological environmental monitoring results from onsite environmental programs included (1) effluent sampling results for airborne emissions and liquid discharges to containment ponds and (2) environmental sampling and study results for onsite surveillance conducted by Reynolds Electrical & Engineering Co., Inc., (REECo). Offsite surveillance was conducted by the EPA Environmental Monitoring Systems Laboratory - Las Vegas (EMSL-LV). Onsite monitoring results indicated that environmental concentrations of radioactivity resulting from NTS air emissions were statistically no different than background except in the immediate vicinity of the emissions. These short-term emissions over a period of hours or days, and radioactive liquid discharges to onsite containment ponds, produced concentrations that were only a small fraction of a percent above background in terms of potential exposure of onsite workers. Offsite monitoring indicated that environmental radiation concentrations and exposure rates were statistically no different than background, with no measurable exposure of offsite residents from current NTS test operations.

5.1 RADIOLOGICAL EFFLUENT MONITORING

Daniel A. Gonzalez and Omer W. Mullen

Monitoring efforts for potential airborne radioactive effluents at the NTS consisted primarily of intensive air sampling and radiation detection through instrumentation deployed in the vicinity of nuclear tests during and following tests. This instrumentation showed no prompt release of radioactivity for any of the eight announced tests in 1990. Subsequent gas seepage occurred as a result of post-test operations. These occurred during three 1990 and following one 1989 post-test operations, and resulted in releases of approximately 66 curies of gaseous radioactivity. Air samples collected in and around the Area 5 Radioactive Waste Management Site (RWMS) indicated that the facility contributed no airborne concentrations that were statistically different from background. However, samples from the Area 3 Bulk Waste Management Facility (BWMF) showed above-background levels of $^{239+240}$Pu. The primary liquid effluents were Rainier Mesa tunnel seepage water collected in containment ponds at the tunnel mouths. Influent to these ponds essentially contained only tritium (^{3}H), with a total tunnel discharge of 216 curies. Additionally, 454 curies were released in water discharged to a surface pond from a research well used in a radionuclide migration study.

5.1.1 AIRBORNE EFFLUENTS

The majority of radiological air effluents at the NTS in 1990 originated from underground nuclear explosive tests conducted by NTS user organizations; the Lawrence Livermore National Laboratory (LLNL), Los Alamos National Laboratory

127

(LANL), and Defense Nuclear Agency (DNA) of the Department of Defense (DOD). (See Table 5.1 for a listing of all onsite effluent releases.) Each user organization performed effluent monitoring at the time of detonation and continued monitoring until all research activities were completed. Upon request, REECo performed radioactive noble gas monitoring at test sites within Rainier Mesa and Pahute Mesa. This involved deployment of one or more noble gas samplers near surface ground zeros (SGZs) to monitor possible release of radioactive gases. Considering all radionuclides detected, approximately 62 curies were released as airborne effluents.

An increase in efforts to monitor radioactive air emissions at the NTS began in November 1988 as a result of requirements in DOE Order 5400.1, DOE Order 5400.5, and draft DOE Order 5400.6, as well as from EPA requirements in the National Emission Standards for Hazardous Air Pollutants, 40 CFR 61. Before November 1991 the Area 12 tunnels, Area 6 Decontamination Facility, nuclear test sites, RWMSs, and all other potential effluent sites throughout the NTS will be assessed for their potential to contribute to public dose and be considered in designing the Site Effluent Monitoring Program, part of the NTS Environmental Monitoring Plan required by DOE Order 5400.1.

5.1.1.1 NUCLEAR EVENT MONITORING

This section is a summary of the specific nuclear event monitoring conducted at the NTS prior to and after each event, as well as routine effluent monitoring on the NTS. The various events, by name, and the results of measurements taken at each event site are presented in Table 5.2. This section also discusses other NTS facilities which are monitored for effluents on a routine basis.

Air emissions from nuclear testing operations consisted primarily of radioactive noble gases and ^{3}H released (1) during post-test drill-back, mine-back, or sampling operations following three 1990 underground nuclear tests and (2) through gas seepage after completion of post-test operations following one 1989 test. None of the tests resulted in a prompt release or venting (i.e., a release of radioactive materials within 60 minutes of the nuclear test). Seepage rates have been found to vary depending on atmospheric pressure changes, reflecting the pressure differential between underground gases and the atmosphere. This pressure-related variation in surface seepage rates of radioactive gases diffusing from the underground nuclear test point is sometimes referred to as "atmospheric pumping." Air emissions were monitored for source characterization and operational safety as well as environmental monitoring purposes.

Onsite radiological safety support, including monitoring for effluents (air emissions), were provided during the eight announced nuclear tests conducted at the NTS in 1990 by NTS user organizations (LANL, LLNL, and DNA). Also, routine air sampling was conducted for emissions from the G Tunnel complex. The amount of tritiated water vapor emitted from G Tunnel was calculated by multiplying the total flow of air discharged by the concentration of ^{3}H in the discharged air.

The test-associated services included detecting, recording, evaluating, and reporting of radiological conditions prior to, during, and for an extended period after each test and provision of aerial monitoring teams during each test to detect airborne releases. Personnel equipped with specialized collection and measurement instruments were prepared to respond rapidly should an accidental release of airborne radioactive materials have occurred from the underground test.

Complete radiological safety coverage was also provided during post-event drill-back (for vertical shaft testing) and mine-back (for tunnel testing) operations. These activities involved either drilling or mining into the vicinity of the nuclear detonation to acquire samples of test-associated material. These operations bore a potential for releasing radioactive gases to the atmosphere.

Table 5.1 NTS Radionuclide Emissions - 1990

Airborne Effluent Releases

Event or Facility Name (Airborne Releases)	Curies[a]									
	^{3}H	^{37}Ar	^{39}Ar	^{85}Kr	^{131m}Xe	^{133}Xe	^{133m}Xe	^{135}Xe	^{131}I	^{133}I
Area 2, METROPOLIS Event						5.7×10^{0}	1.8×10^{-1}	8.0×10^{-2}	8.8×10^{-5}	1.9×10^{-4}
Area 12, G Tunnel	2.8×10^{1}									
Area 12, N Tunnel		2.4×10^{0}	1.3×10^{-3}	7.6×10^{-2}	6.0×10^{-2}	3.1×10^{-1}	3.7×10^{-3}		5.0×10^{-7}	
Area 19, HOUSTON Event						1.0×10^{-4}				
Area 20 TENABO Event						2.4×10^{-5}			1.2×10^{-3}	
Area 20, BARNWELL Event				4.3×10^{0}	1.1×10^{0}	2.4×10^{1}				
TOTAL	2.8×10^{1}	2.4×10^{0}	1.3×10^{-3}	4.4×10^{0}	1.2×10^{0}	3.0×10^{1}	1.8×10^{-1}	8.0×10^{-2}	1.3×10^{-3}	1.9×10^{-4}

Liquid Effluent Releases

Containment and Radionuclide Migration (RNM) Ponds	Curies[a]						
	Gross Beta	^{3}H	^{90}Sr	^{131}I	^{137}Cs	^{238}Pu	$^{239+240}Pu$
Area 5, U5eRNM2S		4.5×10^{2}					
Area 6, Decontamination Pad Pond	8.5×10^{-4}	2.3×10^{-3}	1.4×10^{-3}	5.8×10^{-4}		9.7×10^{-8}	2.5×10^{-7}
Area 12, E Tunnel	3.0×10^{-4}	2.8×10^{0}	7.8×10^{-3}		4.0×10^{-3}	3.0×10^{-6}	1.8×10^{-5}
Area 12, N Tunnel	2.0×10^{-3}	1.7×10^{1}			5.9×10^{-3}	1.1×10^{-6}	2.2×10^{-4}
Area 12, T Tunnel	1.0×10^{-2}	2.0×10^{2}	7.1×10^{-2}		1.8×10^{-3}	2.2×10^{-6}	2.6×10^{-5}
TOTAL	1.3×10^{-2}	6.7×10^{2}	8.0×10^{-2}	5.8×10^{-4}	1.2×10^{-2}	6.4×10^{-6}	2.6×10^{-4}

(a) Multiply by 3.7×10^{10} to obtain Bq.

Table 5.2 Nuclear Event Release Summary - 1990

Announced 1990 Nuclear Events - Nevada Test Site

Event Name	Test Org.	Hole/ Area No.	Location	Date/ Time of Event	Prompt Release?	Telemetry Measurement Start	Telemetry Measurement Stop	Initial Radiation Survey Began	Initial Radiation Survey Ended	Maximum Exposure Rate	Release Information
METROPOLIS	LLNL	U2gh Area 2	Yucca Basin	03/10/90 0800 hrs	No	03/10/90 0801 hrs	03/11/90 0800 hrs	03/10/90 0856 hrs	03/10/90 0936 hrs	0.05 mR/h	Release included 5.96 Ci of xenons through the ventline system (3/14-3/15) and 0.28 mCi of iodines during post-event operations (3/14)
BULLION	LLNL	U20bd Area 20	Pahute Mesa	06/13/90 0900 hrs	No	06/13/90 0901 hrs	06/14/90 1122 hrs	06/13/90 0924 hrs	06/13/90 1042 hrs	0.05 mR/h	No release
AUSTIN	LANL	U6e Area 6	Yucca Basin	06/21/90 1115 hrs	No	06/21/90 1115 hrs	06/22/90 1300 hrs	06/21/90 1245 hrs	06/21/90 1300 hrs	0.05 mR/h	No release
MINERAL QUARRY	DNA	U12n.22 drift Area 12	N Tunnel (Rainier Mesa)	07/12/90 0800 hrs	No	07/25/90 0800 hrs	07/26/90 1245 hrs	07/25/90 1015 hrs	07/26/90 1245 hrs	0.05 mR/h	Release included 0.5 µCi of iodine (8/16-8/17) and 2.87 Ci of noble gas (8/16-8/17) during post-event purging, drilling, and gas sampling operations
SUNDOWN	LANL	U1d Area 1	Yucca Basin	09/20/90 0915 hrs	No	09/20/90 0915 hrs	09/21/90 0925 hrs	09/20/90 0950 hrs	09/20/90 1003 hrs	0.05 mR/h	No release
LEDOUX	LANL	U1a Area 1	Yucca Basin	09/27/90 1103 hrs	No	09/27/90 1103 hrs	09/28/90 1005 hrs	09/27/90 1135 hrs	09/27/90 1142 hrs	0.05 mR/h	No release
TENABO	LLNL	U20bb Area 20	Rainier Mesa	10/12/90 1031 hrs	No	10/12/90 1031 hrs	10/12/90 1030 hrs	10/12/90 1135 hrs	10/12/90 1224 hrs	0.05 mR/h	Release included 24 µCi of xenon (10/19) and 1.2 mCi of iodine (10/18-10/30) during post-event operations
HOUSTON	LANL	U19az Area 19	Rainier Mesa	11/14/90 1117 hrs	No	11/14/90 1117 hrs	11/15/90 1132 hrs	11/14/90 1254 hrs	11/14/90 1336 hrs	0.05 mR/h	Release included 10^{-4} Ci of xenon (9/11-9/12) during post-event operations

Pre-1990 Events with 1990 Releases

Event Name	Test Org.	Hole/ Area No.	Location	Date/ Time of Event	Prompt Release?	Release Information
BARNWELL	LLNL	U20az Area 20	Pahute Mesa	12/08/89 0700 hrs	No	Ground seepage from this event released 24 Ci of ^{133}Xe, 1.1 Ci of ^{131m}Xe, and 4.3 Ci of ^{85}Kr during the period 1/1 through 12/31/90

130

5458

5453

Seepage of these gases to the surface might also have occurred. Methods of data accumulation included recording telemetered radiation measurements from the test area, air sampling, worker bioassays, and, if warranted, whole-body counting.

The radiation detection array surrounding SGZ was there to provide the first telemetered data if venting were to have occurred following detonation of a nuclear device. A typical array for a vertical shaft event is shown in Figure 5.1. Each gamma-sensitive, ion-chamber detector was linked by microwave and hard-wire communications to a console in one of two buildings at the NTS Control Point and/or the Control and Data Acquisition Center. The console also displayed information from each of the permanent telemetered remote area monitor (RAM) arrays. The levels were displayed on each console and the time of the measurement, in minutes after zero time (detonation), were recorded and displayed.

Following each test, when control of the test area was released by the DOE Test Controller, REECo personnel accompanied the Test Group Director's inspection party entering the potential radiological exclusion area to perform initial surveys. Radiation measurements, obtained using portable detection instruments, plus measurements of time and location were recorded on survey forms and the information reported by radio. Survey locations were determined from roadside numbered reference stakes and road junctions. Maps showing the locations of these reference stakes in relation to roads and landmarks were provided to participating test groups. Radiation exposure rates obtained with portable instruments usually were made at waist-high level (approximately one meter above the ground).

During the post-event drill-back and mining activities, REECo personnel maintained continuous environmental surveillance in the work area. For drill-back coverage, radiation detector probes were placed in strategic locations in the work areas and connected to recorders and alarms to warn of increases in radiation levels. Radiation monitoring personnel using portable instruments periodically checked work area radiation levels and issued protective equipment or evacuated area personnel when necessary. For drill-back containment of radioactive material releases to the atmosphere, LANL utilized a pressurized recirculation system. LLNL used a ventline filter system designed to trap radioactive particulates released from the drill casing. In the ventline system, trapped radioactive material was allowed to decay under controlled conditions. For DNA tunnel operations, the effluent was passed through a charcoal/high-efficiency particulate aerosol (HEPA) filter system before release. This trapped radioactive material was also allowed to decay under controlled conditions.

When requested by the organization conducting the test, portable air sampling units were placed at predetermined locations. The portable air sampling system drew air through a paper filter and charcoal cartridge. Gaseous radioiodine present was trapped in the cartridges and particulates were trapped on the paper filter. The filters and cartridges were changed at specific times and analyzed by the REECo or LANL laboratory.

NOBLE GAS MONITORING

Portable air samplers were set up surrounding or in the vicinity of the SGZ for the four events conducted in the Rainier Mesa/Pahute Mesa region during 1990. These air samplers were similar to the samplers used to monitor noble gases as part of the Site-wide environmental surveillance program (see Section 5.2.1). The only modification to the sampler was that those sampling units deployed at the event sites could operate for several weeks on battery power. Otherwise the samples were taken and analyzed using the same methods described for the environmental surveillance noble gas samplers.

Typically, two noble gas samplers were deployed near one of the RAM stations

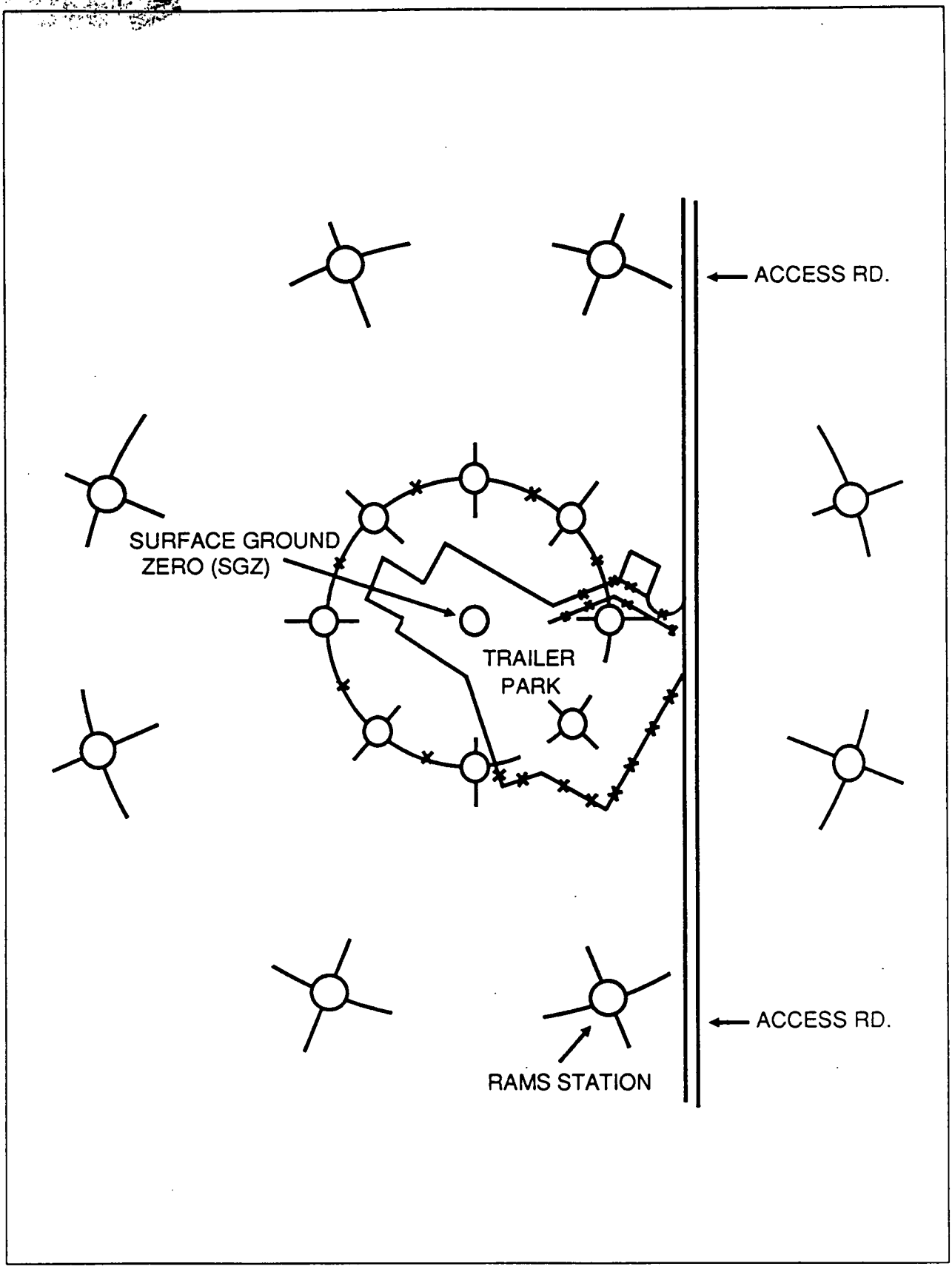


Figure 5.1 Typical RAM Array for a Nuclear Test. *The stations on the inner arc are at a radius of 320 feet from SGZ; the outer arc stations are at 1000 feet from SGZ*

5453

which surround the SGZ in a circular array. This deployment at RAM stations was performed to establish a common reference point with the surveyed RAM locations. Predominant wind direction and ease of access were the two main factors used when choosing the appropriate RAM station.

Data results for the four events monitored are presented in Appendix E, "Radioactive Noble Gases in Air Onsite," Tables E.2 and E.4. A maximum ^{85}Kr concentration of 5.4 x 10^{-8} µCi/mL (64,000 pCi/m^3) was detected at the BARNWELL event site in Area 20, detonated in December 1989. This concentration and the maximum concentration of ^{133}Xe detected of 1.1 x 10^{-5} µCi/mL were both less than the Derived Air Concentrations (DACs) for these radionuclides. Late-time, post-test seepage from this test resulted in releases of ^{85}Kr, ^{133}Xe, and ^{133m}Xe throughout the year. These data are shown on Table 5.1 and 5.2. A total of 29.4 curies was released from this test.

5.1.1.2 TUNNEL COMPLEX EFFLUENT

The G Tunnel complex ventilation system was routinely monitored during 1990 for ^3H in water vapor (HTO). Sampling was conducted weekly for four hours. A desiccant was used to extract the tritiated water vapor from the air. The Sandia National Laboratory (SNL) calculated a total release of 28.1 curies of airborne ^3H from the G Tunnel complex for 1990.

5.1.1.3 RADIOACTIVE WASTE MANAGEMENT SITES

Two permanent particulate/halogen samplers were located within the disposal pits at the RWMS in Area 5. The low-level waste disposal pits in Area 5 may be considered to be diffuse effluent sources. A diffuse source is an area source or several point sources near each other. The disposal site, along with other NTS sites, will be investigated and assessed according to the requirements of DOE Order 5400.1 by November 1991 to determine their ultimate classification as effluent sources.

The annual average concentration of samples taken within Pit #3 in Area 5 was 2.0 x 10^{-14} µCi/mL of gross beta activity. The NTS annual average gross beta concentration, not including the Area 5 samplers distributed around the disposal site, was 1.7 x 10^{-14} µCi/mL. There is no statistical difference between these averages at the five percent significance level. The gross beta results from air samples from Pit #4 also had an annual average concentration of 2.0 x 10^{-14} µCi/mL.

Analysis of samples taken within Pit #3 and #4 indicate that the operations in the RWMS are not contributing radiological effluents in concentrations statistically different at the five percent significance level from concentration levels present in the NTS environment. Average annual gross beta and plutonium results from all the samples collected at the RWMS facility are displayed in Figure 5.2.

Nine ^3H samplers were located surrounding the RWMS. These samplers are placed near the perimeter berm of the disposal site as seen in Figure 5.3. The annual average ^3H concentration for the nine stations was 7.9 ± 2.4 x 10^{-12} µCi/mL. This average was not statistically different at the five percent significance level from the annual average of other sampling locations distributed throughout the NTS. The results indicate the waste disposal operations at the RWMS did not contribute measurable levels of tritiated water vapor to the NTS environment. The annual average ^3H concentrations from the samplers surrounding the RWMS facility are displayed in Figure 5.3.

The results from thermoluminescent dosimeters (TLDs) deployed surrounding the RWMS facility indicated that the gamma exposure rates measured in 1990 were not statistically different from the levels measured in 1989. The exposure rates in mR/day are shown in Figure 5.4. The gamma exposure rates detected at the

- 5458

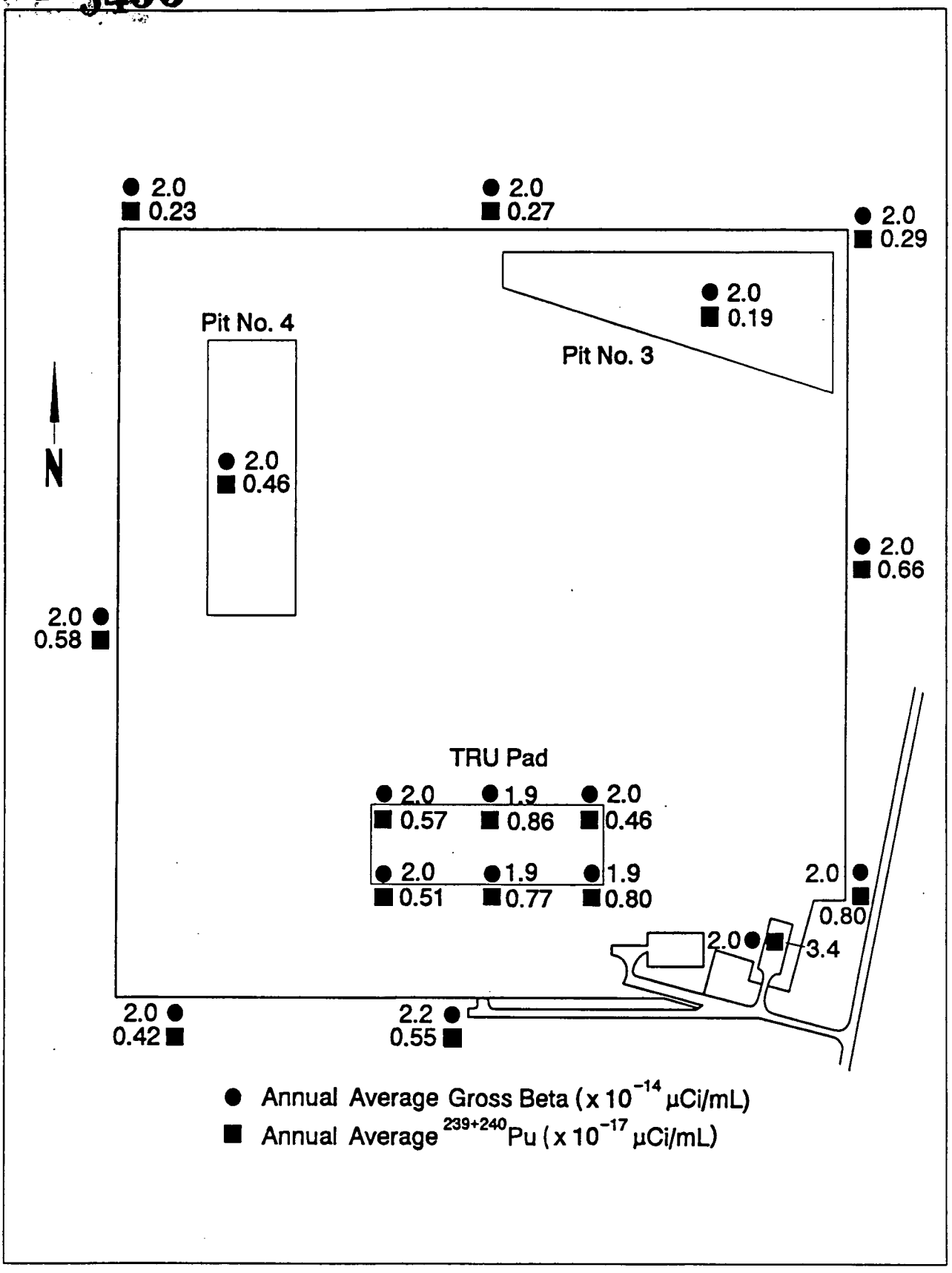


Figure 5.2 RWMS Air Sampling Annual Average Results - 1990

134

5453

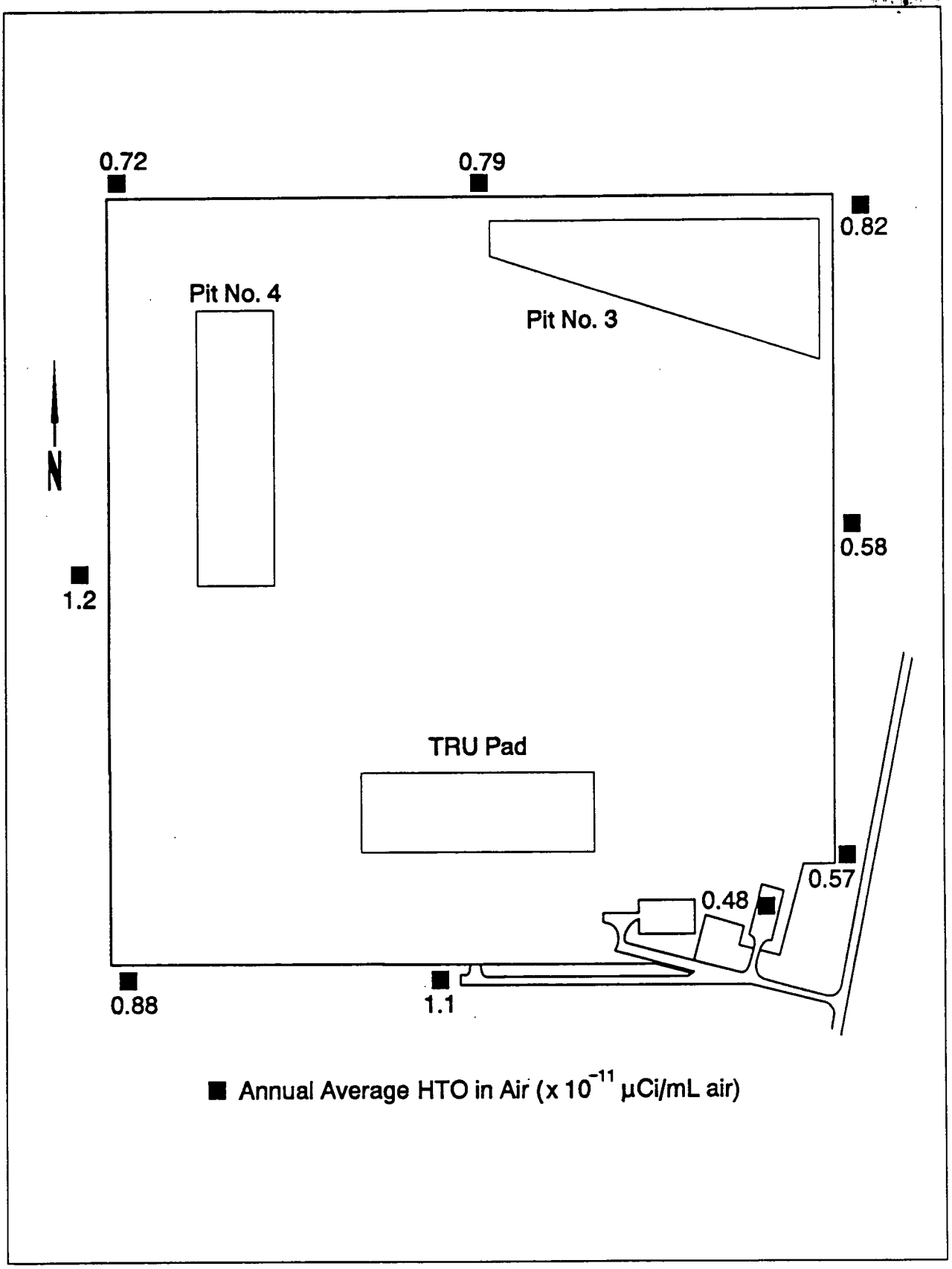


Figure 5.3 RWMS Tritiated Water Vapor Annual Average Results - 1990

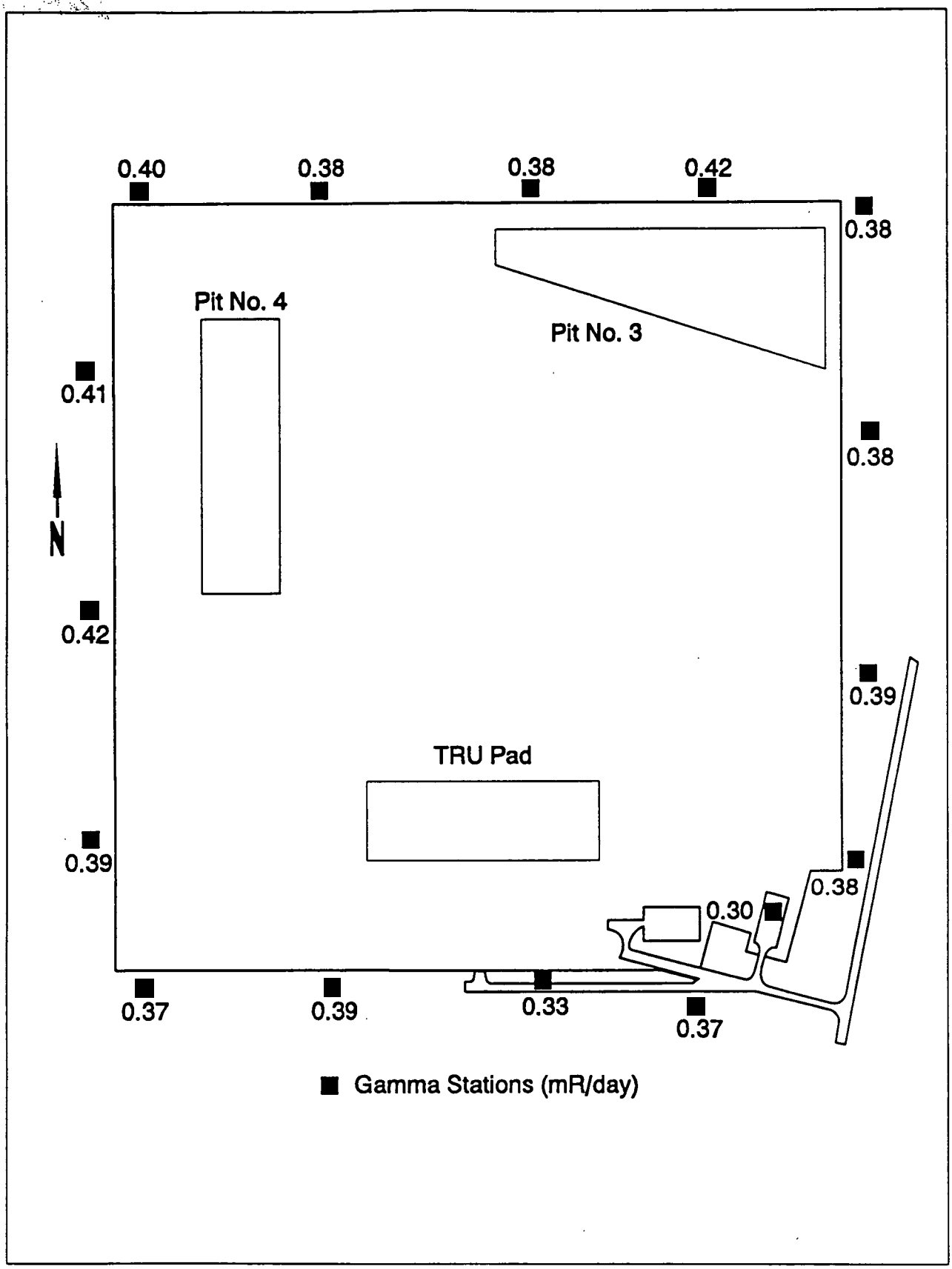


Figure 5.4 RWMS TLD Annual Average Results - 1990

5453

RWMS perimeter were determined not to be atypical from the majority of gamma measurements taken at other NTS locations. This information is presented in Volume II, Appendix F, "Onsite Thermoluminescent Dosimeter Data."

The Area 3 Bulk Waste Management Facility (BWMF) is used for disposal of radiologically contaminated waste from NTS operations. This waste is buried in subsidence craters much like waste is buried at the Area 5 RWMS. The BWMF is surrounded by four permanent particulate/halogen samplers located approximately north, south, east, and west of the burial pit. Several TLDs were distributed at the BWMF and surrounding areas. The gross beta annual average at the BWMF of 1.9 x 10^{-14} µCi/mL was not statistically different at the five percent significance level from to the Site-wide average. However, $^{239+240}$Pu results indicated that levels at the BWMF were consistently above the NTS average (see Appendix A of Volume II). During disposal of earth contaminated with plutonium at the BWMF, a small fraction becomes suspended in air. As such, the elevated $^{239+240}$Pu levels indicated that the BWMF was a diffuse source of effluents. Air sampling results are displayed in Section 5.2.1.2, Tables 5.5 and 5.6, and TLD results are listed and discussed in Appendix F of Volume II.

5.1.2 LIQUID EFFLUENTS

Liquid effluents at the NTS originated from tunnels, research studies of radionuclide movement through groundwater, and cleanup of radiologically contaminated equipment. Typically, all liquid discharges within the NTS were held in containment ponds. Monthly grab samples were taken from each pond and, where possible, from the influent. Radioactive liquid effluents discharged to onsite ponds contained approximately 670 curies of ^{3}H during 1990.

5.1.2.1 TUNNELS

Rainier Mesa in Area 12 is the location for nuclear tests that are conducted within tunnels by the DOD. As a result of drilling operations and seepage, water discharged from these tunnels was collected in ponds outside the tunnels. This water was usually contaminated with radionuclides, mainly ^{3}H, which were generated during nuclear tests.

Liquid effluents were discharged during 1990 from three tunnels: N, T, and E. A monthly grab sample was taken from each containment pond and from the tunnel discharge. Monitoring results indicated that the water discharged from the three tunnels listed contained measurable quantities of ^{3}H and fission products. Total quantities of ^{3}H, ^{238}Pu, $^{239+240}$Pu, and beta activity were reported for each liquid effluent source and are listed in Table 5.1.

The primary source of liquid discharges was from tunnel seepage to near-portal containment ponds. Onsite discharges to evaporating ponds contained a total of 216 curies of ^{3}H. No liquid effluents were discharged offsite. An additional 454 curies was released to the Area 5 radionuclide migration study ditch, see Section 5.1.2.2 below, for a total NTS release of 670 curies of ^{3}H to onsite ponds. Discharges of other radionuclides totaled less than 20 mCi.

Radioactivity in liquid discharges released to onsite waste treatment or disposal systems (containment ponds) was monitored to assess the efficacy of treatment and control and provide a quantitative and qualitative annual summary of the radioactivity released onsite.

During 1990 an estimated 3.2 x 10^{7} liters of water were discharged into the T Tunnel containment ponds. Sampling results from the tunnel effluent pipe indicated an annual average of 6.1 x 10^{-3} µCi/mL (1.9 x 10^{5} Bq/L) of ^{3}H. Therefore, the total quantity of ^{3}H discharged out of the T Tunnel complex was calculated to be 196 curies. Additional ^{3}H effluent data for T Tunnel and other sites discussed in Section 5.1.2 are found in Table 5.3.

At N Tunnel an estimated 3.7×10^7 liters of water were discharged into the containment ponds. The average 1990 annual concentration of ^3H from samples taken at the N Tunnel effluent pipe was 4.6×10^{-4} µCi/mL (1.7×10^4 Bq/L). The gamma emitters were for the most part undetected. The total ^3H discharge from N Tunnel activities for 1990 was calculated to be 17 curies.

The E Tunnel complex has been inoperative for several years. However, water continued to discharge from the tunnel. The total flow during 1990 was estimated to be 1.9×10^6 liters. Samples taken from this liquid discharge displayed an annual average of 1.5×10^{-3} µCi/mL (5.6×10^4 Bq/L) of ^3H. The containment ponds for this tunnel were dry during 1990. The total ^3H activity discharged into the environment from E Tunnel effluents was calculated to be 3 curies.

5.1.2.2 RADIONUCLIDE MIGRATION STUDY

Pumping of the radionuclide migration study well in Area 5 continued through 1990. This well (U5eRNM2S), located 90 meters (297 feet) from the CAMBRIC underground nuclear test location, has been pumped continuously since 1975 to force migration of radionuclides from the CAMBRIC cavity to the well through the subsurface geology in order to study migration potential and rates. The CAMBRIC test was conducted 73 meters (241 feet) below the water table in 1965. Water pumped to the surface is released to a man-made ditch, which drains to the edge of the Frenchman Flat playa, forming a small pond area. Tritium has been observed in the pumped water since 1978 (Burbey and Wheatcraft 1986). During 1990 the well did not operate during September 25 through December 3 and from December 18 through the end of the year.

The concentration of ^3H in the water discharged from the well averaged 4.8×10^{-4} µCi/mL (1.8×10^4 Bq/L) during 1990. The flow from this well, measured at 600 gallons per minute (22.7×10^5 liters per minute), discharged a total volume of 9.5×10^8 liters during 1990 for a total ^3H discharge into the NTS environment of 454 curies. The water is not used for drinking or industrial purposes.

5.1.2.3 DECONTAMINATION FACILITY

The Decontamination Facility, located in Area 6, discharged contaminated water generated during equipment decontamination processes into a containment pond. Grab samples are

Table 5.3 Tritium in NTS Effluents - 1990

Location	Discharge Volume (L)	Average ^3H Concentration (µCi/mL)	Total ^3H Discharge (Ci)[a]
T Tunnel	3.2×10^7	6.1×10^{-3}	196
N Tunnel	3.7×10^7	4.6×10^{-4}	17
E Tunnel	1.9×10^6	1.5×10^{-3}	3
U5eRNM2S	9.5×10^8	4.8×10^{-4}	454
Area 6 Decontamination Facility Pond	3×10^6	7.5×10^{-7}	2.3×10^{-3}

(a) Multiply by 3.7×10^{10} to obtain Bq.

5453

taken from this pond on a monthly basis and analyzed for ^{3}H, beta, ^{238}Pu, $^{239+240}Pu$, and gamma activity.

During 1990 sampling results from influent to the containment pond at the Decontamination Facility were consistently below detection limits for all radionuclides except ^{3}H, as discussed under "Containment Ponds" in Section 5.2.1.5. The annual average of ^{3}H at the Decontamination Facility containment pond was 7.5×10^{-7} µCi/mL (28 Bq/L). The total volume of liquid discharged to the containment pond during 1990 was estimated to be 3×10^{6} liters. Therefore, the total discharge of ^{3}H for 1990 was estimated to be 2.3×10^{-3} curies.

5.2 RADIOLOGICAL ENVIRONMENTAL SURVEILLANCE

Bruce B. Dicey, Christopher A. Fontana, Daniel A. Gonzalez, Anita A. Mullen, Victoria E. Niemann, Scott E. Patton, William G. Phillips, Donald D. Smith, and Daryl S. Thomé

Onsite surveillance of airborne particulates, noble gases, and tritiated water vapor indicated onsite concentrations that were generally not statistically different from background concentrations. Surface water samples collected from open reservoirs of natural springs and industrial-purpose water gave no indication of statistically significant contamination levels. Groundwater monitoring results also showed no levels different from background. External gamma exposure monitoring indicated that the gamma environment within the NTS remained consistent with previous years. All gamma monitoring stations displayed expected results, ranging from the background levels predominant throughout the NTS to the types of exposure rates associated with known contaminated zones and radiological material storage facilities. Special environmental studies included soil radionuclide transport studies and development of a NTS-specific dose assessment model. Results of offsite environmental surveillance by the EMSL-LV indicated no NTS-related radioactivity was detected at any air sampling station, and there were no apparent net exposures detectable by the offsite dosimetry network.

5.2.1 ONSITE ENVIRONMENTAL SURVEILLANCE

Onsite radiological surveillance consists of (1) a network of 52 air sampling stations; (2) 7 radioactive noble gas sampling stations; (3) 17 tritiated water vapor sampling stations; (4) surface water samples from 15 open water supply reservoirs, 7 springs, 10 wastewater containment ponds, and 4 sewage lagoons; (5) groundwater samples from 14 supply wells and from 9 drinking water consumption points; and (6) 184 ambient gamma exposure measurements taken with TLDs. Additional radiological studies were conducted through the Basic Environmental Compliance and Monitoring Program (BECAMP), including (7) investigating the movement of radionuclides on and around the NTS through horizontal movement, water-driven erosion, vertical migration, and wind-driven erosional resuspension; (8) development of a human dose-assessment model specific to the environmental and radiological conditions of the NTS; (9) preparation of a peer-reviewed publication that addresses an important issue related to the potential environmental impacts of past, present, and future activities on the NTS; and (10) monitoring of the flora and fauna on the NTS to assess changes over time in the ecological condition of the NTS (see Section 7 of this volume).

5.2.1.1 RADIOACTIVITY IN AIR

Fifty-two air sampling stations were operated continuously. At each of the stations, samples were collected weekly on glass fiber filters (for particulate) and charcoal cartridges (for halogens). The filters were counted for gross beta and gamma activity each week, combined at the end of the month, and then analyzed for ^{238}Pu and $^{239+240}$Pu. The charcoal cartridge was counted for gamma activity each week. The individual gross beta, ^{238}Pu, $^{239+240}$Pu, and gamma sampling

140

5453

results are listed in Volume II, Appendix A, "Onsite ^{238}Pu, $^{239+240}Pu$, Gross Beta, and Gamma-Emitting Radionuclides in Air," Attachments A.1 through A.4.

Air monitoring for the noble gases ^{85}Kr and ^{133}Xe was performed at seven fixed locations. These air samples were also collected weekly. A distillation process separated the components of the air, and the radioactive krypton and xenon in the sample were measured.

Tritiated water vapor was monitored continuously at 17 locations. Samples were collected every two weeks and analyzed for ^{3}H.

For the purpose of comparing measured quantities of airborne radioactivity to the DAC (the guide for occupational exposures) found in DOE Order 5480.11 and to the Derived Concentration Guide (DCG, the guide for exposures to members of the general public) found in DOE Order 5400.5, the following assumptions were made:

- The chemical species of the radionuclides detected was unknown, so the most restrictive DAC or DCG was used (almost always Class Y compounds, which take on the order of years to clear from the respiratory system). All of the DCGs and DACs used are listed in Table 5.4.
- For air sampling results, all of the gross beta activity detected was assumed to be ^{90}Sr.

5.2.1.2 PARTICULATE SAMPLING RESULTS

GROSS BETA

Figure 5.5 displays the average NTS gross beta results for 1990 sampling. Sampling results from the RWMS in Area 5 were detailed previously in Figures 5.2 through 5.4. Air particulate samples were held for seven days prior to gross beta counting and gamma spectrum analysis to allow for the decay of radon and radon daughters. In previous years samples collected at Gate 200 in Area 5 were not held for decay of radon daughters prior to gross beta analysis. The results from this station provided a useful indication of any Site-wide anomalous concentrations. However, a procedural error made this early counting practice sporadic during 1990. Consequently, the results were highly variable since that radon daughter activity was present in some samples and not present in others. This information was considered during the statistical evaluation of this analysis presented in Appendix A of Volume II. Table 5.5 presents the network arithmetic averages, minimums, and maximums for 1990 airborne gross beta sampling results.

The network (all locations excluding Gate 200) annual average gross beta concentration was 1.9×10^{-14} µCi/mL (7.0×10^{-4} Bq/m^3). This concentration is 0.0002 percent of the ^{90}Sr DAC listed in DOE Order 5480.11 and 0.21 percent of the DCG noted in DOE Order 5400.5. One sample standard deviation of this annual average was 6.8×10^{-15} µCi/mL (2.5×10^{-4} Bq/m^3). The statistical evaluation of the gross beta concentrations indicated that a lognormal distribution provides an adequate approximation to the true distribution. The network annual geometric mean and geometric standard deviation of the data were $(1.8 \pm 1.4) \times 10^{-14}$ µCi/mL ($[6.7 \pm 5.2] \times 10^{-4}$ Bq/m^3). All results were above the MDC.

The data were distributed into two groups (excluding Area 5 Gate 200 sample results which could fit either group). For discussion, these two groups were designated as the "upper" and "lower" groups. The statistical analysis is presented in Appendix A of Volume II.

PLUTONIUM

Monthly composite samples from each particulate sampling location were analyzed

Table 5.4 Radionuclide Concentration Guides for Air and Water

	µCi/mL			
Radionuclide	DAC (air)[a]	DCG (air)[b]	DCG (water)	MCL (water)[c]
^{3}H	2×10^{-5}	1×10^{-7}	2×10^{-3}	2×10^{-5}
^{40}K	2×10^{-7}	9×10^{-10}	7×10^{-6}	-
^{85}Kr (ns)	1×10^{-4}	3×10^{-6}	-	-
^{90}Sr	8×10^{-9}	9×10^{-12}	1×10^{-6}	8×10^{-9}
^{133}Xe (ns)	1×10^{-4}	5×10^{-7}	-	-
^{226}Ra	3×10^{-10}	1×10^{-12}	1×10^{-7}	5×10^{-9}
^{238}Pu	3×10^{-12}	3×10^{-14}	4×10^{-8}	-
$^{239+240}Pu$	2×10^{-12}	2×10^{-14}	3×10^{-8}	-

(ns) = nonstochastic value

(a) DAC - The Derived Air Concentration used for limiting radiation exposures through inhalation of radionuclides by workers. The values are based on either a stochastic (committed effective dose equivalent) dose of 5 rem or a nonstochastic (organ) dose of 50 rem, whichever is more limiting. In the table, the value shown is a stochastic limit unless followed by (ns).

(b) DCG - Derived Concentration Guides are reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. The DCG values for internal exposure shown are based on a committed effective dose equivalent of 100 mrem for the radionuclide taken into the body by ingestion or inhalation during one year.

(c) MCL - The Maximum Contaminant Level is the maximum permissible level of a contaminant in water which is delivered to the free-flowing outlet of the ultimate user of a public water system. MCL values are reported in the EPA National Primary Drinking Water Standards (40 CFR 141). The values listed in the table are based on 4 mrem committed effective dose equivalent for the radionuclide taken into the body by ingestion of water during one year.

for ^{238}Pu and $^{239+240}Pu$. Sampling results averaged below 10^{-15} µCi/mL (10^{-4} Bq/m^3) of $^{239+240}Pu$ and 10^{-17} µCi/mL (10^{-6} Bq/m^3) of ^{238}Pu for all locations during 1990, with the majority of results for both isotopes being on the order of 10^{-18} µCi/mL (10^{-6} Bq/m^3). Figure 5.6 shows the airborne $^{239+240}Pu$ annual average results at their respective locations. Tables 5.6 and 5.7 list the measured minimum, maximum, and average $^{239+240}Pu$ and ^{238}Pu concentrations for the year, respectively. A negative result indicates that the sample count was less than the background count.

The maximum annual average $^{239+240}Pu$ concentration was found at the Area 3, U3ah/at West sampling location. Results from the samples taken at this location averaged 2.1×10^{-16} µCi/mL (7.4×10^{-6} Bq/m^3) during 1990. This quantity was 0.01 percent of the DAC and 1.0 percent of the

142

5453

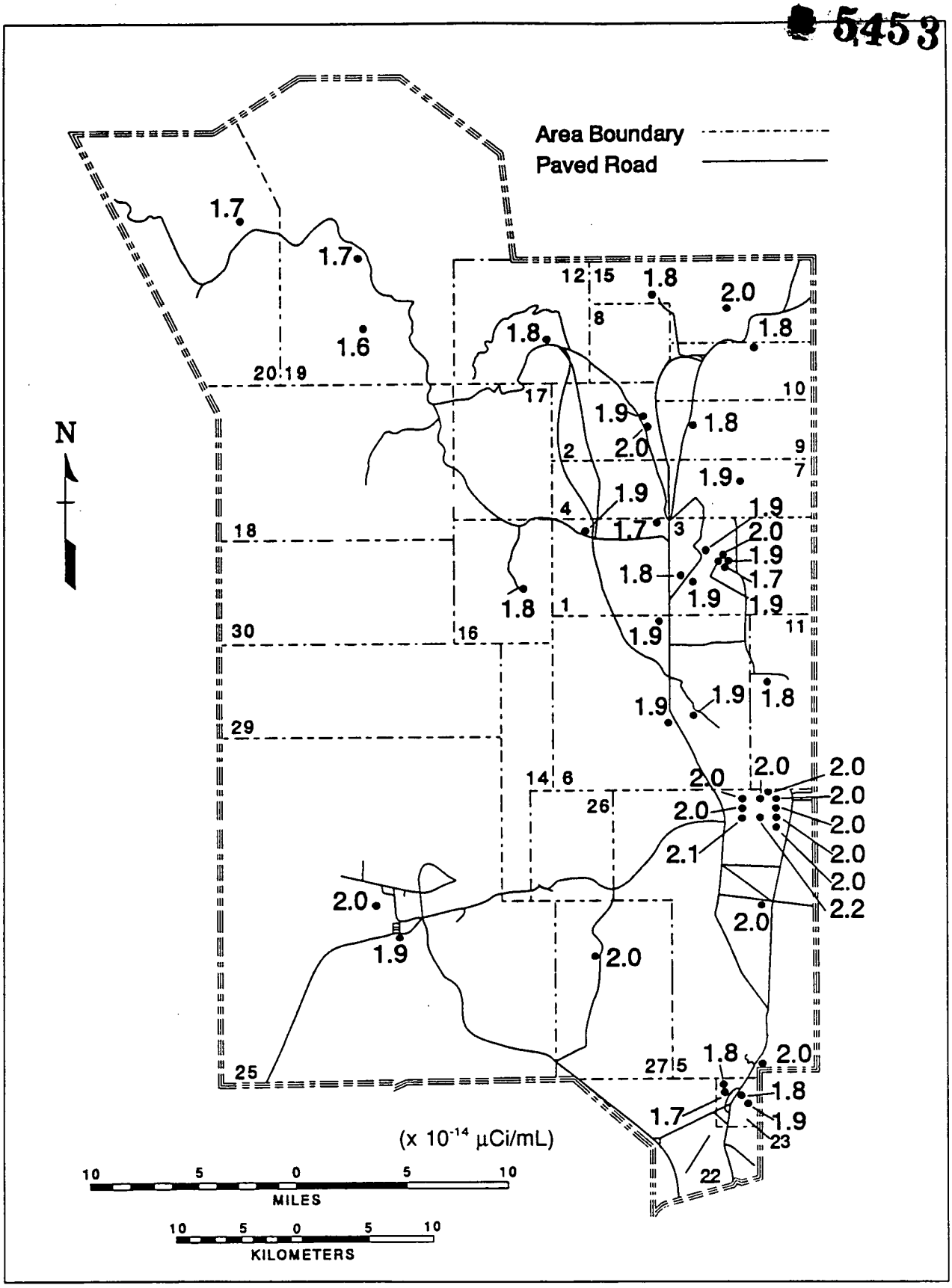


Figure 5.5 NTS Airborne Gross Beta Annual Average Concentrations - 1990

143

Table 5.5 Airborne Gross Beta Concentrations on the NTS - 1990

Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
	Gross Beta Concentration x 10^{-9} µCi/mL					
Area 1, BJY	53	1.70	0.52	0.07	0.76	2.97
Area 1, Gravel Pit	53	1.89	0.63	0.09	0.95	3.75
Area 2, 2-1 Substation	53	1.97	0.65	0.09	0.85	4.04
Area 2, Complex	49	1.92	0.26	0.04	1.31	2.33
Area 3, 3-300 Bunker	53	1.89	0.57	0.08	0.97	3.72
Area 3, Complex	53	1.78	0.61	0.08	0.42	3.48
Area 3, Complex No. 2	51	1.89	0.52	0.07	0.63	3.36
Area 3, U3ah/at East	53	1.88	0.59	0.08	0.80	3.65
Area 3, U3ah/at North	53	2.02	1.17	0.16	1.10	7.82
Area 3, U3ah/at South	53	1.73	0.44	0.06	0.70	2.86
Area 3, U3ah/at West	53	1.91	0.62	0.09	1.01	3.99
Area 5, DOD Yard	53	1.97	0.70	0.10	0.90	4.60
Area 5, Gate 200	51	1.95	0.70	0.10	0.86	3.95
Area 5, RWMS No. 1	53	2.02	0.66	0.09	1.14	4.37
Area 5, RWMS No. 2	53	1.97	0.61	0.08	1.14	4.18
Area 5, RWMS No. 3	53	1.96	0.63	0.09	0.65	4.27
Area 5, RWMS No. 4	53	2.00	0.64	0.09	1.14	4.25
Area 5, RWMS No. 5	53	1.96	0.66	0.09	1.09	4.42
Area 5, RWMS No. 6	53	2.00	0.69	0.10	0.81	4.37
Area 5, RWMS No. 7	53	1.99	0.65	0.09	1.09	4.34
Area 5, RWMS No. 8	53	2.06	0.61	0.08	1.10	4.31
Area 5, RWMS No. 9	53	2.15	1.30	0.18	0.24	9.81
Area 5, RWMS Pit No. 3	51	1.95	0.67	0.09	0.76	4.02
Area 5, RWMS Pit No. 4	52	2.01	0.71	0.10	1.07	4.47
Area 5, RWMS TRU Pad (TP) North	52	1.94	0.67	0.09	0.83	4.27
Area 5, RWMS TP Northeast	52	1.97	0.69	0.10	1.11	4.69
Area 5, RWMS TP Northwest	52	2.02	0.69	0.10	1.06	4.49
Area 5, RWMS TP South	52	1.94	0.60	0.08	1.22	4.14
Area 5, RWMS TP Southeast	52	1.87	0.59	0.08	0.94	3.98
Area 5, RWMS TP Southwest	51	2.01	0.76	0.11	0.80	4.74
Area 5, Well 5B	53	2.04	0.71	0.10	1.12	4.66
Area 6, CP-6	53	1.91	0.63	0.09	0.80	3.82
Area 6, Well 3 Complex	53	1.86	1.11	0.15	0.00	7.85
Area 6, Yucca Complex	53	1.93	0.68	0.09	0.72	4.21
Area 7, Ue7ns	53	1.88	0.71	0.10	0.32	4.45
Area 9, 9-300 Bunker	53	1.83	0.62	0.09	0.97	3.67
Area 10, Gate 700 South	53	1.83	0.46	0.06	0.91	3.28
Area 11, Gate 293	53	1.84	0.61	0.08	0.95	4.01
Area 12, Complex	52	1.82	0.35	0.05	1.39	3.27
Area 15, EPA Farm	53	1.96	0.59	0.08	0.81	3.49
Area 15, PILEDRIVER	53	1.76	0.62	0.09	0.89	3.66
Area 16, 3545 Substation	52	1.76	0.50	0.07	0.76	3.42
Area 19, Echo Peak	49	1.59	0.57	0.08	0.62	3.16
Area 19, Pahute Substation	52	1.69	0.60	0.08	0.83	3.33
Area 20, Dispensary	53	1.69	0.54	0.07	0.83	3.16
Area 23, Building 790	53	1.81	0.63	0.09	0.79	3.96
Area 23, Building 790 No. 2	53	1.69	0.60	0.08	0.62	3.96
Area 23, East Boundary	53	1.88	0.65	0.09	0.99	4.13
Area 23, H&S Building Roof	52	1.80	0.60	0.08	0.95	3.64

Table 5.5 (Airborne Gross Beta Concentrations on the NTS - 1990, cont.)

	Gross Beta Concentration x 10^{-9} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 25, E-MAD North	52	1.99	0.61	0.08	1.17	3.77
Area 25, NRDS Warehouse	53	1.86	0.59	0.08	0.95	3.70
Area 27, Cafeteria	52	2.03	0.86	0.12	0.13	4.63

DCG. Statistical analysis of the $^{239+240}$Pu results indicated that sampling stations could be broken down into three categories: "upper," "middle," and "lower" concentration levels. The Area 3 U3ah/at West station and several others were within the upper group. Results from two sampling stations appear within the middle group, and the remainder belong to the lower group. Further discussion can be found in Appendix A of Volume II.

Over 90 percent of all ^{238}Pu analysis results were below the limit of detection. A review of the data using statistical analysis methodology indicated that all the data fall within one group; that is, no set of results were different from any other set of results at the five percent significance level. The data and the statistical analysis are presented in Appendix A of Volume II.

The presence of plutonium on the NTS is primarily due to atmospheric tests and tests in which nuclear devices were detonated with high explosives (called "safety shots"). These tests spread low-fired plutonium in the eastern and northeastern areas of the NTS (see Section 2, Figure 2.3 for these locations). Two decades later, higher than normal levels of plutonium in the air are still detected in Areas 1, 2, 3, 7, 8, 9, 10, and 15. During cleanup efforts for these atmospheric safety shot sites at the Area 3 Bulk Waste Management Facility (BWMF), some of the ^{238}Pu and $^{239+240}$Pu becomes airborne. As such, elevated levels of plutonium have been detected around the Area 3 BWMF for several years. (The BWMF samples are designated as the Area 3, U3ah/at sampling sites in the data tables.)

GAMMA

The charcoal cartridges used to collect halogen gases and glass fiber filters used to collect particulate radiation were analyzed each week by gamma spectroscopy. The results from the gamma spectroscopy analyses are provided in Appendix A, Attachment A.4. The majority of the isotopes detected by gamma spectroscopy were naturally occurring in the environment (^{40}K, ^{7}Be, and members of the uranium and thorium series) and hence were not reported. Very few isotopes were detected which were not naturally occurring. Those isotopes which were detected in air samples are provided in Appendix A of Volume II along with statistical discussions. The non-naturally occurring isotopes in sample results were seen early in the year. In March a new validation procedure was adopted which screened out those results with counting errors in excess of a predetermined level. With the exception of naturally occurring radionuclides, no other gamma emitters were detected for the remainder of the year.

5.2.1.3 NOBLE GAS SAMPLING RESULTS

The locations at which compressed air samples were routinely collected throughout the year are shown in Figure 5.7 with the annual averages of the ^{85}Kr and ^{133}Xe analyses. All average concentrations were well below the DCG of 1 x 10^{-4} µCi/mL (3.7 x 10^{6} Bq/m^{3}) for each radionuclide.

5453

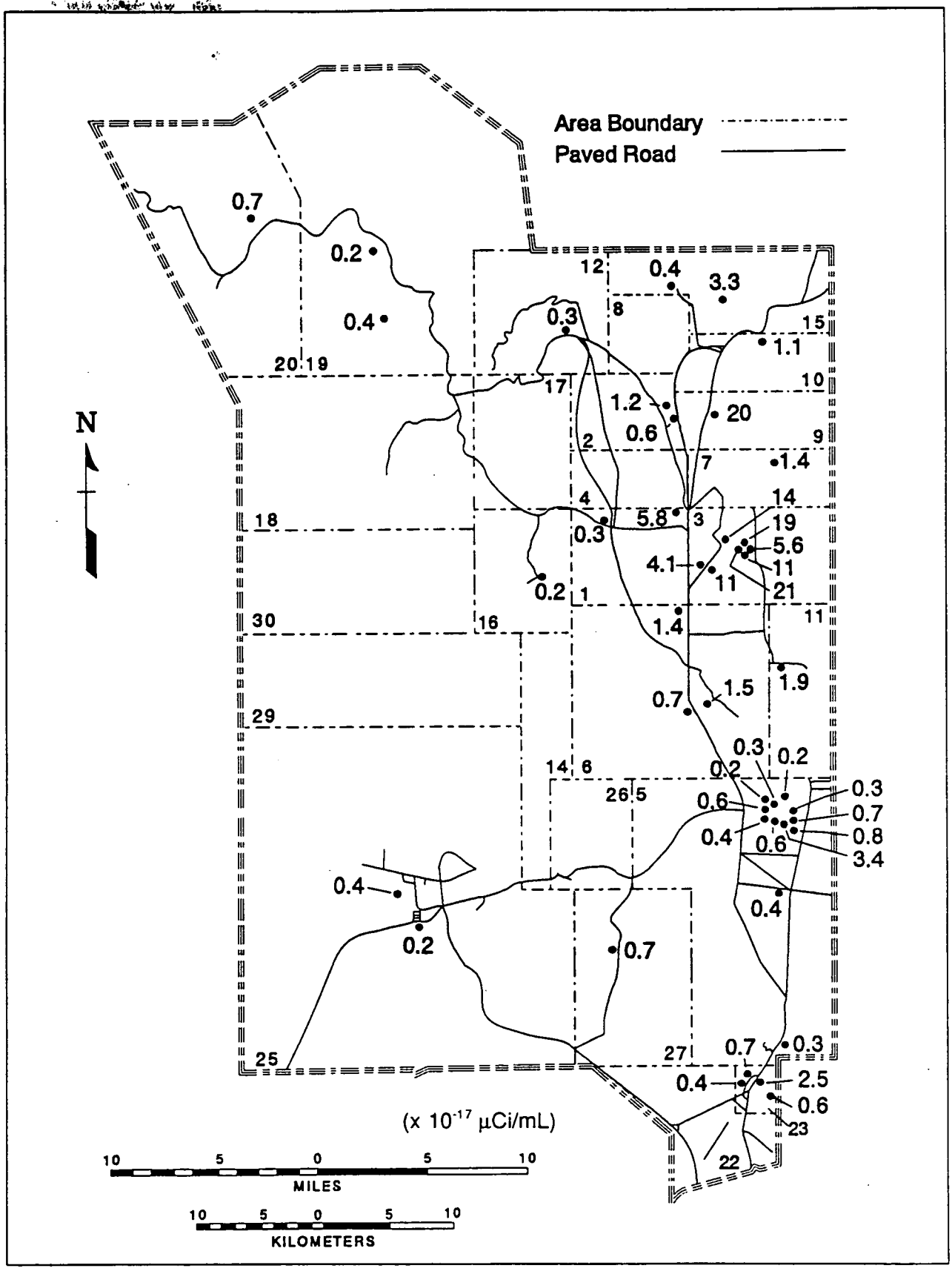


Figure 5.6 NTS Airborne $^{239+240}Pu$ Annual Average Results - 1990

146

5453

Table 5.6 Airborne $^{239+240}Pu$ Concentrations on the NTS - 1990

	$^{239+240}Pu$ Concentration x 10^{-18} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 1, BJY	12	58.0	56.0	16.2	-0.70	191
Area 1, Gravel Pit	12	2.58	2.72	0.79	-0.57	6.90
Area 2, 2-1 Substation	12	5.88	5.49	1.58	-0.54	19.3
Area 2, Complex	12	11.9	9.37	2.70	1.93	32.3
Area 3, 3-300 Bunker	12	143.7	112	32.3	34.2	408
Area 3, Complex	12	40.9	12.0	3.46	25.1	62.1
Area 3, Complex No. 2	12	110	81.2	23.4	15.7	328
Area 3, U3ah/at East	11	55.9	35.9	10.8	0.00	104
Area 3, U3ah/at North	12	189	175	50.6	55.1	679
Area 3, U3ah/at South	11	107	68.8	20.7	18.7	285
Area 3, U3ah/at West	12	209	170	49.1	44.2	565
Area 5, DOD Yard	12	1.96	1.94	0.56	-0.53	5.87
Area 5, Gate 200	11	3.23	5.60	1.69	-0.60	18.1
Area 5, RWMS No. 1	12	33.8	78.2	22.6	-0.50	271
Area 5, RWMS No. 2	12	8.04	14.7	4.25	-0.55	53.7
Area 5, RWMS No. 3	12	6.62	7.06	2.04	-0.48	19.7
Area 5, RWMS No. 4	12	2.93	4.16	1.20	-0.54	11.9
Area 5, RWMS No. 5	12	2.68	1.93	0.56	-0.48	6.23
Area 5, RWMS No. 6	12	2.26	2.12	0.61	-0.51	7.01
Area 5, RWMS No. 7	12	5.79	3.27	0.95	0.72	12.1
Area 5, RWMS No. 8	12	4.21	6.02	1.74	-0.49	21.9
Area 5, RWMS No. 9	12	5.50	5.08	1.47	-0.57	18.8
Area 5, RWMS Pit No. 3	12	1.86	3.00	0.87	-0.94	9.70
Area 5, RWMS Pit No. 4	12	4.63	3.65	1.05	0.55	14.2
Area 5, RWMS TP North	12	8.59	7.81	2.26	0.94	21.3
Area 5, RWMS TP Northeast	11	4.57	4.95	1.49	-0.51	15.4
Area 5, RWMS TP Northwest	12	5.70	7.97	2.30	-0.52	28.8
Area 5, RWMS TP South	12	7.72	6.23	1.80	-0.49	18.0
Area 5, RWMS TP Southeast	12	7.95	6.37	1.84	-0.50	19.7
Area 5, RWMS TP Southwest	12	5.07	5.26	1.52	-0.57	18.2
Area 5, Well 5B	11	3.91	6.30	1.90	-0.53	22.3
Area 6, CP-6	12	6.78	5.01	1.45	1.85	21.0
Area 6, Well 3 Complex	12	14.1	17.0	4.92	0.68	52.0
Area 6, Yucca Complex	12	14.6	9.81	2.83	-0.55	38.2
Area 7, Ue7ns	12	13.8	12.0	3.46	-0.83	40.6
Area 9, 9-300 Bunker	12	195	156	45.0	27.5	498
Area 10, Gate 700 South	12	11.4	10.8	3.12	0.74	42.5
Area 11, Gate 293	12	18.9	35.3	10.2	-0.50	107
Area 12, Complex	12	2.69	3.03	0.88	-2.55	10.4
Area 15, EPA Farm	12	33.2	40.8	11.8	3.70	151
Area 15, PILEDRIVER	12	4.03	4.49	1.30	-0.43	12.7
Area 16, 3545 Substation	12	2.00	1.83	0.53	-0.53	5.83
Area 19, Echo Peak	12	3.52	3.33	0.96	-0.62	11.0
Area 19, Pahute Substation	12	2.16	1.27	0.37	-0.52	3.92
Area 20, Dispensary	12	6.71	4.46	1.29	1.85	16.8
Area 23, Building 790	12	7.37	14.0	4.04	0.62	50.3
Area 23, Building 790 No. 2	12	3.93	3.62	1.05	-0.59	9.81
Area 23, East Boundary	12	5.59	9.64	2.78	0.00	34.9
Area 23, H&S Building Roof	12	24.9	69.5	20.1	-0.60	243

147

Table 5.6 (Airborne $^{239+240}$Pu Concentrations on the NTS - 1990, cont.)

	$^{239+240}$Pu Concentration x 10^{-18} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 25, E-MAD North	12	4.38	6.29	1.82	-0.63	18.2
Area 25, NRDS Warehouse	12	1.47	1.68	0.48	-0.68	4.34
Area 27, Cafeteria	12	7.16	11.5	3.32	-0.85	35.1

Table 5.7 Airborne ^{238}Pu Concentrations on the NTS - 1990

	^{238}Pu Concentration x 10^{-18} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 1, BJY	12	9.52	7.14	2.06	2.88	23.8
Area 1, Gravel Pit	11	6.68	7.29	2.20	-4.16	20.7
Area 2, 2-1 Substation	12	2.26	7.42	2.14	-11.4	12.0
Area 2, Complex	12	7.08	10.3	2.97	-11.4	31.0
Area 3, 3-300 Bunker	12	4.17	5.87	1.69	-6.72	14.7
Area 3, Complex	12	6.17	3.79	1.09	-1.98	12.0
Area 3, Complex No. 2	12	4.28	6.85	1.98	-12.2	14.1
Area 3, U3ah/at East	10	4.69	4.40	1.39	-3.45	11.0
Area 3, U3ah/at North	12	7.71	5.25	1.52	-0.76	16.2
Area 3, U3ah/at South	11	7.77	12.23	3.69	-25.2	19.1
Area 3, U3ah/at West	12	3.02	8.15	2.35	-12.1	13.2
Area 5, DOD Yard	12	4.42	4.05	1.17	-1.12	13.7
Area 5, Gate 200	11	-0.37	9.10	2.74	-26.8	6.91
Area 5, RWMS No. 1	12	1.32	5.16	1.49	-4.01	13.6
Area 5, RWMS No. 2	12	-2.12	14.41	4.16	-45.0	9.95
Area 5, RWMS No. 3	12	2.88	4.37	1.26	-3.83	8.94
Area 5, RWMS No. 4	11	-2.00	23.3	7.04	-70.4	11.6
Area 5, RWMS No. 5	12	3.98	5.18	1.50	-4.73	13.0
Area 5, RWMS No. 6	12	2.50	4.10	1.18	-3.18	11.9
Area 5, RWMS No. 7	12	0.58	6.35	1.83	-15.7	10.4
Area 5, RWMS No. 8	12	2.01	7.18	2.07	-15.1	11.2
Area 5, RWMS No. 9	12	6.33	6.25	1.80	-3.46	14.3
Area 5, RWMS Pit No. 3	11	3.75	6.06	1.83	-5.12	13.5
Area 5, RWMS Pit No. 4	12	3.60	5.18	1.49	-5.65	12.3
Area 5, RWMS TP North	12	2.53	1.82	0.53	0.12	5.04
Area 5, RWMS TP Northeast	10	1.69	3.61	1.14	-5.40	5.85
Area 5, RWMS TP Northwest	12	6.95	5.28	1.53	-1.16	18.8
Area 5, RWMS TP South	12	2.72	7.23	2.09	-12.6	14.1
Area 5, RWMS TP Southeast	12	4.62	8.25	2.38	-5.91	23.5
Area 5, RWMS TP Southwest	12	-0.08	28.0	8.09	-87.8	18.7
Area 5, Well 5B	10	4.67	6.14	1.94	-5.37	15.4
Area 6, CP-6	11	4.67	6.74	2.03	-2.68	17.2
Area 6, Well 3 Complex	12	5.22	4.08	1.18	-0.85	12.8
Area 6, Yucca Complex	12	2.85	5.89	1.70	-4.83	12.1
Area 7, Ue7ns	11	4.40	6.27	1.89	-5.75	15.4
Area 9, 9-300 Bunker	12	7.41	6.44	1.86	-6.05	19.9

5453

Table 5.7 (Airborne ^{238}Pu Concentrations on the NTS - 1990, cont.)

	^{238}Pu Concentration x 10^{-18} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 10, Gate 700 South	12	4.31	9.03	2.61	-13.17	17.5
Area 11, Gate 293	12	-1.96	17.2	4.96	-49.0	12.1
Area 12, Complex	12	0.99	15.4	4.43	-42.5	17.2
Area 15, EPA Farm	12	-1.85	11.6	3.35	-29.5	11.7
Area 15, PILEDRIVER	11	-3.69	24.9	7.50	-59.0	15.4
Area 16, 3545 Substation	12	3.58	4.44	1.28	-3.37	11.3
Area 19, Echo Peak	12	3.17	6.46	1.86	-7.39	15.0
Area 19, Pahute Substation	11	6.34	9.72	2.93	-4.62	20.9
Area 20, Dispensary	12	0.38	8.67	2.50	-22.7	10.2
Area 23, Building 790	12	2.14	12.28	3.54	-33.9	15.6
Area 23, Building 790 No. 2	12	-0.33	12.6	3.62	-34.3	17.0
Area 23, East Boundary	11	4.81	6.87	2.07	-5.49	16.3
Area 23, H&S Building Roof	11	4.88	7.03	2.12	-4.82	16.3
Area 25, E-MAD North	12	-0.13	8.96	2.59	-18.1	13.2
Area 25, NRDS Warehouse	12	6.05	6.42	1.85	-3.93	14.6
Area 27, Cafeteria	12	-1.16	3.99	1.15	-6.86	4.62

Summaries of the results are listed in Tables 5.8 and 5.11. All individual results are listed in Volume II, Appendix E. Due to the extended sampling that was required at the BARNWELL event site (U20az), the samplers normally at Area 25 E-MAD and Area 5 Gate 200 were used at that site from January through April.

As in the past, the levels of ^{85}Kr (half-life of 10.76 years) observed in the samples were from world-wide nuclear power and fuel processing operations, with some contribution of ^{85}Kr from underground nuclear tests at the NTS. Xenon-133 is not normally detected in the environment due to its short half-life of 5.27 days, so when any is detected it is usually attributed to nuclear testing operations at the NTS.

KRYPTON-85

A summary of all ^{85}Kr results appears in Table 5.8. An evaluation of the distributions of ^{85}Kr concentrations at each sampling location was performed to identify those values which were atypical, namely those which did not appear to be a part, statistically, of the ambient concentration of ^{85}Kr resulting from worldwide nuclear operations. From this evaluation, the ^{85}Kr values listed in Table 5.9 were found to be atypically high. When these and any atypically low values were omitted from the population of values measured for each sampling location, the data for each location appeared to be lognormally distributed.

A summary of the concentrations by location, after omission of the atypical values from the calculation of statistical parameters, is shown in Table 5.10. Again this year the highest annual average concentration of ^{85}Kr occurred at the Area 20 Dispensary, 29 x 10^{-12} µCi/mL (1.1 Bq/m^3), and the lowest occurred at the Area 25 E-MAD station, 21 x 10^{-12} µCi/mL (7.8 x 10^{-1} Bq/m^3). This is reasonable as the sampler at the Area 20 Dispensary is in the northern portion of the NTS in the proximity of the sites where seepage of noble gases from the ground has been observed in the past, whereas Area 25 E-MAD is in the southwestern portion of the NTS away from the test areas. The statistical evaluation of these data (Volume II, Appendix E) showed that the Area 20

149

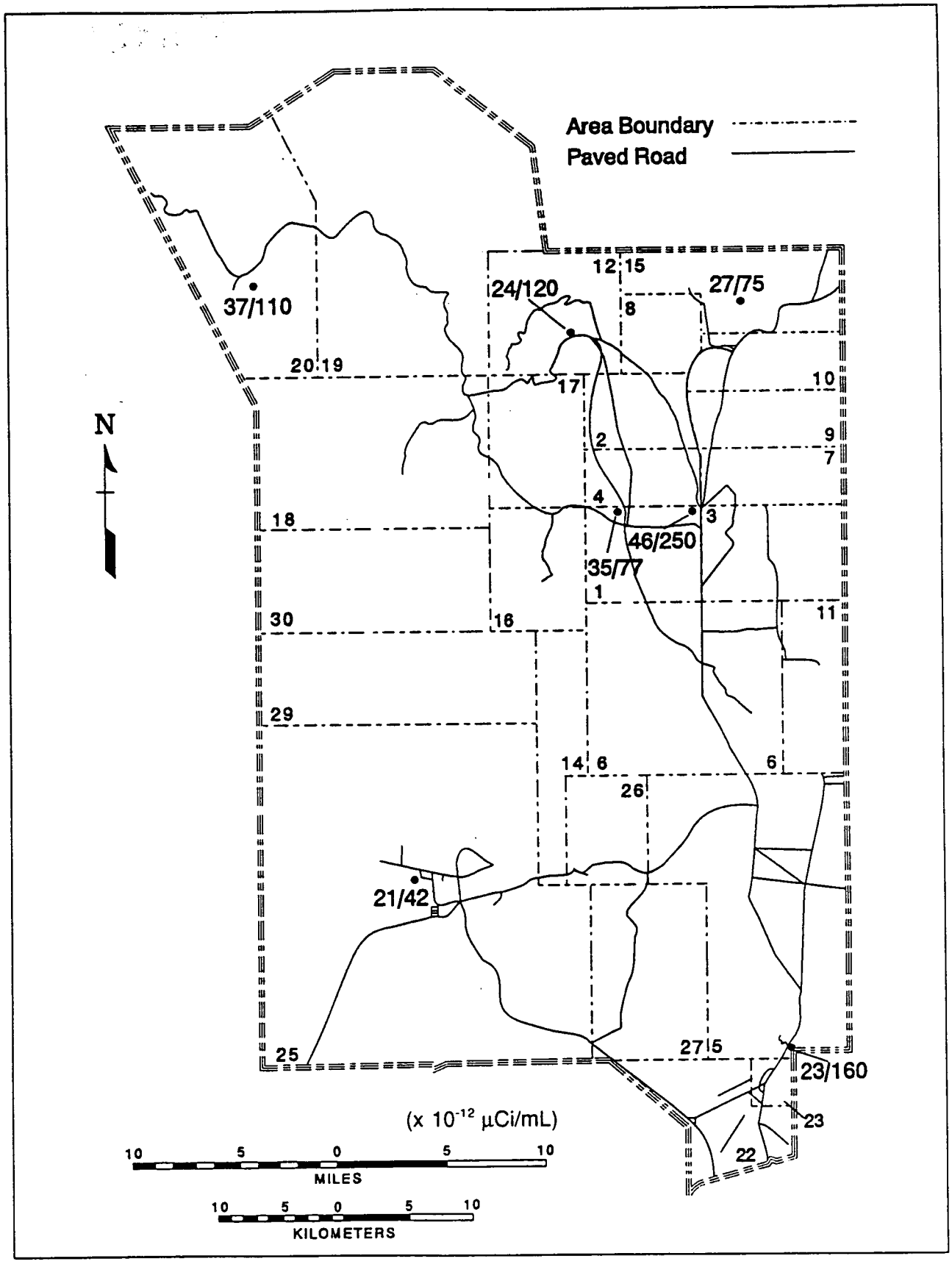


Figure 5.7 NTS $^{85}Kr/^{133}Xe$ Annual Average Concentrations - 1990

150

Table 5.8 Summary of All NTS ^{85}Kr Concentrations - 1990

Location	Number of Samples	^{85}Kr Concentration x 10^{-12} µCi/mL Minimum	Maximum	Average	1s
Area 1, BJY	44	13	660	46	100
Area 1, Gravel Pit	40	7.9	470	35	70
Area 5, Gate 200	27	13	38	23	6
Area 12, Camp	38	9.6	72	24	9.2
Area 15, PILEDRIVER	40	15	120	27	17
Area 20, Dispensary	41	8.3	170	37	32
Area 25, E-MAD	27	13	31	21	5
All Locations	257	7.9	660	32	53

Dispensary average concentration was significantly higher than the other averages at the five percent significance level.

XENON-133

The analytical results for ^{133}Xe are normally below the lower limit of detection of 10 x 10^{-12} µCi/mL (0.37 Bq/m^3) except for occasional detectable amounts due to seepage through the ground after tests. Table 5.11 summarizes the ^{133}Xe results for samples collected at each location. The highest average concentration was 2.50 x 10^{-10} µCi/mL (9.2 Bq/m^3) at BJY, which is near the testing sites, and the lowest average was 4.2 x 10^{-11} µCi/mL (1.6 Bq/m^3) at the Area 25 E-MAD station, which is

Table 5.9 Atypical NTS ^{85}Kr Concentrations - 1990

Location	Start	Stop	(^{85}Kr Conc. ± 1s) x 10^{-12} µCi/mL
Area 1, BJY	01/30/90	02/06/90	140 ± 2
	02/06/90	02/12/90	660 ± 10
	04/06/90	04/09/90	270 ± 3
Area 1, Gravel Pit	05/01/90	05/08/90	470 ± 3
Area 12, Camp	01/08/90	01/16/90	72 ± 2
	03/13/90	03/20/90	110 ± 5
Area 15, PILEDRIVER	03/06/90	03/13/90	120 ± 2
Area 20, Dispensary	12/26/89	01/02/90	160 ± 2
	01/02/90	01/08/90	96 ± 2
	05/14/90	05/22/90	170 ± 3

Table 5.10 Summary of 1990 NTS ^{85}Kr Concentrations with Atypical Values Omitted

Location	Number of Samples	^{85}Kr Concentration x 10^{-12} µCi/mL Minimum	Maximum	Average	1s
Area 1, BJY	41	13	38	23	4
Area 1, Gravel Pit	37	11	54	25	8
Area 5, Gate 200	26	13	38	23	6
Area 12, Camp	34	18	31	24	4
Area 15, PILEDRIVER	39	15	44	24	7
Area 20, Dispensary	37	15	54	29	9
Area 25, E-MAD	27	13	31	21	5
All Locations	241	11	54	24	7

further removed to the southwest from the testing sites.

A statistical evaluation of the ^{133}Xe data is contained in Appendix E. From this evaluation, the concentrations were found to be lognormally distributed. Most values were near the detection limit with a few high and some intermediate values occurring throughout the year. All of the detectable xenon concentrations were attributed to underground nuclear tests at the NTS.

5.2.1.4 TRITIATED WATER VAPOR SAMPLING RESULTS

The annual average concentration of tritiated water vapor from sampling conducted at 17 permanent sampling locations was (6.9 ± 11) x 10^{-12} µCi/mL ([2.6 ± 4.1] x 10^{-1} Bq/m^3). This concentration was 0.007 percent of the DCG. The annual averages of the stations are shown in Figure 5.8. Statistical analysis of the data indicated that the concentrations of ^3H in air may be considered to fall into

Table 5.11 Summary of NTS ^{133}Xe Concentrations - 1990

Location	Number of Samples	^{133}Xe Concentration x 10^{-12} µCi/mL Minimum	Maximum	Average	1s
Area 1, BJY	44	-51	9000	250	1300
Area 1, Gravel Pit	44	-24	1000	77	170
Area 5, Gate 200	28	-39	2300	160	460
Area 12, Camp	42	-66	3400	120	500
Area 15, PILEDRIVER	41	-69	730	75	160
Area 20, Dispensary	45	-49	2800	110	420
Area 25, E-MAD	28	-45	350	42	78
All Locations	272	-69	9000	120	630

5458

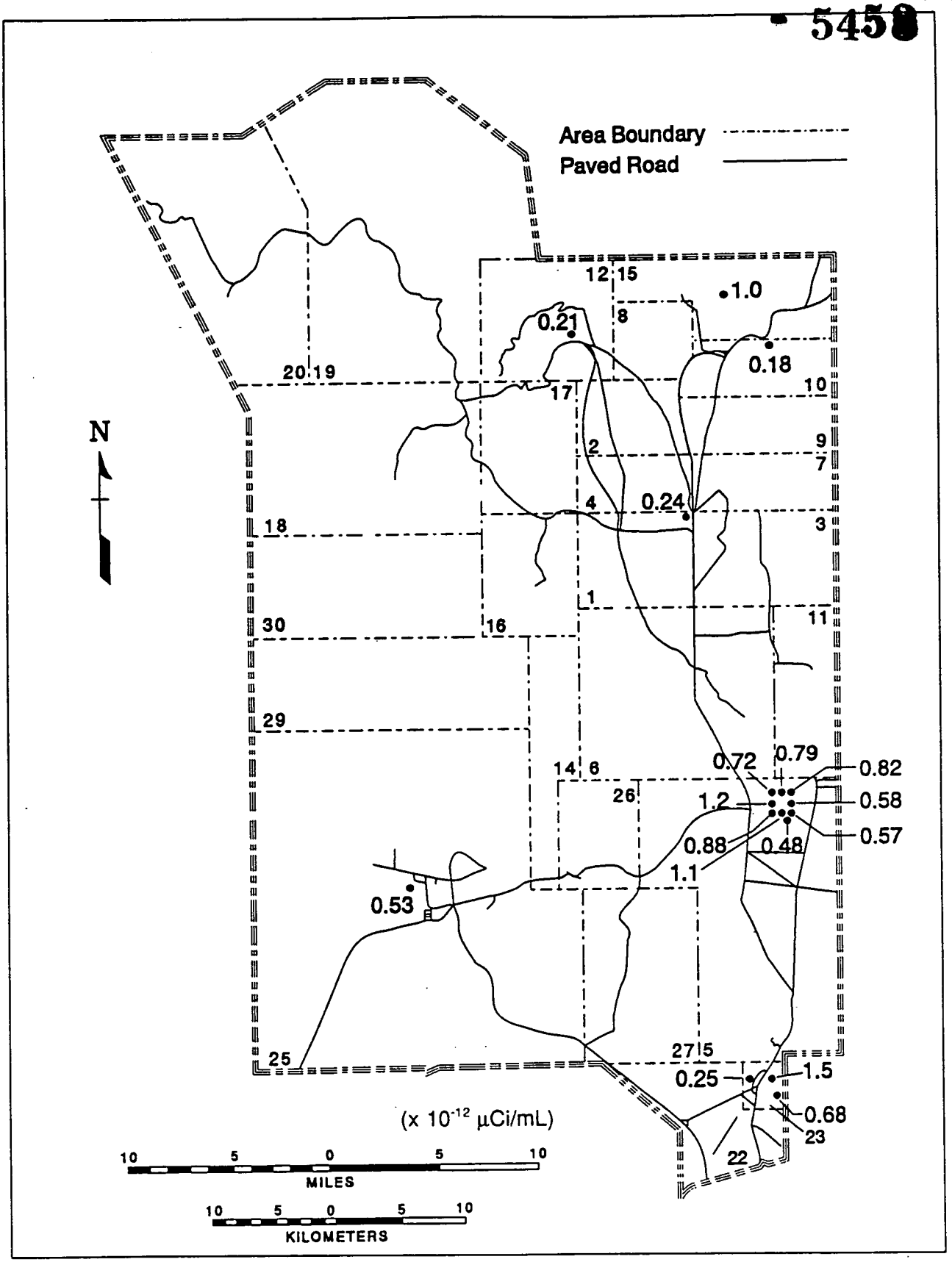


Figure 5.8 NTS Tritiated Water Vapor Annual Average Concentrations - 1990

153

three overlapping groups. The "upper" group (that group which contained the comparatively higher average concentrations) was mostly comprised of the data from the Area 5 RWMS stations. The upper group average differed from the "lower" group by less than one order of magnitude, so all of the results were distributed about the overall Site-wide mean as is indicated from the reported standard deviation. Each of these locations was sampled continuously for a two-week period. Table 5.12 lists the maximum, minimum, and annual average concentration for each tritiated water vapor sampling location. Volume II, Appendix B, "Onsite Tritium in Air," Table B.1, lists the measurement results for each location.

5.2.1.5 RADIOACTIVITY IN SURFACE WATER

Surface water sampling at the NTS was conducted at 15 open reservoirs, 7 natural springs, 10 containment ponds, and 3 sewage lagoons. A grab sample was taken each month from each surface water location. The sample was analyzed for ^{3}H, gross beta, and gamma activity. Each quarter an additional sample was collected and analyzed for ^{238}Pu and $^{239+240}Pu$, and in July a sample was collected for ^{90}Sr analysis. Gamma results for all sample locations indicated that radionuclide levels were consistently below the detection limit except for samples from the containment ponds. The data from the containment ponds are shown in Volume II, Appendix C, Attachments C.1 through C.7. Surface water at the NTS was scarce during 1990 because of the continuing drought. Sources of surface water were, for the most part, man-made, created for or by NTS operations. There is no known human consumption of any surface water on the NTS.

Tritium, gross beta, and gamma analyses were performed for each monthly sample, ^{238}Pu and $^{239+240}Pu$ analyses were performed quarterly, and ^{90}Sr analyses were performed annually.

Table 5.12 Airborne Tritium Concentrations on the NTS - 1990

	^{3}H Concentration x 10^{-12} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 1, BJY	24	2.38	1.96	0.40	0.42	7.37
Area 5, RWMS No. 1	24	4.82	3.40	0.69	1.12	12.9
Area 5, RWMS No. 2	23	5.72	2.79	0.58	2.56	14.0
Area 5, RWMS No. 3	20	5.79	3.08	0.69	1.85	13.6
Area 5, RWMS No. 4	23	8.51	8.18	1.67	2.50	34.7
Area 5, RWMS No. 5	24	7.93	4.79	0.98	2.13	24.0
Area 5, RWMS No. 6	22	7.52	4.59	0.96	3.00	21.2
Area 5, RWMS No. 7	22	11.7	10.90	2.32	0.89	44.3
Area 5, RWMS No. 8	22	9.14	8.86	1.85	2.00	32.8
Area 5, RWMS No. 9	22	11.4	11.2	2.33	1.60	43.0
Area 10, Gate 700 South	23	1.77	2.65	0.55	-0.02	13.0
Area 12, Complex	20	2.05	1.01	0.23	0.59	3.99
Area 15, EPA Farm	24	10.4	4.85	0.99	2.50	22.9
Area 23, Building 790 No. 2	22	2.46	2.55	0.54	-0.14	8.59
Area 23, East Boundary	19	7.16	18.2	4.08	-0.0004	82.4
Area 23, H&S Bldg. Roof	22	15.3	32.3	6.88	-0.14	135.
Area 25, E-MAD North	21	5.52	5.79	1.23	-0.05	21.4

The annual average for each isotope analyzed is presented and compared to the DCG for ingested water. The one exception is the containment ponds, which are not compared to ingested water permissible concentrations. All sampling results are presented in tabular form beginning with Appendix C, Attachment C.1. In each appendix table, the result and corresponding one standard deviation (1s) counting error are presented. Any station which was determined to be statistically different from the average was noted and discussed.

With the exception of containment ponds, no single annual average of any sampling location in surface waters was found to be statistically different from any other at the five percent significance level. The analytical results from containment ponds showed measurable quantities of radioactivity and displayed identifiable trends. The following sections report statistical summary data for all surface water sampling locations.

OPEN RESERVOIRS

Open reservoirs have been established at various locations on the NTS for industrial uses. Comparisons of the annual average concentrations of radioactivity were made to the DCGs for ingested water listed in DOE Order 5400.5, even though there was no known consumption of these waters.

Gross Beta

The location of each open reservoir sampled is shown in Figure 5.9 along with its annual average gross beta concentration level. The annual average beta concentration for all open reservoirs was 8.3 x 10^{-9} µCi/mL (0.31 Bq/L). This beta concentration is 0.12 percent of the ^{40}K DCG for ingested water. None of the reservoirs were found to be different from the annual average at the five percent significance level. Table 5.13 includes a list of the 1990 annual averages for each monitored location. Appendix C, Attachment C.5, contains the individual data results. Statistical analyses of results from open reservoir samples are presented in Appendix C.

5453

Tritium

The annual average concentration of ^{3}H in open reservoirs during 1990 was 4.8 x 10^{-8} µCi/mL (1.8 Bq/L). This concentration was 0.002 percent of the DCG for ^{3}H. No single sampling location displayed an annual average different at the five percent significance level from the network annual average for ^{3}H. The individual results are listed in Appendix C, Attachment C.7, and a statistical discussion is presented at the beginning of Appendix C.

Plutonium

The annual average concentration of $^{239+240}$Pu for all open reservoirs was 1.3 x 10^{-11} µCi/mL (4.8 x 10^{-4} Bq/L). This annual average was 0.04 percent of the DCG for ingested water. None of the annual averages from any sampling location was different from the network average at the five percent significance level. All individual sampling results are tabulated in Appendix C, Attachment C.4.

The network annual average for ^{238}Pu was 1.9 x 10^{-11} µCi/mL (7 x 10^{-4} Bq/L). This value was 0.05 percent of the DCG for ^{238}Pu in potable water. None of the open reservoir annual averages was statistically different from the network average at the five percent significance level. All individual results are presented in Appendix C, Attachment C.3. Statistical analyses results appear at the beginning of Appendix C.

Strontium

The annual average concentration of ^{90}Sr for all open reservoirs was -1.1 x 10^{-10} µCi/mL (-4.1 x 10^{-3} Bq/L). (When analysis of a sample yields a result that is less than the background activity, subtraction of background from that result yields a negative number. This process is statistically

5458

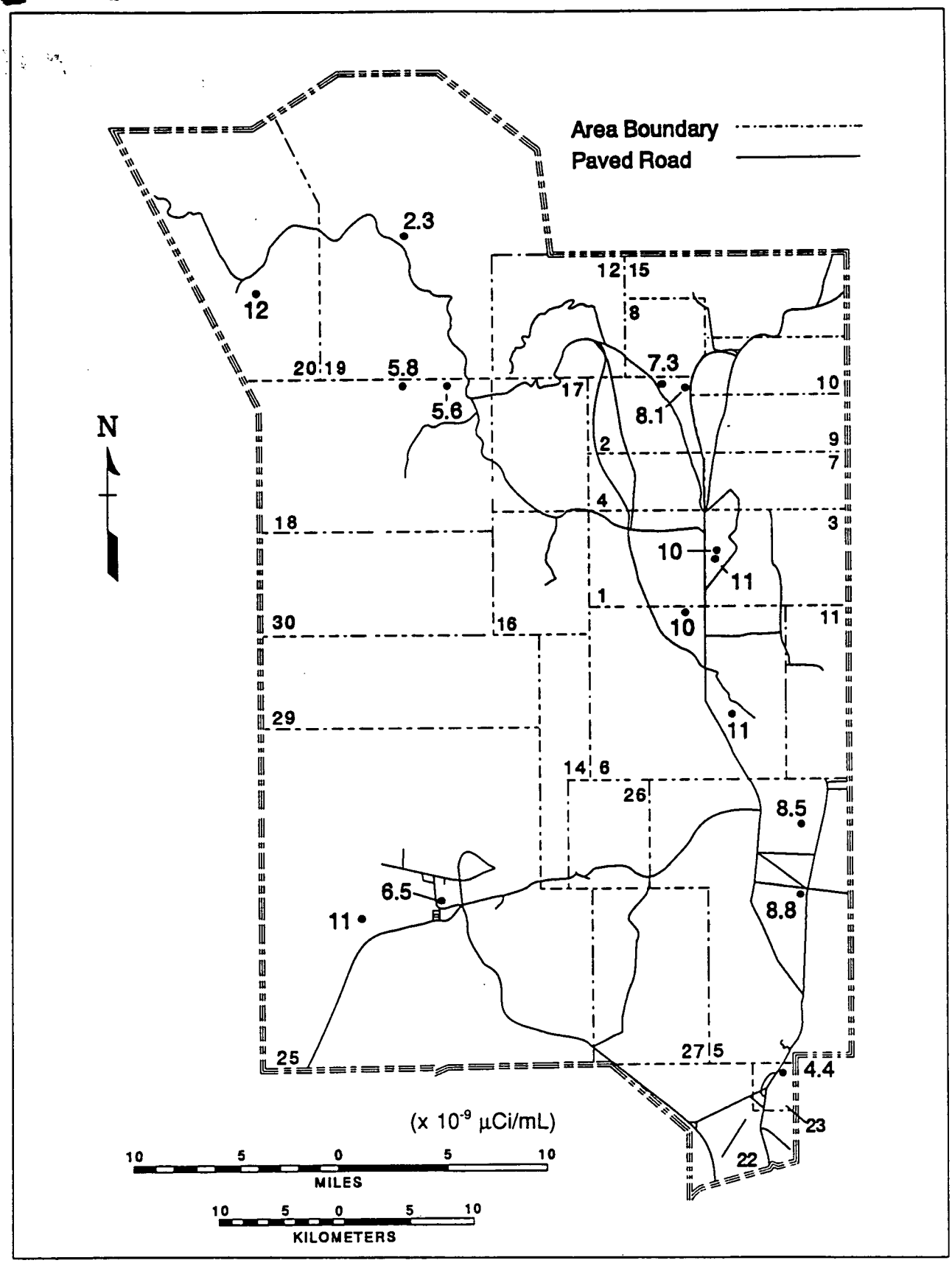


Figure 5.9 NTS Open Reservoir Annual Average Gross Beta Concentrations - 1990

156

Table 5.13 NTS Open Reservoir Gross Beta Analysis Results - 1990

- 5458

Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
	Gross Beta Concentration x 10^{-9} µCi/mL					
Area 2, Mud Plant Reservoir	12	8.09	1.16	0.34	6.65	10.4
Area 2, Well 2 Reservoir	12	7.29	1.70	0.49	3.76	9.39
Area 3, Mud Plant Reservoir	12	11.2	1.62	0.47	8.78	14.1
Area 3, Well A Reservoir	12	10.4	2.63	0.76	6.82	15.6
Area 5, Ue5c Reservoir	13	8.46	1.68	0.47	5.73	12.4
Area 5, Well 5B Reservoir	12	8.83	0.80	0.23	7.94	10.0
Area 6, Well 3 Reservoir	12	10.4	4.30	1.24	0.99	18.0
Area 6, Well C1 Reservoir	12	11.3	3.29	0.95	5.52	17.6
Area 18, Camp 17 Reservoir	12	5.64	3.80	1.10	1.85	16.8
Area 18, Well 8 Reservoir	7	5.76	2.48	0.94	3.12	9.77
Area 19, Well U19c Reservoir	12	2.33	1.97	0.57	0.73	7.94
Area 20, Well 20A Reservoir	12	12.0	9.87	2.85	0.66	31.2
Area 23, Swimming Pool	10	4.38	1.63	0.51	1.91	6.75
Area 25, Well J-11 Reservoir	12	6.54	0.61	0.18	5.33	7.50
Area 25, Well J-12 Reservoir	13	10.5	10.4	2.87	3.88	33.8

probable when the activity of the radionuclide in the sample is less than the detection capability of the counting equipment. The annual average for several sample results can therefore be positive or negative.) This concentration was less than zero percent of the ^{90}Sr DCG for ingested water. None of the results from sampled locations were determined to be statistically different at the five percent significance level from the network average. All individual sampling results are tabulated in Appendix C, Attachment C.1, Volume II.

NATURAL SPRINGS

Of the nine natural springs found onsite, seven were consistently sampled. The term *natural springs* was a label given to the spring-supplied pools located within the NTS. Water from all of the springs was consumed by wild animals.

Gross Beta

The locations of all natural springs sampled are shown in Figure 5.10 along with the annual average gross beta results. The annual average gross beta concentration for all samples collected from natural springs was 2.4 x 10^{-8} µCi/mL (0.89 Bq/L), which is 0.34 percent of the ^{40}K DCG. None of the gross beta annual averages from natural springs were determined to be statistically different from the network average at the five percent significance level.

Table 5.14 presents a list of the gross beta averages at each natural spring sampling location. Appendix C, Attachment C.5, displays the individual sampling results. Statistical analyses are presented in at the beginning of Appendix C.

Tritium

The network annual average ^{3}H from samples taken at seven natural springs was 8.5 x 10^{-8} µCi/mL (3.2 Bq/L), which was 0.004 percent of the DCG for ^{3}H in drinking water.

As with the ^{3}H results from open reservoirs, most of the sampling results from natural springs were not significantly different from the network average at the five percent

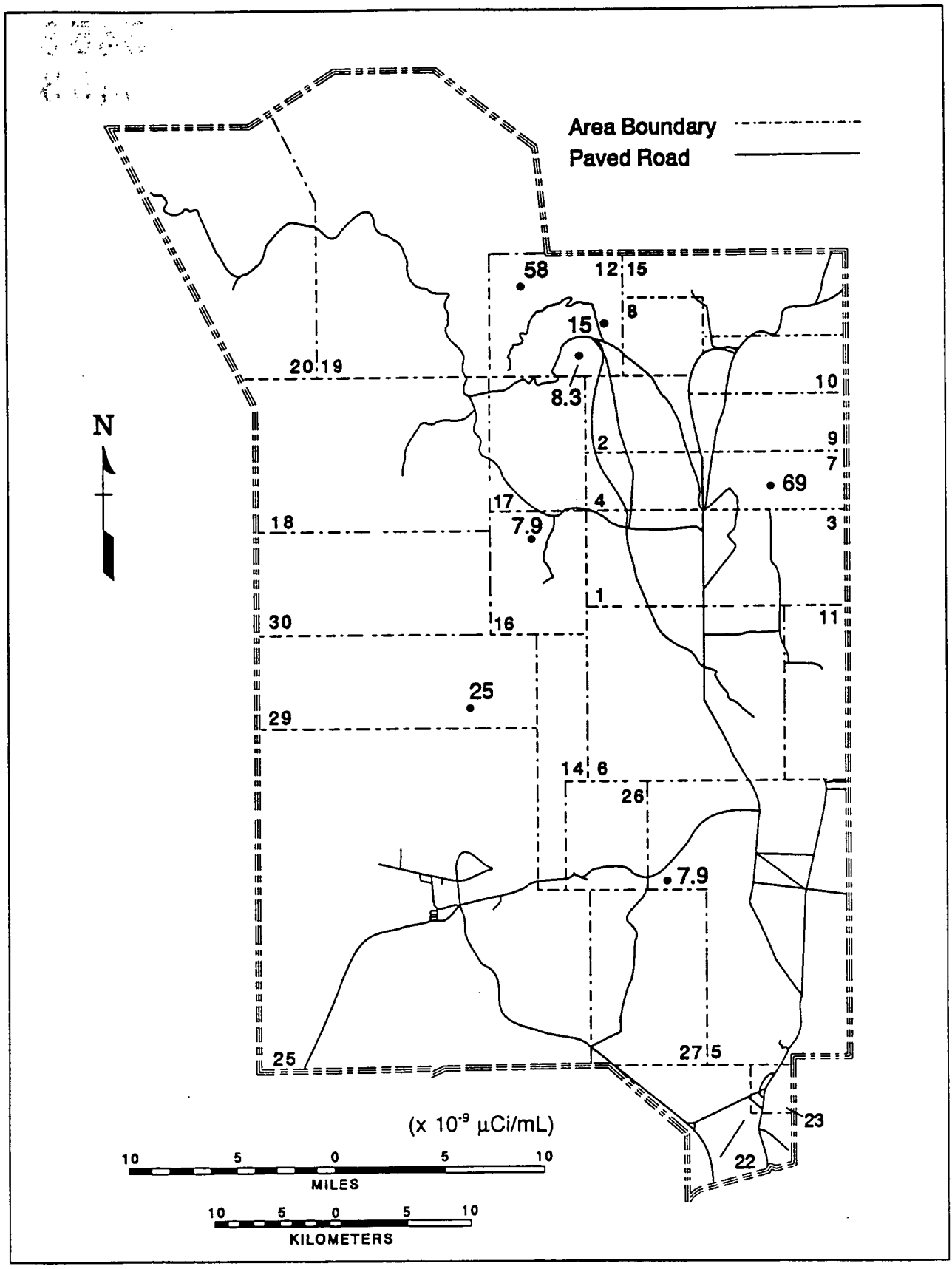


Figure 5.10 NTS Natural Spring Annual Average Gross Beta Concentrations - 1990

5453

Table 5.14 NTS Natural Spring Gross Beta Analysis Results - 1990

	Gross Beta Concentration x 10^{-9} µCi/mL					
Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
Area 5, Cane Spring	12	7.91	2.30	0.66	5.59	14.4
Area 7, Reitmann Seep	12	68.5	64.3	18.6	16.6	253
Area 12, Captain Jack Spring	9	8.26	1.59	0.53	5.27	10.9
Area 12, Gold Meadows	3	57.9	46.1	26.6	30.4	111
Area 12, White Rock Spring	12	14.7	6.86	1.98	3.47	26.4
Area 16, Tippipah Spring	12	7.94	9.12	2.63	-4.17	35.0
Area 29, Topopah Spring	9	24.9	31.3	10.4	7.90	105.

significance level. The individual results are listed in Appendix C, Attachment C.7. The beginning of Appendix C contains the results of statistical analysis.

Plutonium

The annual average concentration of $^{239+240}$Pu for all natural springs was 5.4 x 10^{-11} µCi/mL (2.0 x 10^{-3} Bq/L). This annual average was 0.18 percent of the $^{239+240}$Pu DCG for ingested water. A number of sample results from spring water (Reitmann Seep in Area 7, for example) displayed results abnormally high in plutonium when compared to the historical data from these springs. One possible reason for the abnormal results is that several water samples were uncharacteristically muddy, very high in dissolved solids. This was directly attributable to the continuing drought which reduced the water seeping from the springs to a very low rate. To obtain sufficient sample for all of the required analyses, it is sometimes necessary to dig into the area. Therefore, the plutonium detected in these samples is more likely from sediment in the water which was contaminated from safety shots and atmospheric nuclear tests in the 1950s and 1960s. One sample result from Reitmann Seep was not included in the network average for the reason cited. Further discussion of results may be found in the statistical evaluation of the data in Appendix C of Volume II. Individual sample results are listed in Attachment C.4 of Volume II, Appendix C.

The network annual average for ^{238}Pu was 2.2 x 10^{-11} µCi/mL (8.1 x 10^{-4} Bq/L). This annual average was 0.06 percent of the ^{238}Pu DCG for ingested water. None of the sampling results were statistically different (at the five percent significance level) from the network average. All individual results are presented in Appendix C, Attachment C.3 of Volume II.

Strontium

The annual average concentration of ^{90}Sr for four of the natural springs was 1.2 x 10^{-10} µCi/mL (4.4 x 10^{-3} Bq/L). This concentration was 0.01 percent of the ^{90}Sr DCG for ingested water. Not all samples could be collected from two springs due to the low volume of water. These were the Area 12 Gold Meadows and Area 29 Topopah Spring sampling points. The sample taken at Reitmann Seep again displayed abnormal results (the plutonium sample and the strontium sample were taken the same day). This result was not included in the network average. Discussion of these data is found in Appendix C, Volume II, and individual results may be found in Attachment C.1 following the statistical analysis.

CONTAINMENT PONDS

Ten containment ponds were sampled on a monthly basis. These ponds were impounded waters from tunnel test areas (including the effluent liquid as it is

159

discharged from the tunnel), a contaminated laundry release point, and effluent from the Mercury Building 650 Radiological Laboratory drains. All active containment ponds were fenced, restricted access areas posted with radiological warning signs. The average gross beta concentration for each containment pond location is shown in Figure 5.11. At each tunnel complex, sampling was conducted at all active containment ponds and at the effluent discharge point. The Area 6 Decontamination Facility containment pond was grab sampled once per month. All samples taken from these sources were analyzed for ^{3}H, ^{238}Pu, $^{239+240}Pu$, gross beta, and gamma activity. The annual average of gross beta analyses from each sampling location is listed in Table 5.15. All data and statistical analyses are listed in Appendix C, Attachments C.1 through C.7.

T Tunnel

The annual average ^{3}H concentration in samples taken from two sequential containment ponds at the Area 12 T Tunnel complex was 6.1 x 10^{-3} µCi/mL (2.3 x 10^{5} Bq/L). Gross beta activity from samples taken at the same locations averaged 3.4 x 10^{-7} µCi/mL (12.6 Bq/L) during 1990, while annual concentrations of ^{238}Pu and $^{239+240}Pu$ averaged 8.4 x 10^{-11} (3.1 x 10^{-3} Bq/L) and 8.1 x 10^{-10} µCi/mL (3 x 10^{-2} Bq/L), respectively. The annual average ^{90}Sr concentration was 2.6 x 10^{-9} µCi/mL (9.6 x 10^{-2} Bq/L).

N Tunnel

The ^{3}H and gross beta annual average concentrations from samples taken from three containment ponds at the Area 12 N Tunnel complex were 4.2 x 10^{-4} and 4.6 x 10^{-8} µCi/mL (1.6 x 10^{4} and 1.7 Bq/L), respectively. Concentrations of $^{239+240}Pu$ and ^{238}Pu averaged 5.5 x 10^{-11} and 2.1 x 10^{-11} µCi/mL (2 x 10^{-3} and 7.8 x 10^{-4} Bq/L), respectively, during 1990. The annual average ^{90}Sr concentration was -1 x 10^{-9} µCi/mL (0 Bq/L).

E Tunnel

Because very little water discharged from the Area 12 E Tunnel complex, there was not enough water in the containment ponds to sample during 1990. Therefore, sampling was conducted at the tunnel effluent discharge to the pond. The ^{3}H annual average concentration from samples taken of E Tunnel effluent was 1.5 x 10^{-3} µCi/mL (5.6 x 10^{4} Bq/L). The annual average beta activity from samples taken at this site was 1.6 x 10^{-7} µCi/mL (5.9 Bq/L). Concentrations of $^{239+240}Pu$ and ^{238}Pu averaged 9.4 x 10^{-9} and 1.6 x 10^{-9} µCi/mL (0.35 and 5.9 x 10^{-2} Bq/L), respectively.

Area 6 Decontamination Facility Pond

During the decontamination of equipment at the Area 6 Decontamination Facility, the water used may become contaminated with various radionuclides. The water used during 1990 for decontamination was discharged into a nearby fenced and posted containment pond. A grab sample was taken and analyzed once per month. The annual average concentration of ^{3}H from these grab samples was 7.5 x 10^{-7} (28 Bq/L), while beta activity averaged 2.8 x 10^{-7} µCi/mL (10 Bq/L) during 1990. Annual averages of ^{238}Pu and $^{239+240}Pu$ from samples taken at this pond were 3.2 x 10^{-11} and 8.3 x 10^{-11} µCi/mL (1.2 x 10^{-3} and 3.1 x 10^{-3} Bq/L), respectively.

Radionuclide Migration Study Pond

At the Area 5 U5eRNM2S migration research well, a monthly grab sample was taken and analyzed for ^{3}H. The U5eRNM2S well was part of a radionuclide migration through groundwater study, which is discussed in Section 5.1.2 under "Radionuclide Migration Project."

H&S Sump

The ^{3}H and gross beta annual average concentrations from samples taken from the REECo Radiological Laboratory discharge were 4.6 x 10^{-8} µCi/mL (1.7 Bq/L) and 6.0 x

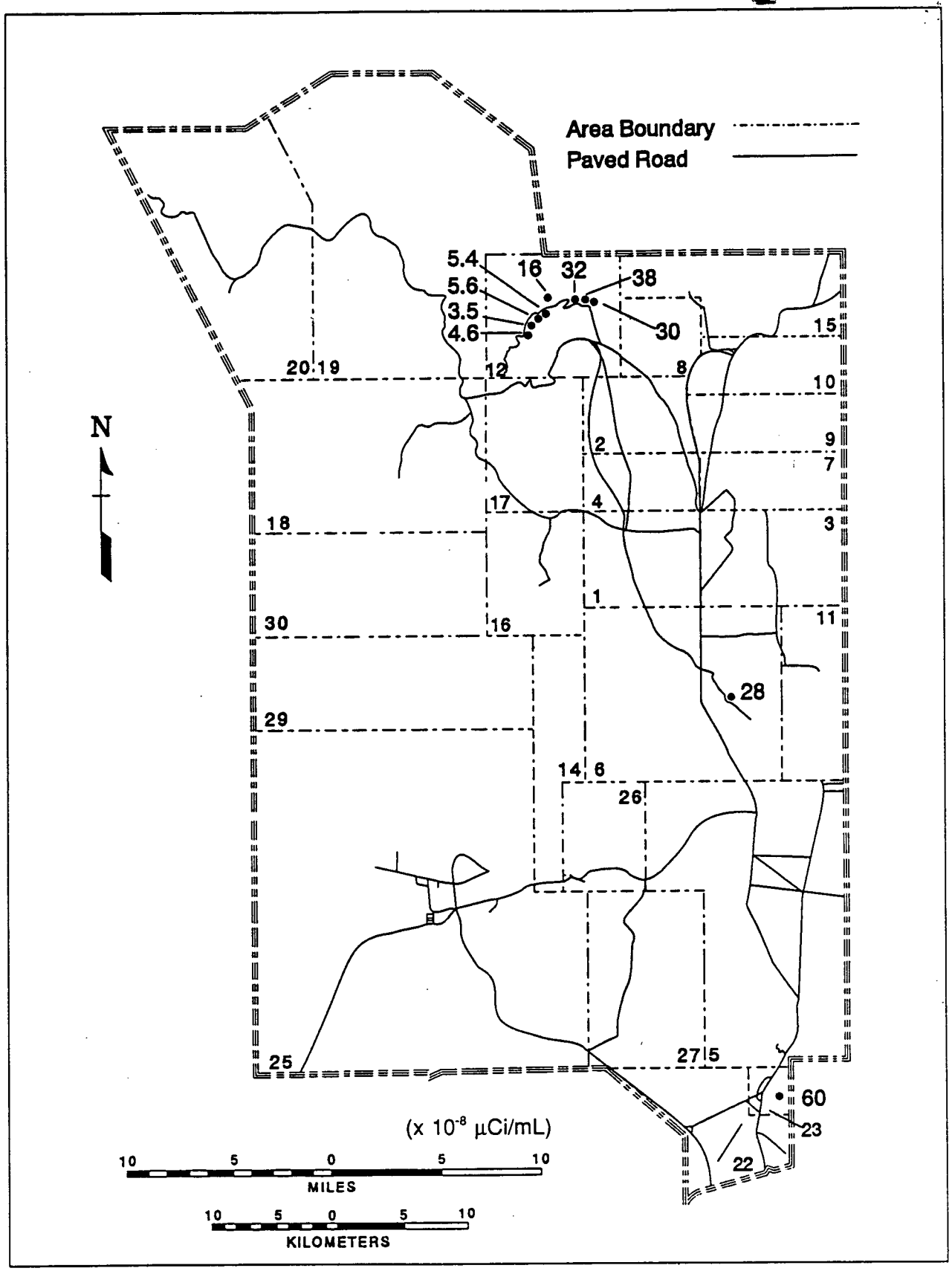


Figure 5.11 NTS Containment Pond Annual Average Gross Beta Concentrations - 1990

Table 5.15 NTS Containment Pond Gross Beta Analysis Results - 1990

Location	Number	Arithmetic Mean	Standard Deviation (1s)	Standard Error of the Mean	Minimum	Maximum
	Gross Beta Concentration x 10^{-9} µCi/mL					
Area 6, Decontamination Facility Pond	12	281	515	149	58.0	1900
Area 12, E Tunnel Effluent	12	161	146	42.3	57.8	611
Area 12, N Tunnel Effluent	12	53.6	102	29.6	-26.9	371
Area 12, N Tunnel Pond No. 1	12	56.2	86.0	24.8	10.0	323
Area 12, N Tunnel Pond No. 2	12	34.7	28.8	8.31	10.0	111
Area 12, N Tunnel Pond No. 3	12	46.1	73.3	21.2	0.60	272
Area 12, T Tunnel Effluent	12	322	52.0	15.0	258	432
Area 12, T Tunnel Pond No. 2	12	301	49.5	14.3	231	354
Area 12, T Tunnel Pond No. 1	12	383	250	72.0	210	1130
Area 23, H&S Sump	3	600	1010	582	15.0	1760

10^{-7} µCi/mL (22 Bq/L), respectively. Because very little water was discharged from the laboratory drains, there was not enough water in 1990 to sample for ^{238}Pu, $^{239+240}$Pu, and ^{90}Sr.

SEWAGE LAGOONS

Samples from three sewage lagoons were collected during 1990. These lagoons are part of a closed system used for evaporative treatment of sanitary waste. They are located in Areas 6, 12, and 23. There was no known contact by the working population during 1990.

The ^{3}H annual average of four quarterly samples taken at the lagoons was 2.4 x 10^{-7} µCi/mL (8.9 Bq/L). The annual average gross beta concentration was 2.6 x 10^{-8} µCi/mL (0.96 Bq/L). Annual averages of $^{239+240}$Pu and ^{238}Pu were 1.5 x 10^{-12} and 5.8 x 10^{-12} µCi/mL (5.6 x 10^{-5} and 2.1 x 10^{-4} Bq/L), respectively. The annual average ^{90}Sr concentration was 1.0 x 10^{-10} µCi/mL (3.7 x 10^{-3} Bq/L). No station was determined to be statistically different at the five percent significance level from the overall annual sewage lagoon average for any analyses result. All sampling results for sewage lagoons are presented in Appendix C, Attachments C.1 through C.7. Statistical discussions of these data are provided at the beginning of Appendix C.

5.2.1.6 RADIOACTIVITY IN GROUNDWATER

The principal water distribution system on the NTS is the potential critical pathway for the ingestion of waterborne radionuclides. Consequently, the water distribution system is sampled and evaluated frequently. The NTS water system consists of 14 supply wells, 9 of which supply potable water to onsite distribution systems. The drinking water is pumped from the wells to the points of consumption. The supply wells are generally sampled on a monthly basis. Occasionally, some operational problems interrupt the sampling schedule. All drinking water is sampled weekly to provide a constant check of the end-use activity and to allow frequent comparisons to the radioactivity of the water in the supply wells. This section examines results from samples taken at the 14 supply wells, which furnished the water for consumption and industrial use at the NTS during 1990. Well C1 in Area 6 was shut down during January 1990 and again in April 1990 for pump removal. Well Ue5c in Area 5 was shut down in January 1990 due to the proximity of a previous event, though it continues to be sampled on

a monthly basis for environmental surveillance purposes. All other wells functioned continuously during 1990.

Each monthly sample was analyzed for ^{3}H, gross beta, and gamma activity. An extra sample was taken each quarter and analyzed for ^{238}Pu, $^{239+240}Pu$, and gross alpha activity. A sample was collected in July and analyzed for ^{90}Sr. Annual average results are presented for each analyses conducted on groundwater samples. (Statistical comparisons of the ^{3}H data in this table and the EPA data in Table 5.26 are not considered valid or meaningful since the laboratory analytical procedures used for the two data groups are different and produce different minimum detectable concentration [MDC] levels.)

SUPPLY WELLS

Water from 14 supply wells (shown in Figure 5.12) was used for a variety of purposes during 1990. Samples were collected from those wells which could potentially provide water for onsite human consumption. These data were used to help document the radiological characteristics of the NTS groundwater system. The sample results were maintained in a data base so that long-term trends and changes could be studied. Table 5.16 lists the supply wells and their respective sampling stations. Individual sampling results are presented in Appendix C, Attachments C.1 through C.7, and statistical discussions of the samples may be found at the beginning of the appendix.

Gross Beta

The network average gross beta activity for supply wells was 8.6 x 10^{-9} µCi/mL (0.32 Bq/L), which was 0.12 percent of the DCG for ^{40}K and 0.86 percent of the DCG for ^{90}Sr. In previous reports (Scoggins 1983 and Scoggins 1984), it was shown that the majority of gross beta activity was attributable to naturally occurring ^{40}K. The gross beta annual averages are shown at their respective supply well sampling locations in Figure 5.12.

Tritium

There were no supply well stations which displayed annual average concentrations different at the five percent significance level from the network annual average ^{3}H concentration of 8.5 x 10^{-8} µCi/mL (3.2 Bq/L). This annual average was 0.4 percent of the drinking water regulations for ^{3}H. The annual ^{3}H averages for supply well stations are shown in Table 5.16.

Plutonium

The annual average network $^{239+240}Pu$ concentration of 5.0 x 10^{-12} µCi/mL (1.9 x 10^{-4} Bq/L) was 0.02 percent of the DCG for this radionuclide. The annual average ^{238}Pu concentration of 2.0 x 10^{-11} µCi/mL (7.4 x 10^{-4} Bq/L) was 0.05 percent of the DCG. The annual averages for these radionuclides are shown in Table 5.16.

Gross Alpha

The network average gross alpha activity for supply wells was 6.3 x 10^{-9} µCi/mL (0.23 Bq/L), which was 6.3 percent of the DCG for ^{226}Ra. None of the annual averages from samples collected at the supply well locations were statistically different from the network average. The gross alpha annual averages for supply wells are shown in Table 5.16.

Strontium

The annual average network for supply wells was 3.0 x 10^{-12} µCi/mL (1.1 x 10^{-4} Bq/L), which was 0.04 percent of the MCL for ^{90}Sr in drinking water. None of the annual averages from any sampling location was different from the network average at the five percent significance level. Table 5.16 shows the annual ^{90}Sr averages for the supply well locations.

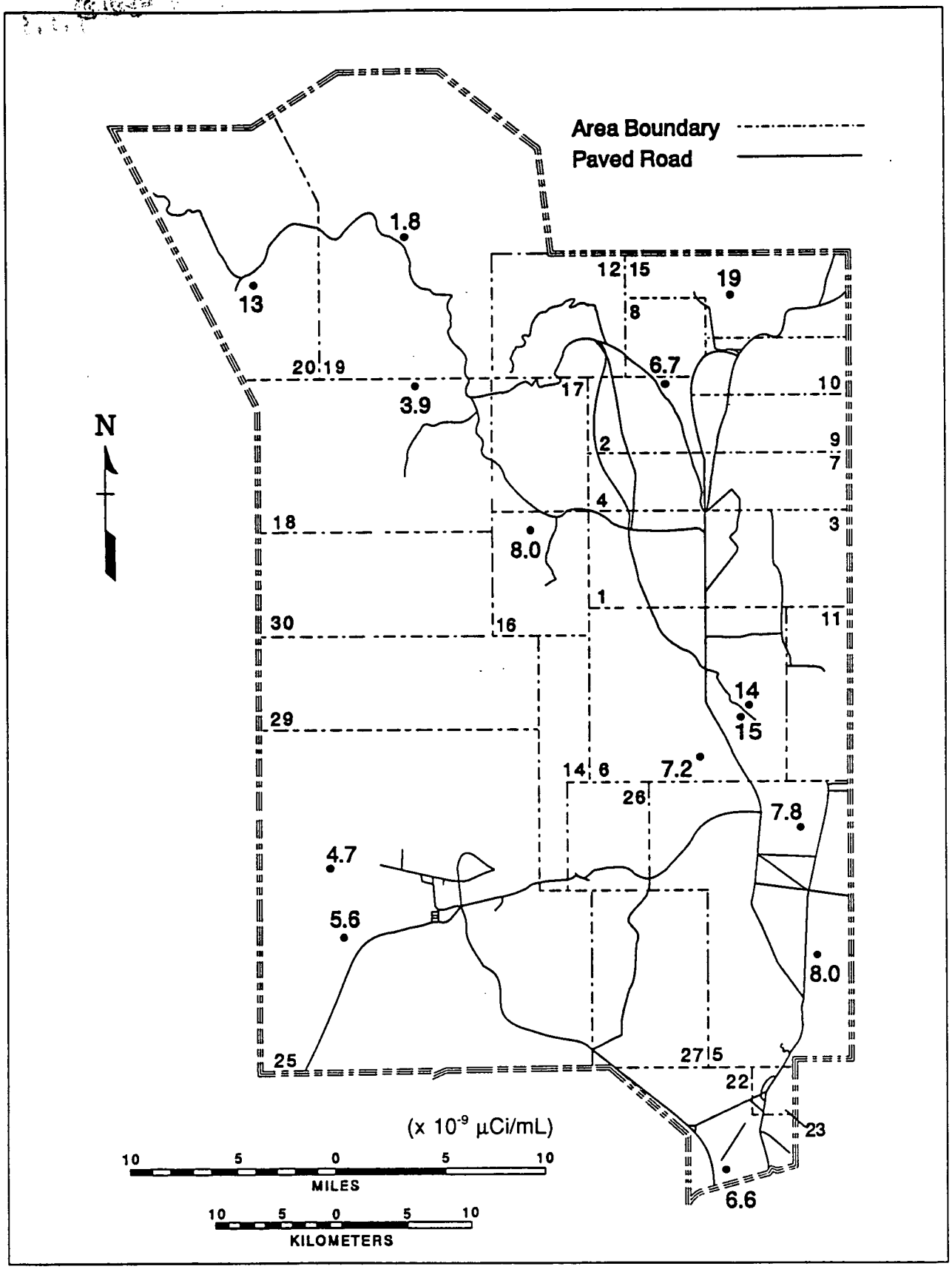


Figure 5.12 NTS Supply Well Annual Average Gross Beta Concentrations - 1990

5458

Table 5.16 NTS Water Supply Well Radioactivity Averages - 1990

	µCi/mL					
Description	Gross Beta	^{3}H	$^{239+240}Pu$	^{238}Pu	Gross Alpha	^{90}Sr
Area 2, Well 2	6.7×10^{-9}	2.1×10^{-8}	7.0×10^{-12}	3.4×10^{-11}	3.0×10^{-9}	-1.3×10^{-10}
Area 5, Well 5C[a]	8.0×10^{-9}	5.3×10^{-8}	6.5×10^{-12}	3.6×10^{-11}	9.2×10^{-9}	-5.5×10^{-11}
Area 5, Well Ue5c	7.8×10^{-9}	-4.5×10^{-8}	4.7×10^{-12}	1.1×10^{-11}	5.1×10^{-9}	6.3×10^{-11}
Area 6, Well 4[a]	7.2×10^{-9}	1.2×10^{-7}	-1.1×10^{-12}	6.3×10^{-12}	8.0×10^{-9}	7.1×10^{-11}
Area 6, Well C[a]	1.4×10^{-8}	2.0×10^{-7}	6.9×10^{-12}	5.4×10^{-11}	1.3×10^{-8}	-3.8×10^{-11}
Area 6, Well C1[a]	1.5×10^{-8}	7.7×10^{-8}	2.1×10^{-11}	-1.7×10^{-12}	1.1×10^{-8}	-6.4×10^{-12}
Area 15, Well Ue15d	1.9×10^{-8}	1.9×10^{-7}	4.5×10^{-12}	3.3×10^{-11}	1.4×10^{-8}	-1.1×10^{-10}
Area 16, Well 16d[a]	8.0×10^{-9}	4.1×10^{-8}	2.7×10^{-12}	2.5×10^{-11}	7.4×10^{-9}	-9.3×10^{-11}
Area 18, Well 8[a]	3.9×10^{-9}	-3.0×10^{-9}	-3.0×10^{-12}	3.1×10^{-11}	7.6×10^{-10}	3.4×10^{-11}
Area 19, Well U19c	1.8×10^{-9}	2.3×10^{-7}	-2.0×10^{-12}	-1.7×10^{-11}	1.6×10^{-9}	6.3×10^{-11}
Area 20, Water Well	1.3×10^{-8}	7.2×10^{-8}	-3.1×10^{-13}	2.2×10^{-11}	7.2×10^{-9}	9.3×10^{-11}
Area 22, Army Well No. 1[a]	6.6×10^{-9}	4.1×10^{-8}	6.6×10^{-12}	1.8×10^{-11}	5.5×10^{-9}	-4.7×10^{-11}
Area 25, Well J-12[a]	5.6×10^{-9}	9.5×10^{-8}	5.7×10^{-12}	1.7×10^{-11}	8.4×10^{-10}	1.1×10^{-10}
Area 25, Well J-13[a]	4.7×10^{-9}	7.0×10^{-8}	7.8×10^{-12}	1.2×10^{-11}	1.7×10^{-9}	8.9×10^{-11}

(a) Drinking water sources for onsite distribution systems.

5.2.1.7 RADIOACTIVITY IN DRINKING WATER

As a check on any effect the water distribution system might have on end-use activity, nine consumption points were sampled during the reporting period. In order to be certain that all of the water available for consumption was being considered, each drinking water system had in previous years been identified and sampled. The NTS contained five drinking water systems, each fed by a series of supply wells during most of 1990. The components of the five systems were as shown in Table 5.17.

Table 5.18 contains the results from sampling conducted at the potable water stations. This table lists annual averages from all analytical results for each station during 1990. Appendix C contains the individual sampling results and presents statistical evaluations.

GROSS BETA

The annual average gross beta concentration in water samples from nine potable water locations was 5.6×10^{-9} µCi/mL (0.21 Bq/L). This annual average was 2.0 percent of the EPA-equivalent DCG for ^{40}K. The DCGs

Table 5.17 NTS Drinking Water Sources - 1990

Supply Well	End-point
Well C, C1, 4	Area 3, Cafeteria Area 27, Cafeteria Area 6, Cafeteria
Well 8	Area 2, Cafeteria Area 12, Cafeteria
Well 16D	Area 1, Building 101
Well 5C, Army Well #1 (Mercury)	Area 23, Cafeteria
Well J-12, J-13	Area 25, Building 4221

Table 5.18 Radioactivity in NTS Drinking Water - 1990

	µCi/mL					
Description	Gross Beta	^{3}H	$^{239+240}Pu$	^{238}Pu	Gross Alpha	^{90}Sr
Area 1, Building 101	7.5×10^{-9}	1.0×10^{-7}	1.7×10^{-11}	3.0×10^{-13}	8.6×10^{-9}	-1.0×10^{-11}
Area 2, Rest Room	3.8×10^{-9}	6.1×10^{-8}	2.7×10^{-12}	2.1×10^{-11}	6.5×10^{-10}	-5.5×10^{-11}
Area 3, Cafeteria	8.9×10^{-9}	4.7×10^{-8}	3.7×10^{-11}	-1.9×10^{-12}	6.1×10^{-9}	3.8×10^{-11}
Area 6, Bottled Water	2.2×10^{-10}	6.2×10^{-8}	3.2×10^{-11}	-3.5×10^{-12}	5.0×10^{-11}	5.7×10^{-11}
Area 6, Cafeteria	8.7×10^{-9}	8.9×10^{-8}	1.9×10^{-11}	4.4×10^{-11}	5.3×10^{-9}	5.2×10^{-12}
Area 12, Cafeteria	3.6×10^{-9}	5.1×10^{-8}	2.7×10^{-12}	8.2×10^{-12}	5.3×10^{-10}	9.0×10^{-11}
Area 23, Cafeteria	4.0×10^{-9}	2.1×10^{-7}	4.8×10^{-13}	1.2×10^{-11}	5.6×10^{-9}	1.8×10^{-11}
Area 25, Building 4221	5.0×10^{-9}	2.9×10^{-8}	6.0×10^{-12}	1.5×10^{-11}	1.4×10^{-9}	-3.4×10^{-11}
Area 27, Cafeteria	8.8×10^{-9}	4.4×10^{-8}	1.8×10^{-12}	2.1×10^{-11}	7.8×10^{-9}	3.7×10^{-11}

given in DOE Order 5400.5 were based on a committed effective dose equivalent of 100 mrem for the radionuclide taken into the body by ingestion during one year. The EPA MCLs are based on similar assumptions but with a more restrictive committed effective dose equivalent of 4 mrem when ingested during one year.

Therefore, to calculate an EPA-equivalent DCG, the 100 mrem DCG is multiplied by 0.04. It is unduly conservative to assume that the beta activity in the drinking water originates from ^{90}Sr since, as was previously stated, most of the beta activity in the drinking water has been attributed to ^{40}K. Results of ^{90}Sr in drinking water have, for several years, reaffirmed this evaluation.

None of the gross beta annual averages from potable water locations was determined to be statistically different from the network average. The locations of all potable water stations are shown in Figure 5.13, along with their gross beta annual averages, and also in Table 5.18.

TRITIUM

The annual average ^{3}H concentration in samples taken at nine potable water locations was 7.8×10^{-8} µCi/mL (2.9 Bq/L). This concentration was 0.004 percent of the DOE Order 5400.5 DCG value and 0.39 percent of the MCL for ^{3}H in drinking water. None of the annual averages from samples collected at the potable water stations were statistically different from the network average. The annual ^{3}H averages for potable water are shown in Table 5.18.

PLUTONIUM

The annual averages of $^{239+240}Pu$ and ^{238}Pu from quarterly samples taken at nine potable water sampling locations were both 1.3×10^{-11} µCi/mL (4.8×10^{-4} Bq/L). These averages, composed of results which were below the detection limits, were 0.04 and 0.03 percent of the DCGs for $^{239+240}Pu$ and ^{238}Pu, respectively. None of the annual averages from individual locations were statistically different from the network averages. The annual averages for these radionuclides are shown in Table 5.18.

GROSS ALPHA

In accordance with the National Primary Drinking Water Regulation, gross alpha measurements were conducted on the drinking water systems for 1990. Samples from the five potable water wells were collected and analyzed for ^{226}Ra. Results from these samples averaged over 5×10^{-9} µCi/mL (5 pCi/L; 0.19 Bq/L), which was the screening level for ^{226}Ra analysis. The five locations sampled, including all potable water end-points on the NTS, and the annual average and gross alpha results from

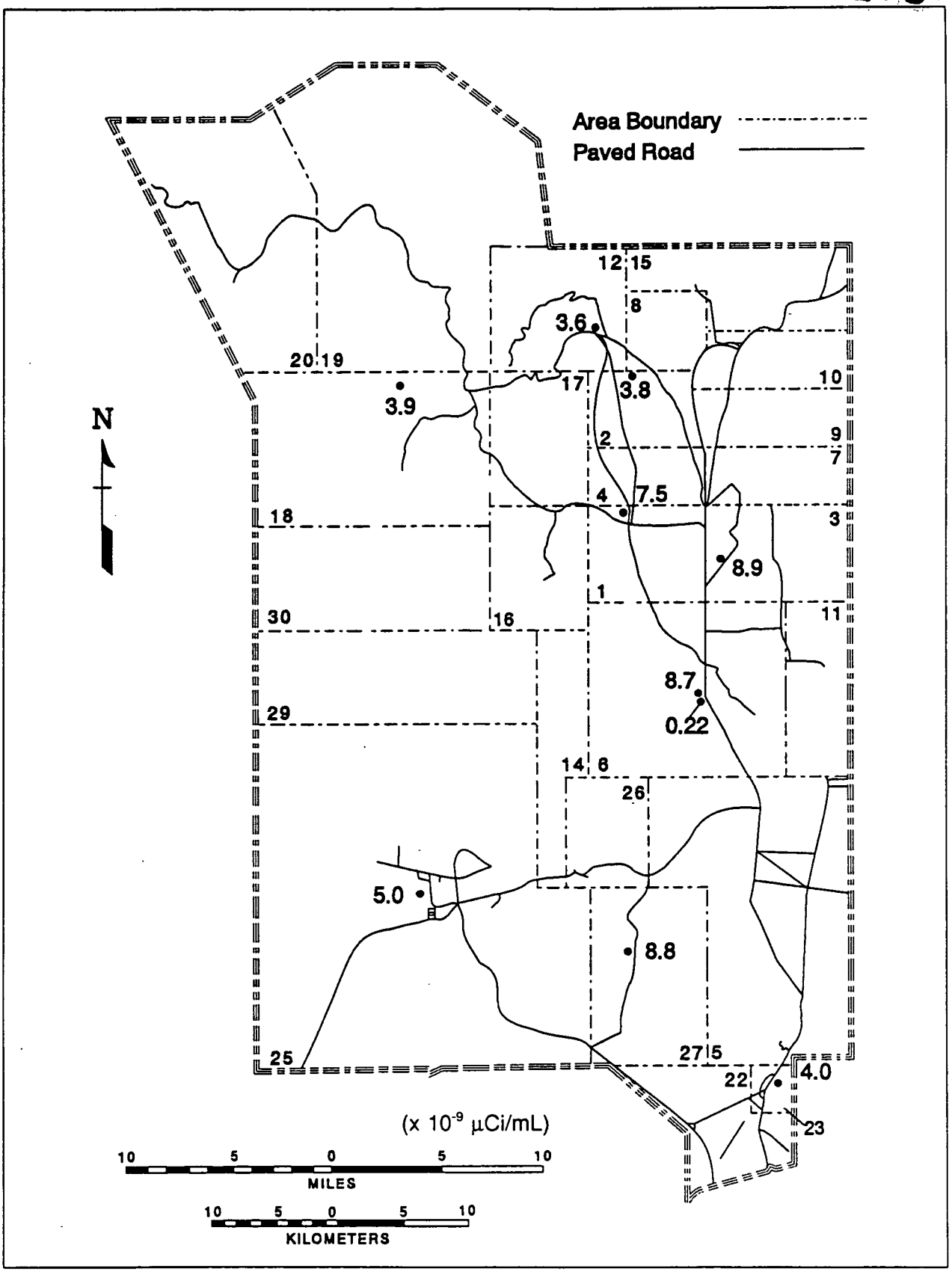


Figure 5.13 NTS Potable Water Gross Beta Annual Averages - 1990

sampling conducted quarterly at each location are shown in Table 5.18. The ^{226}Ra results are shown in Table 5.19. None were above 3 x 10^{-9} µCi/mL (0.18 Bq/L); thus, onsite drinking water was in compliance with drinking water regulations.

STRONTIUM

The annual average network for the nine potable water locations was 7.3 x 10^{-11} µCi/mL (2.7 x 10^{-3} Bq/L), which was 0.91 percent of the MCL for ^{90}Sr in drinking water. No potable water locations displayed annual average concentrations different at the five percent significance level from the network average.

5.2.1.8 EXTERNAL GAMMA EXPOSURES - ONSITE AREA

TLDs were deployed at 184 locations throughout the NTS to measure ambient gamma radiation levels. These dosimeters were manufactured by Panasonic and designed to measure the typical gamma conditions present in the environment. The TLDs were deployed on the NTS at locations with radiological conditions ranging from background levels to areas with known contamination. This report presents the data results from TLDs deployed during each quarter of 1990.

The average gamma exposures recorded during 1990 were statistically not different from the average exposures in 1989. TLDs measured gamma exposures which ranged from 69 mR/year at the Area 23, Building 650 Roof station, to 5581 mR/year at the Area 5, RWMS MSM 2 East station. The latter location was much higher than the maximum result reported last year due to the uranium and thorium content of the material stored at this facility.

A plot of the data shows that the TLD results were normally distributed about a mean of 149 mR/year when obvious outliers were not included. These data may be described as the NTS gamma exposure rates which were not influenced by radiological areas. The remaining data range from 365 to 5581 mR/year. The TLDs collecting these data were deployed at locations with known contamination from, for example, weapons tests or radioactive material storage.

Table 5.19 Radium-226 Analysis Results for NTS Drinking Water - 1990

Consumption Point	^{226}Ra Results ± 1s in Units of 10^{-9} µCi/mL
Area 1, Building 101	1.4 ± 0.1
Area 6, Cafeteria	0.2 ± 0.1
Area 12, Cafeteria	0.2 ± 0.1
Area 23, Cafeteria	0.1 ± 0.1
Area 25, Bldg. 4221	0.2 ± 0.1

Statistical analyses of the data are presented in Appendix F; Table F.1 contains a summary of the individual TLD results. Table 5.20 displays the results of gamma monitoring conducted at the NTS boundary. These locations were close to the physical boundary of the NTS and were reachable only via helicopter. The data collected at these locations were statistically not different from the data collected from the control locations.

A group of locations which were not, to the best available knowledge, influenced by radiological contamination, served as controls for the NTS. The data from these locations are presented in Table 5.21. The overall network exposure range for the control locations for 1990 was 0.19 to 0.40 mR/day, with an average exposure rate of 0.30 mR/day or 110 mR/year.

5.2.1.9 SPECIAL ENVIRONMENTAL STUDIES

The BECAMP conducts special environmental studies on the NTS that

Table 5.20 NTS Boundary Gamma Monitoring Result Summary - 1990

Area	UTM Coordinate Location	First Quarter (mR/day)	Second Quarter (mR/day)	Third Quarter (mR/day)	Fourth Quarter (mR/day)	Average (mR/day)	1989 Annual Exposure (mR/yr)	1990 Annual Exposure (mR/yr)
3	N843,555 E704,945 (13)	0.24	0.26	0.22	0.24	0.24	88	88
5	N712,618 E713,111 (15)	0.23	0.23	0.21	0.22	0.22	80	81
9	N875,015 E690,664 (12)	0.26	0.28	0.23	0.27	0.26	91	95
11	N789,449 E709,501 (14)	0.50	0.47	0.45	0.50	0.48	172	175
12	N904,470 E635,530 (10)	0.36	--	0.21	0.37	0.31	135	114
15	N907,578 E684,659 (11)	0.49	0.50	0.47	0.50	0.49	179	180
18	N833,950 E557,892 (4)	0.47	--	0.43	0.52	0.48	179	174
19	N933,423 E637,495 (9)	0.38	0.48	0.48	0.47	0.45	204	165
19	N954,202 E611,581 (8)	0.37	--	0.44	0.48	0.43	212	157
20	N886,398 E556,098 (5)	0.56	0.56	0.56	0.58	0.57	208	207
20	N944,597 E558,448 (7)	0.31	0.32	0.28	0.33	0.31	106	113
20	N948,800 E527,800 (6)	0.38	0.50	0.50	0.51	0.47	208	173
22	N674,614 E671,355 (1)	0.23	0.25	0.19	0.24	0.23	77	83
25	N732,411 E638,710 (2)	0.33	0.33	0.30	0.34	0.32	99	119
25	N759,934 E556,412 (3)	0.45	0.44	0.44	0.48	0.45	164	165

include (1) investigating the movement of radionuclides on and around the NTS through horizontal movement, water-driven erosion, vertical migration, and wind-driven erosional resuspension; (2) development of a human dose-assessment model specific to the environmental and radiological conditions of the NTS; and (3) preparation of an annual thematic, peer-reviewed publication which address important issues related to the potential environmental impacts of past, present, and future activities on the NTS.

The results of 1990 BECAMP investigations relative to onsite radiological monitoring are summarized in the following sections.

Table 5.21 NTS TLD Control Station Comparison - 1984-1990

		Exposure Rate (mR/day)						
Area	Station	1984	1985	1986	1987	1988	1989	1990
5	Well 5B	0.27	0.26	0.22	0.32	0.43	0.36	0.34
6	CP-6	0.18	0.17	0.13	0.21	0.36	0.27	0.25
6	Yucca Oil Storage	0.23	0.21	0.22	0.30	0.29	0.32	0.32
23	Bldg. 650 Dosimetry	0.15	0.13	0.31	0.14	0.26	0.19	0.20
23	Bldg. 650 Roof	0.14	0.12	0.13	0.17	0.24	0.18	0.19
23	Post Office	0.14	0.13	0.16	0.24	0.29	0.23	0.23
25	HENRE Site	0.30	0.28	0.27	0.34	0.47	0.38	0.39
25	NRDS Warehouse	0.32	0.28	0.28	0.39	0.46	0.38	0.39
27	Cafeteria	0.32	0.29	0.27	0.38	0.49	0.32	0.40
Network Average		0.23	0.21	0.22	0.28	0.37	0.29	0.30

MOVEMENT OF RADIONUCLIDES ON AND AROUND THE NTS

Investigations into the movement of radionuclides on and around the NTS were concentrated on the initiation of resuspension monitoring of a plutonium-contaminated site on the Tonopah Test Range. Monitoring the plutonium and americium particle emissions from soils contaminated during atmospheric nuclear testing is important for several reasons. First, quantification of the potential human exposure from inhalation of particles, which is the major exposure pathway from transuranic radionuclides may be accomplished. Second, a determination may be made on the transuranic radionuclide aerosol emission rates by wind erosion so that a source term can be derived for calculating population or occupational doses in the event of significant, long-term transport of aerosols. Finally, information provided by resuspension monitoring is the basis of criteria that will determine soil transuranic concentrations for management and remediation of contaminated soils. Resuspension studies have been conducted at the NTS since 1968 and are summarized by Shinn et al. (1986). The Tonopah Test Range CLEAN SLATE III site was chosen in order to further characterize the resuspension processes at plutonium-contaminated sites that are (1) off the NTS but still managed by DOE/NV and (2) considered for remedial action in the DOE/NV Site Specific Plan for Environmental Restoration and Waste Management.

In 1990 a draft of the "Study Plan for Monitoring Resuspension of Radioactive Aerosols at Nevada Test Site" was prepared. The study plan provides the method used for the resuspension monitoring at the NTS as developed and tested by the Environmental Sciences Division, LLNL. The study plan documents the theory, applications, and methods of measurement and calculation of the site-specific transuranic radionuclide resuspension variables such as air concentration, integrated soil concentration, resuspension factor, resuspension rate, activity coefficient, enhancement factor, median aerodynamic diameter, particle geometric standard deviation, meteorological friction velocity, and turbulent diffusivity. The study plan also details how the combination of these variables is used in a relevant site assessment.

Resuspension monitoring began at the Tonopah Test Range in September 1990 and will continue through September 1991. Prior to construction of the air sampling stations, the general area around the monitoring site was surveyed with a FIDLER portable survey instrument, and soil samples were collected for determination of soil transuranic radionuclide concentrations and ratios. Three types of air samplers are used in the monitoring work: (1) high-volume air samplers for determination of air radionuclide concentrations and particle mass loading, (2) cascade impactors for determination of the aerosol particle-size distribution, and (3) array air samplers that are used to measure the vertical gradient of radioactivity in the air layer a few meters above the soil. A combined automatic weather and micrometeorological boundary-layer profile station was set up near the air samplers for continuous measurement of wind speed, wind direction, and air temperatures up to a two-meter height.

HUMAN DOSE-ASSESSMENT MODEL

The BECAMP dose-assessment model is an extension of the Nevada Applied Ecology Group/NTS model that was used to estimate the internal dose to man from $^{239+240}Pu$. In 1988 the model was modified to include the external dose pathway for gamma-emitting radionuclides (Ng et al. 1988). In 1989 the model was modified to include a multi-compartment gut model for calculating the dose to the gut, the gamma-exposure pathway, and radionuclides ^{60}Co, ^{90}Sr, ^{137}Cs, ^{152}Eu, ^{155}Eu, ^{238}Pu, and ^{241}Am that are found in measurable quantities on the NTS. The results of the sensitivity and uncertainty analyses of the NAEG model (Kercher and Anspaugh 1989) showed the air pathway as

5458

the critical pathway for human exposure to plutonium, and the soil plutonium concentration and the factors controlling air concentration are the most important environmental parameters.

In 1990 the internal and external doses for all radionuclides were codified in the model. Additional radionuclides that are found in small quantities on the NTS were added to the model (^{101}Rh, ^{102m}Rh, ^{125}Sb, ^{134}Cs, and ^{174}Lu). Figure 5.14 is a schematic of the current BECAMP dose-assessment model. Inputs to the model are the radionuclide soil-surface concentrations, factors of soil radionuclide distributions, and coefficients of radionuclide specific effective energy (SEE). Outputs include the 50-year committed dose to internal organs and whole body, external dose, and total dose. This model may be used to assess the dose from all pathways for a person in a plutonium-contaminated environment.

The updated model was analyzed to determine the sensitivity of calculated doses to levels of the various radionuclides in soils and to possible changes or variation in individual parameters of the model. A stochastic code for dose uncertainty was developed. In addition to work on the dose-assessment model, a workshop was held in 1990 to review data on the possible difference in biological availability of plutonium isotopes, ^{238}Pu versus $^{239+240}$Pu. Results of the dose-assessment model analyses and the findings of the workshop will be documented in reports scheduled for completion next year.

THEMATIC, PEER-REVIEWED PUBLICATIONS

In 1990 work began on a paper dealing with the possible differential movement of plutonium isotopes in the NTS environment. In the paper published in 1989 (Gilbert et al. 1989), it was noted that there was a difference in average transfers of plutonium isotopes (^{238}Pu versus $^{239+240}$Pu) to tissues of cattle that had grazed on an area which had been contaminated with plutonium. Uncertainty and sensitivity analyses of the data were conducted. The paper, to be completed in 1991, will provide evidence and hypotheses for the differential behavior, identify sources of variation, and include an evaluation and uncertainty analysis of the data.

Two additional publications were prepared in 1990 by BECAMP participants. A paper by Anspaugh et al. (1990) provided a history of radiation-related monitoring and environmental research at the NTS. The paper presented the significant findings on research at the NTS; (1) monitoring and research programs have made major use of statistical methods of analysis, (2) incorporation of quality assurance in monitoring programs is a necessity to ensure data credibility and facilitate documentation of experimental procedures, and (3) studies of plutonium dynamics and the resultant models, from resuspension through metabolism by cattle, have proved to be valuable in assessing health risks and land-management alternatives. The second paper has been prepared in draft form and is a summary of the results of the Radionuclide and Inventory Distribution Program (RIDP) (McArthur 1990). In this report, the results from the series of five RIDP reports have been combined to provide an integrated picture of the current levels of soil radioactivity on the NTS. The paper is expected to be completed and released early in 1991.

5.2.2 OFFSITE ENVIRONMENTAL SURVEILLANCE

The offsite radiological surveillance program conducted by the EMSL-LV consisted of (1) an Air Surveillance Network (ASN) of 32 continuously operating stations and 78 standby stations for air particulates and reactive gases; (2) a 19-station Noble Gas and Tritium Surveillance Network (NGTSN); (3) a groundwater and surface water surveillance network at over 60 stations on and off the Site (28 at NTS wells);

171

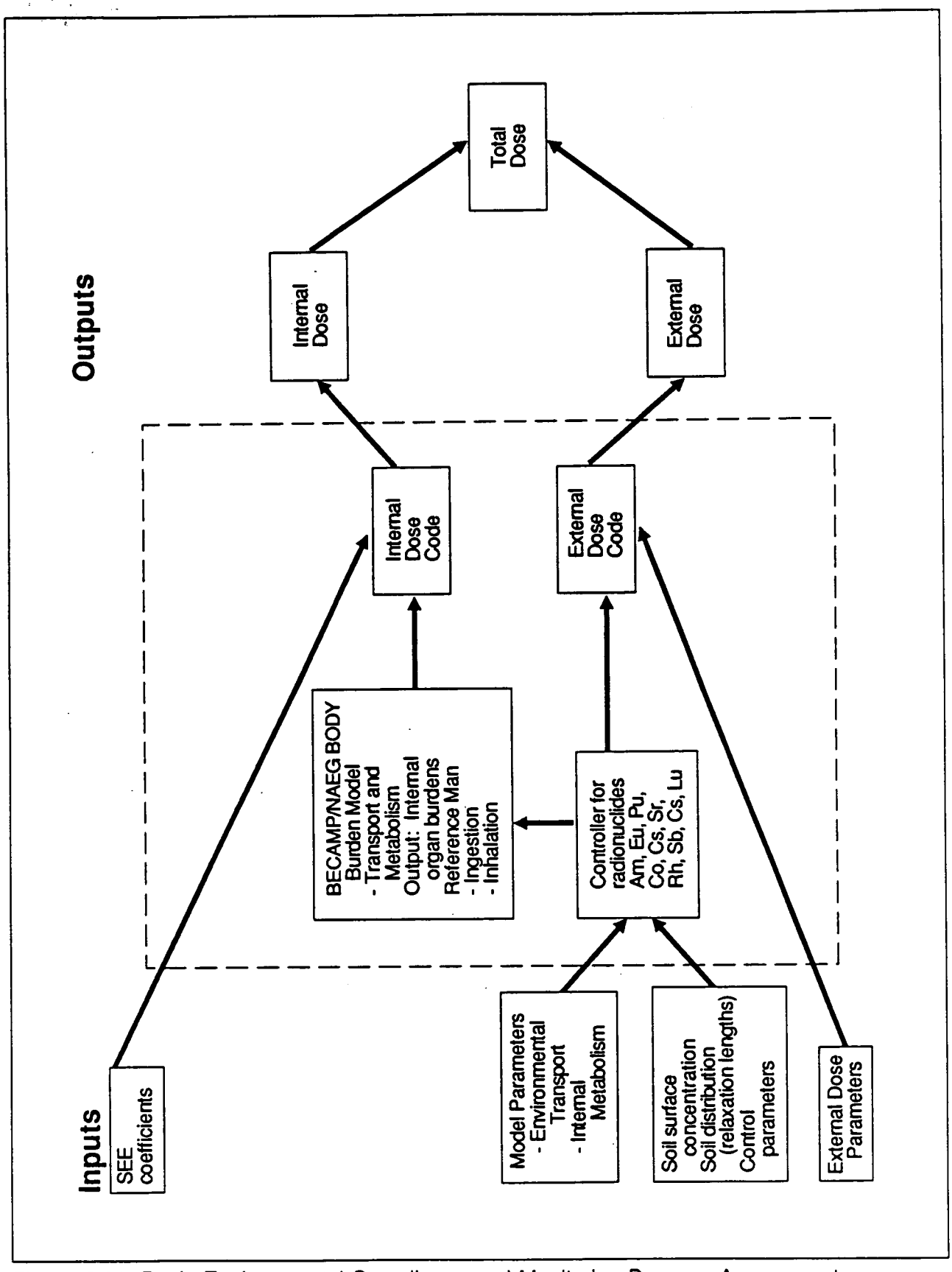


Figure 5.14 Basic Environmental Compliance and Monitoring Program Assessment Model - 1990

5458

(4) sampling of livestock and wildlife tissue and vegetables around the NTS; (5) a 134-station TLD network and 71-person offsite resident dosimetry program; (6) a 28-station external gamma exposure rate monitoring network; and (7) an Offsite Dosimetry Program to estimate exposure of offsite residents to radioactivity produced on the NTS; and (8) a 26-station Milk Surveillance Network (MSN) around the NTS, with 109 standby stations in major milksheds west of the Mississippi River. The results of this surveillance are summarized below. Complete results are published in EMSL-LV's annual Offsite Environmental Monitoring Report.

5.2.2.1 AIR MONITORING NETWORK

During 1990 no airborne radioactivity related to current nuclear testing at the NTS was detected on any sample from the ASN or the Standby Air Surveillance Network (SASN). (The locations of the sampling points are shown in Section 4, Figures 4.5 and 4.6.) Throughout the network, ^{7}Be was the only nuclide detected by gamma spectroscopy. The principal means of ^{7}Be production is from spallation of ^{16}O and ^{14}N by cosmic rays in the atmosphere.

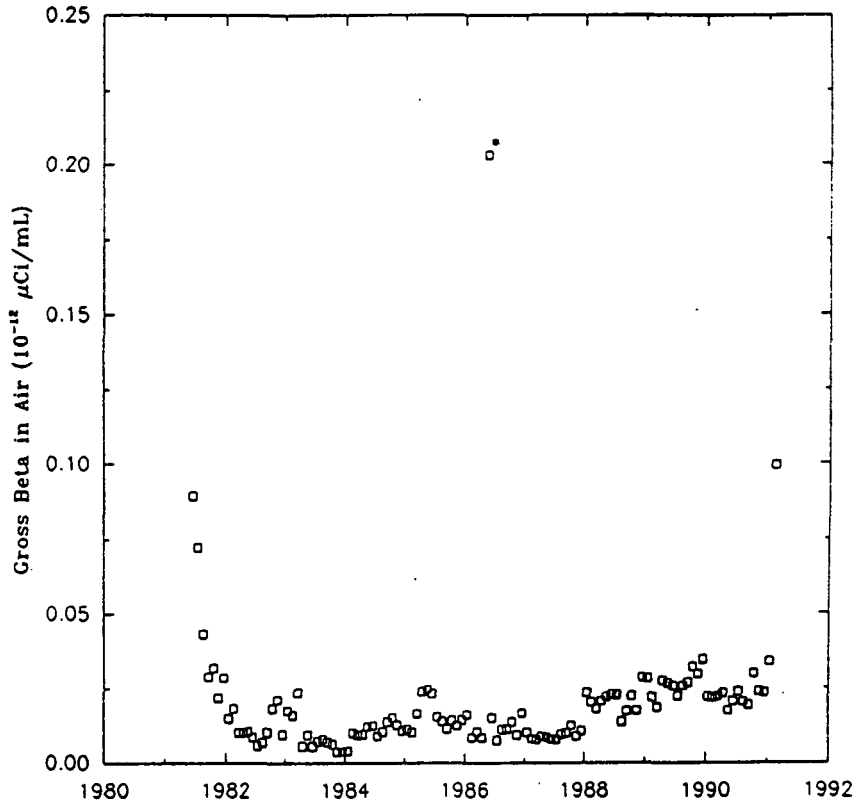
There was one borderline ^{238}Pu sample from Rachel, Nevada, during 1990. A few positive ^{238}Pu and $^{239+240}$Pu results obtained at Rachel over the past three years indicate the need for additional sampling to characterize the area and to pinpoint the source of the very small amounts of plutonium in the air samples there. A sampling program for both Lathrop Wells, Nevada, and Rachel will be designed and undertaken during 1991 to accomplish this. High-volume air samplers will be utilized and soil sample analyses will be performed. Because of the prevailing winds and the plutonium cleanup efforts occurring at the NTS, air samples from the Alamo, Nevada, station will be analyzed routinely for plutonium.

The monthly average gross beta level in air samples from five stations, collected since 1981, is plotted in Figure 5.15. This year's data from all stations were similar and suggest little significant difference among stations. Summaries of the 1990 gross beta results for the ASN stations are shown in Table 5.22 and for 75 of the SASN stations in Table 5.23.

The filters from the stations at Las Vegas, Lathrop Wells, and Rachel, Nevada, and Salt Lake City, Utah, were composited as monthly samples and submitted for plutonium analysis. The other samples for plutonium analysis consisted of composited filters from two stations in each state in which standby stations were located. The results of the ^{238}Pu and $^{239+240}$Pu analyses from 14 states are shown in Table 5.24. The plutonium results from the last two quarters of 1989 and the first two quarters of 1990 were used in this table.

The 19 active stations of the NGTSN are shown in Section 4, Figure 4.7. NGTSN sample results are summarized in Tables 5.25 and 5.26 for all sampled locations. These summary tables consist of the maximum, minimum, and average concentration detected in the weekly samples from each station. The number of samples analyzed is typically less than the expected number (52) since samples are occasionally lost in the analysis process, an insufficient sample volume is collected for analysis, or a sample is lost or not collected due to equipment failure. The measured ^{85}Kr concentrations ranged from 2.0×10^{-11} to 3.3×10^{-11} µCi/mL (0.74 to 1.2 Bq/m^3). Weekly network averages for ^{85}Kr concentrations measured in 1990 are shown in Figure 5.16.

The 1990 average concentration for the ^{85}Kr network was 2.64×10^{-11} µCi/mL (0.98 Bq/m^3). This network average concentration, as shown in Figure 5.17, gradually increased from the time sampling began in 1972 to the present. This trend, observed at all stations, reflects the worldwide increase in ambient concentrations resulting from the use of nuclear technology. There is no evidence in



* Elevated concentration attributable to the April 1986 nuclear reactor accident at Chernobyl, U.S.S.R.

Figure 5.15 Monthly Average Gross Beta in Air Samples, Las Vegas, Nevada - 1981-90

the ^{85}Kr results to indicate that the radioactivity detected was from activities conducted at the NTS.

The analytical results for the 841 xenon samples were all below the MDC, which varied, but was generally about 1.4 x 10^{-11} µCi/mL (0.52 Bq/m^3).

As in the past, ^3H concentrations in atmospheric moisture (HTO) samples collected at network sampling stations were generally below the MDC of about 4.6 x 10^{-12} µCi/mL (0.17 Bq/m^3). Of the 981 network samples analyzed in 1990, only six slightly exceeded the MDC. The range of HTO concentrations observed at sampling stations was considered to be due to statistical variations in counting background samples and not indicative of the presence of actual levels in the environment. In conclusion, there was no evidence in the measured noble gas or HTO levels of any contribution related to activities at the NTS.

5.2.2.2 WATER MONITORING

The 28 wells on the NTS and 35 wells in areas near the NTS are part of the EPA's Long-Term Hydrological Monitoring Program (LTHMP) which is used to monitor surface water and groundwater on and off the NTS. Monitoring of these wells and other groundwater monitoring are discussed in Section 9.

5.2.2.3 BIOMONITORING

Collection sites for animal tissue sampled in late 1989 and 1990 are shown in Section 4,

5458

Table 5.22 Gross Beta Results at Air Surveillance Network Stations - 1989-90

Sampling Location	Number of Days Sampled	Gross Beta Concentration x 10^{-12} µCi/mL[a] Maximum	Minimum	Average
Death Valley Junction, CA	357	0.036	0.011	0.020
Furnace Creek, CA	361	0.069	0.007	0.027
Shoshone, CA	332	0.100	0.000	0.022
Alamo, NV	371	0.051	0.005	0.023
Amargosa Center, NV	357	0.045	0.004	0.022
Austin, NV	351	0.043	0.008	0.020
Beatty, NV	350	0.041	0.011	0.022
Blue Eagle Ranch, NV	362	0.041	0.008	0.019
Caliente, NV	348	0.044	0.011	0.022
Ely, NV	369	0.035	0.005	0.020
Fallini's Twin Springs Ranch, NV	363	0.047	-0.002	0.022
Beatty, NV Fleur-de-Lis Ranch, NV[b]	56	0.027	0.003	0.017
Goldfield, NV	347	0.041	0.009	0.021
Groom Lake, NV	347	0.039	0.002	0.019
Hiko, NV	370	0.043	0.005	0.022
Indian Springs, NV	366	0.038	0.009	0.021
Las Vegas, NV	371	0.046	0.011	0.023
Lathrop Wells, NV	369	0.041	0.002	0.019
Nyala, NV	364	0.036	-0.003	0.014
Overton, NV	370	0.051	0.011	0.024
Pahrump, NV	370	0.039	0.008	0.020
Pioche, NV	355	0.038	0.009	0.021
Rachel, NV	349	0.039	0.001	0.020
Scotty's Junction, NV	368	0.043	0.009	0.022
Stone Cabin Ranch, NV	365	0.036	0.005	0.019
Sunnyside, NV	364	0.042	0.001	0.019
Tonopah, NV	370	0.034	0.004	0.019
Tonopah Test Range, NV	365	0.047	-0.002	0.019
Cedar City, UT	364	0.043	-0.000	0.019
Delta, UT	355	0.072	0.011	0.026
Milford, UT	356	0.068	0.002	0.023
Salt Lake City, UT	370	0.036	0.012	0.022
St. George, UT	370	0.060	0.001	0.021

(a) 10^{-12} µCi/mL ≡ pCi/m^3; Multiply the result by 0.037 to convert to Bq/m^3.

Figure 4.10. The results obtained from analysis of animal tissues are shown in Tables 5.27 and 5.28. (The numbers in the first column of the table refer to the numbered sample locations shown in Figure 4.10). Other than naturally occurring ^{40}K,

Table 5.23 Gross Beta Results at Standby Air Surveillance Network Stations - 1989-90

Sampling Location	Number of Days Sampled	Gross Beta Concentration x 10^{-12} µCi/mL[a] Maximum	Minimum	Average
Globe, AZ	28.9	0.036	0.022	0.026
Kingman, AZ	21.5	0.038	0.017	0.026
Tucson, AZ	28.9	0.022	0.016	0.019
Winslow, AZ	35.0	0.054	0.015	0.029
Yuma, AZ	28.4	0.034	0.010	0.024
Little Rock, AR	28.0	0.025	0.017	0.021
Alturas, CA	30.1	0.024	0.005	0.015
Baker, CA	26.0	0.046	0.016	0.029
Bishop, CA	32.3	0.050	0.014	0.027
Chico, CA	28.0	0.026	0.011	0.017
Indio, CA	14.0	0.027	0.014	0.021
Lone Pine, CA	25.9	0.059	0.018	0.032
Needles, CA	28.0	0.015	0.007	0.010
Ridgecrest, CA	34.5	0.024	0.012	0.016
Santa Rosa, CA	28.1	0.013	0.007	0.008
Cortez, CO	21.1	0.029	0.015	0.023
Denver, CO	21.3	0.024	0.011	0.018
Grand Junction, CO	20.5	0.044	0.025	0.036
Mountain Home, ID	28.1	0.050	0.015	0.026
Nampa, ID	28.0	0.018	0.012	0.015
Pocatello, ID	28.1	0.025	0.011	0.020
Fort Dodge, IA	35.0	0.043	0.010	0.027
Iowa City, IA	28.2	0.044	0.020	0.031
Dodge City, KS	21.0	0.035	0.014	0.022
Monroe, LA	35.1	0.037	0.014	0.023
Minneapolis, MN	21.1	0.025	0.014	0.019
Clayton, MO	35.2	0.044	0.018	0.032
Joplin, MO	28.0	0.041	0.021	0.029
St. Joseph, MO	31.7	0.026	0.017	0.022
Great Falls, MT	21.1	0.019	0.009	0.015
Kalispell, MT	28.2	0.031	0.003	0.018
Miles City, MT	28.0	0.032	0.012	0.021
Adaven, NV	41.0	0.029	0.008	0.016
Battle Mountain, NV	29.9	0.020	0.014	0.017
Blue Jay, NV	20.0	0.047	0.019	0.036
Clarks Station, NV	13.0	0.026	0.023	0.025
Currant, NV				
Angle Worm Ranch	57.9	0.037	0.016	0.024

(a) 10^{-12} µCi/mL ≡ pCi/m^3; Multiply the result by 0.037 to convert to Bq/m^3.

5453

Table 5.23 (Gross Beta Results at Standby Air Surveillance Network Stations - 1989-90, cont.)

Sampling Location	Number of Days Sampled	Gross Beta Concentration x 10^{-12} µCi/mL[(a)] Maximum	Minimum	Average
Currie, NV				
Currie Maintenance Station	29.9	0.021	0.011	0.015
Duckwater, NV	22.8	0.029	0.022	0.025
Elko, NV				
Phillips 66 Truck Stop	35.1	0.029	0.007	0.017
Eureka, NV	34.9	0.027	0.015	0.020
Fallon, NV	14.0	0.061	0.027	0.044
Geyser Ranch, NV	27.6	0.033	0.009	0.018
Lovelock, NV	20.3	0.026	0.011	0.017
Lund, NV	22.3	0.019	0.010	0.015
Mesquite, NV	27.0	0.024	0.005	0.017
Reno, NV	14.0	0.014	0.008	0.011
Round Mountain, NV	29.0	0.032	0.012	0.021
Wells, NV	29.3	0.032	0.017	0.021
Winnemucca, NV	28.1	0.022	0.012	0.017
Albuquerque, NM	19.9	0.032	0.023	0.027
Carlsbad, NM	27.0	0.026	0.009	0.017
Shiprock, NM	12.0	0.020	0.020	0.020
Bismark, ND	28.0	0.032	0.013	0.025
Fargo, ND	21.0	0.041	0.028	0.036
Williston, ND	28.3	0.041	0.023	0.031
Muskogee, OK	41.0	0.043	0.020	0.026
Burns, OR	28.0	0.019	0.004	0.012
Medford, OR	29.3	0.013	0.004	0.009
Rapid City, SD	28.8	0.046	0.022	0.030
Amarillo, TX	7.0	0.046	0.046	0.046
Austin, TX	22.0	0.016	0.014	0.015
Midland, TX	21.0	0.010	0.002	0.006
Tyler, TX	33.4	0.021	0.020	0.020
Bryce Canyon, UT	21.1	0.038	0.018	0.025
Enterprise, UT	21.0	0.018	0.015	0.017
Garrison, UT	36.0	0.030	0.014	0.023
Logan, UT	28.6	0.076	0.012	0.033
Parowan, UT	21.0	0.045	0.019	0.029
Vernal, UT	20.9	0.043	0.011	0.024
Wendover, UT	29.8	0.023	0.006	0.016
Seattle, WA	28.0	0.020	0.001	0.012
Spokane, WA	28.0	0.049	0.006	0.022

(a) 10^{-12} µCi/mL ≡ pCi/m^3; Multiply the result by 0.037 to convert to Bq/m^3.

177

Table 5.23 (Gross Beta Results at Standby Air Surveillance Network Stations - 1989-90, cont.)

Sampling Location	Number of Days Sampled	Gross Beta Concentration x 10^{-12} µCi/mL[a] Maximum	Minimum	Average
Rock Springs, WY	29.0	0.023	0.013	0.016
Worland, WY	28.0	0.041	0.005	0.019

(a) 10^{-12} µCi/mL ≡ pCi/m^3; Multiply the result by 0.037 to convert to Bq/m^3.

Table 5.24 Concentrations of ^{238}Pu and $^{239+240}$Pu in Offsite Composited Air Samples - 1989-90

Composite Sampling Location	Collection Date	Concentration ± 1s (MDC listed in parenthesis)[a] ^{238}Pu x 10^{-18} µCi/mL	$^{239+240}$Pu x 10^{-18} µCi/mL
Arizona Composite (Winslow & Tucson)	08/02/89	7.6 ± 17 (50)	-7.6 ± 7.7 (36)
	11/01/89	46 ± 40 (110)	-11 ± 11 (53)
	01/26/90	8.9 ± 5.9 (15)	3 ± 3 (6.9)
	05/02/90	80 ± 81 (190)	40 ± 70 (190)
California Composite (Bishop & Ridgecrest)	08/23/89	21 ± 26 (74)	0 ± 10 (33)
	11/01/89	0 ± 200 (670)	0 ± 100 (330)
	01/11/90	6.2 ± 5.8 (16)	-1.5 ± 1.5 (7.2)
	05/02/90	-43 ± 38 (150)	14 ± 25 (66)
Colorado Composite (Denver & Cortez)	08/21/89	28 ± 25 (66)	-7.1 ± 12 (47)
	11/01/89	25 ± 36 (100)	0 ± 18 (59)
	03/01/90	8.9 ± 6.4 (17)	0 ± 2.5 (8.3)
	06/27/90	29 ± 29 (67)	-14 ± 14 (67)

(a) All concentrations are below the minimum detectable concentration (MDC) unless denoted by *.

178

Table 5.24 (Concentrations of ^{238}Pu and $^{239+240}Pu$ in Offsite Composited Air Samples - 1989-90, cont.)

Composite Sampling Location	Collection Date	Concentration ± 1s (MDC)[a] ^{238}Pu x 10^{-18} µCi/mL	Concentration ± 1s (MDC)[a] $^{239+240}Pu$ x 10^{-18} µCi/mL
Idaho Composite (Nampa & Mountain Home)	09/18/89	14 ± 26 (80)	0 ± 9.9 (33)
	11/12/89	11 ± 22 (67)	0 ± 11 (36)
	01/29/90	14 ± 7.5 (18)	0 ± 2.7 (9)
	05/02/90	-6.5 ± 20 (68)	0 ± 9.2 (30)
Missouri Composite (Clayton & Joplin)	08/28/89	0 ± 8.2 (27)	-4.1 ± 4.1 (19)
	11/03/89	-58 ± 150 (540)	58 ± 100 (270)
	03/01/90	-7.9 ± 21 (73)	0 ± 11 (37)
	06/25/90	Sample Lost	
Montana Composite (Great Falls & Miles City)	08/21/89	-5.2 ± 7.4 (27)	0 ± 3.7 (12)
	11/01/89	-33 ± 87 (300)	0 ± 46 (150)
	01/25/90	6.8 ± 23 (71)	7 ± 12 (32)
	05/02/90	18 ± 32 (96)	-9.2 ± 9.3 (43)
Las Vegas, Nevada	07/30/89	-28 ± 15 (64)	0 ± 7.9 (26)
	08/28/89	0 ± 2.5 (8.3)	2 ± 1.8 (4.4)
	09/25/89	0 ± 14 (45)	-4.8 ± 4.8 (22)
	10/30/89	2.6 ± 7.8 (24)	0 ± 3.7 (12)
	11/27/89	17 ± 8.6 (20)	0 ± 3.1 (10)
	12/25/89	-51 ± 31 (130)	0 ± 20 (67)
	01/29/90	4.9 ± 2.7 (6.6)	2.1 ± 1.6 (3.3)
	02/26/90	2.4 ± 4.2 (13)	2.4 ± 2.4 (5.6)
	03/26/90	7.5 ± 3.8 (8.7)	0.9 ± 1.6 (4.4)
	04/30/90	2.1 ± 3.7 (9.9)	2.1 ± 3.7 (9.9)
	05/29/90	-27 ± 24 (93)	27 ± 20 (42)
	06/25/90	4.8 ± 8.4 (23)	0 ± 6.8 (23)
Lathrop Wells, Nevada	07/30/89	12 ± 6.6 (14)	-4.1 ± 2.9 (14)
	08/28/89	-2.9 ± 9.6 (33)	0 ± 4.1 (13)
	09/24/89	-3.9 ± 4.3 (16)	1.3 ± 2.9 (8.5)

(a) All concentrations are below the minimum detectable concentration (MDC) unless denoted by *.

Table 5.24 (Concentrations of ^{238}Pu and $^{239+240}Pu$ in Offsite Composited Air Samples - 1989-90, cont.)

Composite Sampling Location	Collection Date	Concentration ± 1s (MDC)[a] ^{238}Pu x 10^{-18} µCi/mL	Concentration ± 1s (MDC)[a] $^{239+240}Pu$ x 10^{-18} µCi/mL
Lathrop Wells, Nevada, cont.			
	10/29/89	-22 ± 24 (91)	7.4 ± 16 (49)
	11/27/89	24 ± 21 (56)	-6 ± 5.9 (28)
	12/26/89	-13 ± 9.6 (40)	0 ± 6 (20)
	01/28/90	3.7 ± 2.6 (6.8)	-0.7 ± 1.6 (5.9)
	02/26/90	6.2 ± 3.1 (7.3)	2.3 ± 1.7 (3.6)
	03/26/90	3 ± 3.6 (11)	2 ± 2 (4.7)
	04/29/90	-21 ± 13 (53)	5.1 ± 8.9 (24)
	05/27/90	5.3 ± 9.2 (25)	16 ± 12 (25)
	06/24/90	-2.9 ± 8.8 (31)	2.9 ± 5.1 (14)
Rachel, Nevada	07/31/89	2.7 ± 8.3 (26)	0 ± 3.9 (13)
	08/28/89	9.6 ± 5.1 (11)	1.6 ± 3.6 (11)
	09/25/89	0 ± 2.9 (9.6)	3.4 ± 2.1 (3.9)
	10/30/89	24 ± 19 (48)	-5.9 ± 5.9 (28)
	11/27/89	-43 ± 34 (130)	11 ± 24 (71)
	12/26/89	-4.5 ± 12 (42)	4.5 ± 7.8 (21)
	01/28/90	6.1 ± 3.1 (7)	1.7 ± 1.7 (4)
	02/26/90	8.2 ± 3.8 (8.5)	-1 ± 2 (7.4)
	03/26/90	6.2 ± 2.6 (5.9) *	1.1 ± 1.1 (2.6)
	04/30/90	4.3 ± 7.5 (20)	8.6 ± 8.6 (20)
	05/28/90	-29 ± 18 (76)	0 ± 10 (34)
	06/25/90	34 ± 26 (54)	23 ± 23 (54)
New Mexico Composite (Albuquerque & Carlsbad)	08/21/89	0 ± 14 (47)	-5.1 ± 8.8 (34)
	11/01/89	32 ± 32 (86)	-11 ± 11 (50)
	01/29/90	13 ± 11 (27)	-3.4 ± 3.4 (16)
	05/02/90	35 ± 61 (160)	-35 ± 35 (160)
North Dakota Composite (Bismarck & Fargo)	08/21/89	-28 ± 28 (110)	-9.4 ± 9.4 (44)
	10/31/89	-110 ± 87 (330)	-27 ± 47 (180)
	02/05/90	19 ± 9.6 (22)	-2.4 ± 5.4 (19)

(a) All concentrations are below the MDC unless denoted by *.

Table 5.24 (Concentrations of ^{238}Pu and $^{239+240}Pu$ in Offsite Composited Air Samples - 1989-90, cont.)

Composite Sampling Location	Collection Date	Concentration ± 1s (MDC)[a] ^{238}Pu x 10^{-18} µCi/mL	Concentration ± 1s (MDC)[a] $^{239+240}Pu$ x 10^{-18} µCi/mL
Oregon Composite (Burns & Medford)	08/04/89	13 ± 17 (44)	0 ± 9.5 (31)
	10/31/89	-40 ± 110 (380)	0 ± 57 (190)
	01/26/90	0 ± 25 (83)	9 ± 15 (42)
	05/10/90	0 ± 15 (48)	10 ± 18 (48)
Texas Composite (Austin & Amarillo)	08/23/89	-23 ± 33 (120)	0 ± 16 (54)
	12/11/89	23 ± 62 (190)	0 ± 33 (110)
	03/30/90	3.2 ± 11 (33)	-3.2 ± 3.2 (15)
	06/28/90	-43 ± 62 (230)	22 ± 38 (100)
Utah Composite (Logan & Vernal)	08/21/89	Sample Lost	
	11/01/89	55 ± 79 (220)	28 ± 48 (130)
	01/29/90	14 ± 11 (27)	0 ± 4.8 (16)
	06/28/90	13 ± 23 (61)	0 ± 18 (61)
Salt Lake City, Utah	07/31/89	3.5 ± 7.1 (22)	1.8 ± 3.9 (12)
	08/28/89	9.6 ± 6.9 (18)	-1.9 ± 1.9 (9)
	09/25/89	5.7 ± 5.1 (13)	-1.9 ± 3.3 (13)
	10/30/89	10 ± 11 (32)	-3.4 ± 3.4 (16)
	11/27/89	7 ± 18 (55)	-6.8 ± 6.8 (32)
	12/26/89	6 ± 23 (72)	0 ± 12 (38)
	01/29/90	10 ± 4.9 (12)	-1.1 ± 1.1 (5.2)
	02/26/90	7.6 ± 3.5 (7.6)	1.9 ± 1.9 (4.4)
	03/26/90	4 ± 3 (7.7)	-0.8 ± 0.8 (3.9)
	04/30/90	-1.9 ± 5.7 (20)	3.8 ± 3.8 (8.8)
	05/28/90	11 ± 11 (25)	-5.3 ± 5.3 (25)
	06/25/90	-27 ± 17 (71)	0 ± 9.7 (32)
Washington Composite (Seattle & Spokane)	08/18/89	0 ± 10 (33)	5.8 ± 5.8 (14)
	10/31/89	-54 ± 43 (170)	0 ± 27 (89)
	01/25/90	-8 ± 25 (88)	8 ± 15 (40)
	05/02/90	Sample Lost	
Wyoming Composite (Worland & Rock Springs)	09/04/89	-9 ± 16 (62)	9 ± 16 (44)
	11/01/89	60 ± 67 (190)	0 ± 28 (93)
	02/05/90	7.6 ± 8.4 (24)	5.1 ± 5.1 (12)
	05/28/90	Sample Lost	

(a) All concentrations are below the MDC unless denoted by *.

Table 5.25 Offsite Noble Gas Surveillance Results - 1990

Sampling Location	Number of Samples Analyzed	Radio-nuclide	Radioactivity Concentration x 10^{-12} µCi/mL[a] Maximum	Minimum	Average	Percent of the Concentration Guide[b]
Shoshone, CA	49	^{85}Kr	33	20	26	<0.01
	49	^{133}Xe	4.5	-14	-0.20	<0.01
Alamo, NV	50	^{85}Kr	31	21	26	<0.01
	51	^{133}Xe	8.3	-16	0.25	<0.01
Austin, NV	49	^{85}Kr	31	21	27	<0.01
	49	^{133}Xe	11	-9.4	0.21	<0.01
Beatty, NV	52	^{85}Kr	32	21	26	<0.01
	52	^{133}Xe	9.0	-9.2	-0.09	<0.01
Caliente, NV	46	^{85}Kr	32	21	26	<0.01
	47	^{133}Xe	11	-12	-0.23	<0.01
Ely, NV	50	^{85}Kr	32	20	27	<0.01
	50	^{133}Xe	11	-13	0.34	<0.01
Goldfield, NV	50	^{85}Kr	32	20	27	<0.01
	52	^{133}Xe	8.0	-12	0.32	<0.01
Indian Springs, NV	52	^{85}Kr	30	21	27	<0.01
	52	^{133}Xe	8.4	-8.1	0.26	<0.01
Las Vegas, NV	47	^{85}Kr	33	20	26	<0.01
	47	^{133}Xe	4.5	-5.6	-0.28	<0.01
Lathrop Wells, NV	50	^{85}Kr	33	22	26	<0.01
	50	^{133}Xe	12	-10	-0.17	<0.01
Overton, NV	50	^{85}Kr	32	22	26	<0.01
	51	^{133}Xe	9.2	-12	0.15	<0.01
Pahrump, NV	49	^{85}Kr	30	21	26	<0.01
	50	^{133}Xe	7.7	-9.4	0.06	<0.01
Rachel, NV	49	^{85}Kr	32	21	27	<0.01
	52	^{133}Xe	10	-14	-0.46	<0.01
Tonopah, NV	49	^{85}Kr	31	22	26	<0.01
	51	^{133}Xe	16	-11	-0.66	<0.01
Cedar City, UT	49	^{85}Kr	32	21	26	<0.01
	49	^{133}Xe	9.0	-11	-0.13	<0.01
St. George, UT	48	^{85}Kr	31	20	27	<0.01
	49	^{133}Xe	6.3	-7.8	-0.48	<0.01

(a) The units used in this table (10^{-12} µCi/mL) are equal to, and the values in the table may be read as, pCi/m^3.

(b) The concentration guides referenced are calculated from the dose conversion factors for immersion as listed in DOE Order 5400.5, adjusted to 10 mrem effective dose equivalent as required by 40 CFR 61 for nonoccupational exposure to radionuclides in air.

Table 5.26 Offsite Tritium Surveillance Results - 1990

Sampling Location	Number of Samples Analyzed	Radioactivity Concentration x 10^{-12} µCi/mL[a]			Percent of the Concentration Guide[b]
		Maximum	Minimum	Average	
Shoshone, CA	53	5.4	-4.6	0.54	<0.01
Alamo, NV	50	13	-3.8	1.0	<0.01
Amargosa Center, NV	50	8.3	-2.7	0.77	<0.01
Amargosa Valley, NV	50	5.3	-3.1	0.25	<0.01
Austin, NV	52	4.6	-2.3	0.46	<0.01
Beatty, NV	52	3.3	-1.8	0.25	<0.01
Caliente, NV	51	8.3	-2.7	1.3	<0.01
Ely, NV	51	7.5	-1.5	0.74	<0.01
Goldfield, NV	50	16	-9.1	0.40	<0.01
Indian Springs, NV	48	2.8	-5.0	0.05	<0.01
Las Vegas, NV	53	2.8	-2.1	0.42	<0.01
Overton, NV	52	7.2	-3.3	0.88	<0.01
Pahrump, NV	52	12	-5.2	0.49	<0.01
Pioche, NV	51	5.1	-6.2	0.59	<0.01
Rachel, NV	51	10	-4.0	0.54	<0.01
Tonopah, NV	52	10	-4.6	0.86	<0.01
Cedar City, UT	52	5.0	-4.9	0.44	<0.01
St. George, UT	51	4.5	-2.3	0.65	<0.01
Salt Lake City, UT	49	6.4	-2.0	0.59	<0.01

(a) 10^{-12} µCi/mL ≡ pCi/m^3 of air.

(b) The concentration guides referenced are calculated from the dose conversion factors for inhalation as listed in DOE Order 5400.5, adjusted to 10 mrem effective dose equivalent as required by 40 CFR 61 for nonoccupational exposure to radionuclides in air.

only five of the samples had a detectable gamma emitter; ^{137}Cs was found in kidney samples.

The results of radiochemical analyses are reported as the median and range of concentrations detected in ashed samples. All the ^{90}Sr levels in the 28 bone samples from cattle, deer, and bighorn sheep were above the MDC. There were detectable levels of $^{239+240}$Pu in three deer lung, two cattle bone, and five cattle liver samples, all at very low levels. A couple of the deer rumen content samples had detectable plutonium levels, as would be expected for animals that graze on the NTS. A graph of the average ^{90}Sr levels found in animal bone ash since 1955 is shown in Figure 5.18.

The ^{3}H analysis of cow and deer blood samples and bighorn sheep kidney samples showed only background levels (median values were less than 400 pCi/L). None of the blood samples from deer contained elevated levels of ^{3}H, as has occurred frequently in previous years, probably because none of the collected deer drank from the tunnel ponds in Area 12.

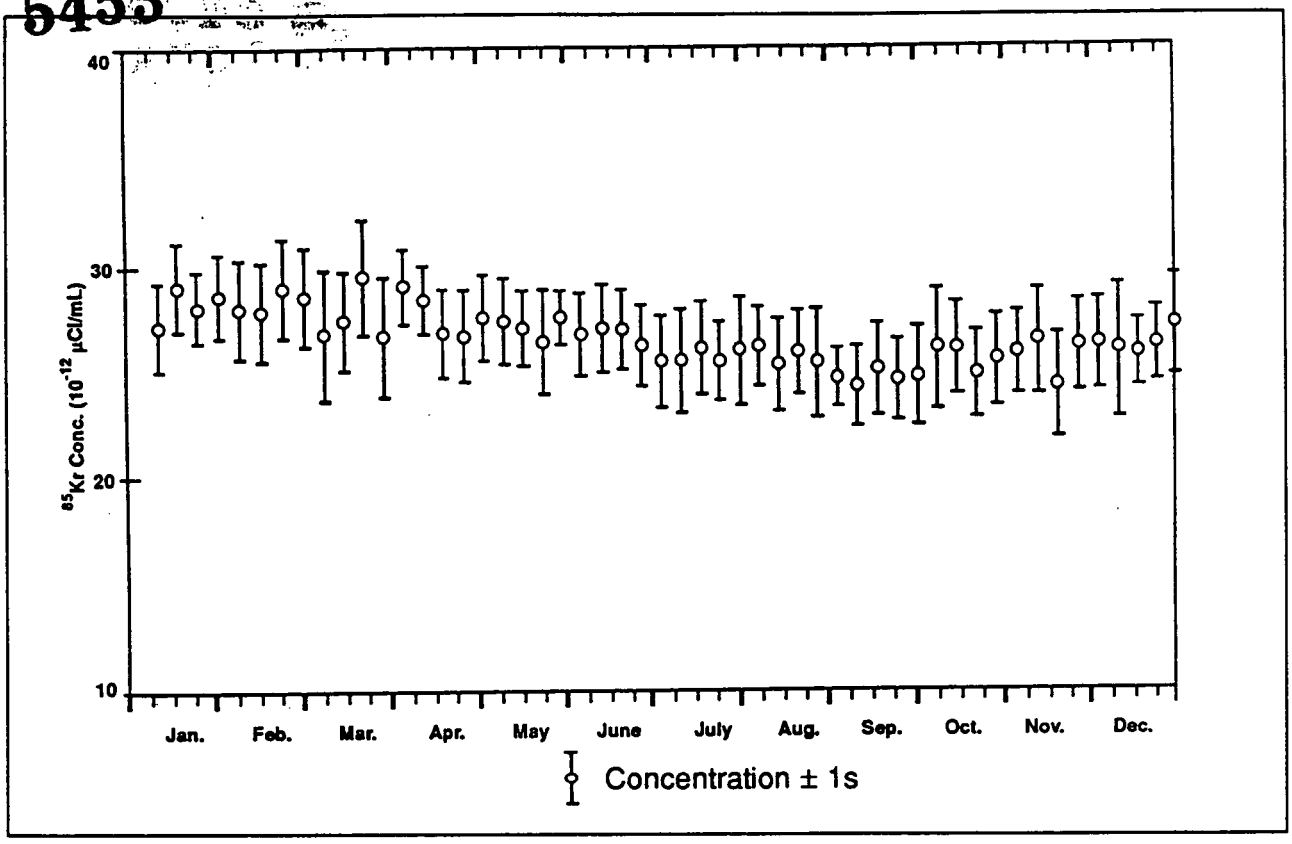


Figure 5.16 Network Weekly Average ^{85}Kr Concentrations in Air - 1990

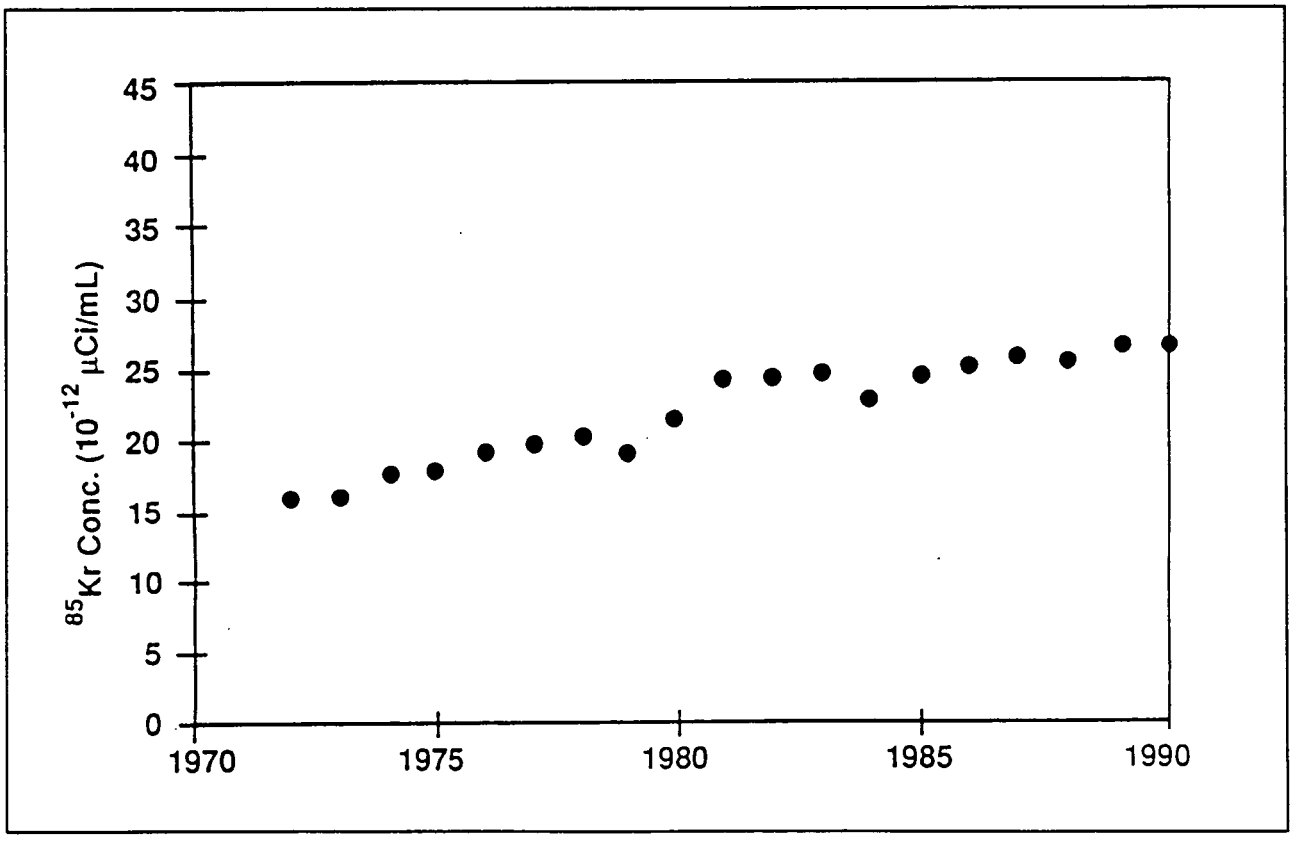


Figure 5.17 Annual EMSL-LV Network Average ^{85}Kr Concentration - 1972-90

Table 5.27 Radionuclide Concentrations in Desert Bighorn Sheep Samples taken in 1989

Bighorn Sheep (Collected in the Winter of 1989)	Percent Ash	Bone (^{90}Sr Concentration ± 1s) in pCi/g Ash	Bone (^{238}Pu Concentration ± 1s) x 10^{-3} pCi/g Ash	Bone ($^{239+240}Pu$ Concentration ± 1s) x 10^{-3} pCi/g Ash	Kidney (^{3}H Concentration ± 1s) x 10^{-9} µCi/mL[a]	Kidney (^{137}Cs Concentration ± 1s) x 10^{-2} pCi/g
1	42	1.7 ± 0.04	-3.4 ± 1.7	1.7 ± 1.6	130 ± 160[d]	5.1 ± 1.4
2	26	1.1 ± 0.04	8.9 ± 4.2	0.4 ± 1.2[d]	330 ± 100	-
3	40	1.1 ± 0.03	8.6 ± 3.3	0.5 ± 0.9[d]	20 ± 100[d]	-
4	32	1.3 ± 0.04	3.7 ± 5.6[d]	0.2 ± 0.8[d]	350 ± 100	-
5	31	1.4 ± 0.04	-0.9 ± 2.9[d]	0.2 ± 0.8[d]	20 ± 300[d]	-
6	26	1.4 ± 0.03	3.2 ± 3.6[d]	0.2 ± 0.9[d]	180 ± 100	-
7	26	0.7 ± 0.02	3.0 ± 3.9[d]	1.2 ± 1.5[d]	-120 ± 155[d]	-
8	28	1.4 ± 0.04	3.3 ± 3.7[d]	-0.3 ± 1.0[d]	95 ± 100[d]	-
9	25	0.3 ± 0.02	1.3 ± 3.1[d]	0.7 ± 1.1[d]	-120 ± 100[d]	-
10	31	0.4 ± 0.02	7.7 ± 4.2	-0.9 ± 0.8[d]	-75 ± 100[d]	-
11	33	1.0 ± 0.03	1.0 ± 3.6[d]	-1.0 ± 0.8[d]	-30 ± 155[d]	2.3 ± 0.7
12	24	1.2 ± 0.04	3.7 ± 3.3	0.7 ± 1.0[d]	100 ± 160[d]	-
13	21	0.5 ± 0.02	0.8 ± 3.3	0.3 ± 1.1[d]	70 ± 160[d]	-
14	22	0.5 ± 0.02	-2.0 ± 4.3[d]	1.2 ± 1.5	-230 ± 155[d]	-
15	30	0.4 ± 0.02	Lost	Lost	350 ± 150	-
16	22	1.9 ± 0.04	Lost	Lost	210 ± 100	-
17		Bone sample not collected			-140 ± 155[d]	9.7 ± 3.2
Median	27	1.1	3.25	0.25	95	5.1
Range	21 - 42	0.3 - 1.9	-3.4 - 8.9	-1.0 - 1.7	-230 - 350	2.3 - 9.7

(a) Aqueous portion of the kidney tissue.
(b) To convert pCi/g to Bq/kg divide the concentration by 0.027.
(c) To convert pCi/L to Bq/L divide the concentration by 27.
(d) The counting error exceeds the reported activity.
N/A = Not analyzed.

During the summer of 1990 samples of produce were collected from farms in Utah and Nevada. Failure of refrigeration at the EMSL-LV laboratory resulted in the loss of all samples except certain root vegetables. The samples analyzed included beets from Rachel, Nevada, and St. George, Utah; carrots from Enterprise, Utah; and potatoes from Hiko, Nevada. Other than naturally occurring ^{40}K, there were no detectable gamma emitters in the samples. None of the samples had concentrations of ^{3}H, ^{90}Sr, or ^{238}Pu that exceeded the MDC. However, beets from St. George, Utah, showed a detectable concentration of $^{239+240}Pu$; (7 ± 5) x 10^{-3} pCi/g of ash (≈0.07 pCi/kg of fresh weight). This was most likely due to incomplete washing of the soil off the sample.

5.2.2.4 EXTERNAL GAMMA EXPOSURE MONITORING

Annual exposures measured at 134 fixed environmental stations (see Section 4, Figure 4.10, for the location of these sampling

Table 5.28 Radiochemical Results For Animal Samples - 1990

Sample Type (Number)	Ash/Fresh Wt. Ratio	^{90}Sr pCi/g Median (Range)	$^{238}Pu \times 10^{-3}$ pCi/g Median (Range)	$^{239+240}Pu \times 10^{-3}$ pCi/g Median (Range)	^{3}H pCi/L Median (Range)
Cattle Blood (8)					145 (90-260)
Cattle Liver (8)	0.011		5.5 (4 - 7)	3 (-0.3 - 30)	
Deer Muscle (4)	0.008		4 (1 - 9)	2.4 (0.5 - 9)	
Deer Lung (4)	0.011		5.5 (4 - 40)	6.5 (3 - 70)	
Deer Liver (2)	0.018		4 (4 - 4)	2 (0.06 - 4)	
Deer Rumen Cont (4)	0.018		3 (2 - 10)	15 (9 - 20)	
Deer Blood (4)					135 (-40 - 240)
Deer Bone (4)	0.32	0.9 (0.5 - 1.0)	4 (0.9 - 8)	0.35 (-0.3 - 0.4)	
Cattle Bone (8)	0.24	1.1 (0.3 - 1.9)	3 (0.7 - 5)	0.9 (-0.9 - 5)	
Sheep Bone (16)	0.30	1.1 (0.3 - 1.7)	3.3 (-0.3 - 8.9)	0.25 (-1 - 1.7)	
Sheep Kidney (16)					95 [a] (-230 - 350)

(a) Aqueous portion of kidney tissue.

points) ranged from 18 to 391 mR, with a median of 73 mR. The low and high occurred at the University of Nevada, Las Vegas (UNLV), and Warm Springs, Nevada, fixed monitoring locations, respectively. The maximum net annual exposure of 391 mR at Warm Springs #2, Nevada, was determined to be due to high levels of naturally occurring radioactive material in spring water at that location (EPA 1991). A second TLD, Warm Springs #1, Nevada, is located in a parking lot approximately 100 feet from the spring. This TLD showed results consistent with historical data from this site. Table 5.29 details the results obtained at each of the fixed environmental stations monitored by TLDs during 1990.

Table 5.30 and Figure 5.19 summarize the range of ambient gamma radiation levels at fixed environmental station locations. These data illustrate that, when the result from Warm Springs #2 is excluded so that the overall network data are more representative

5459

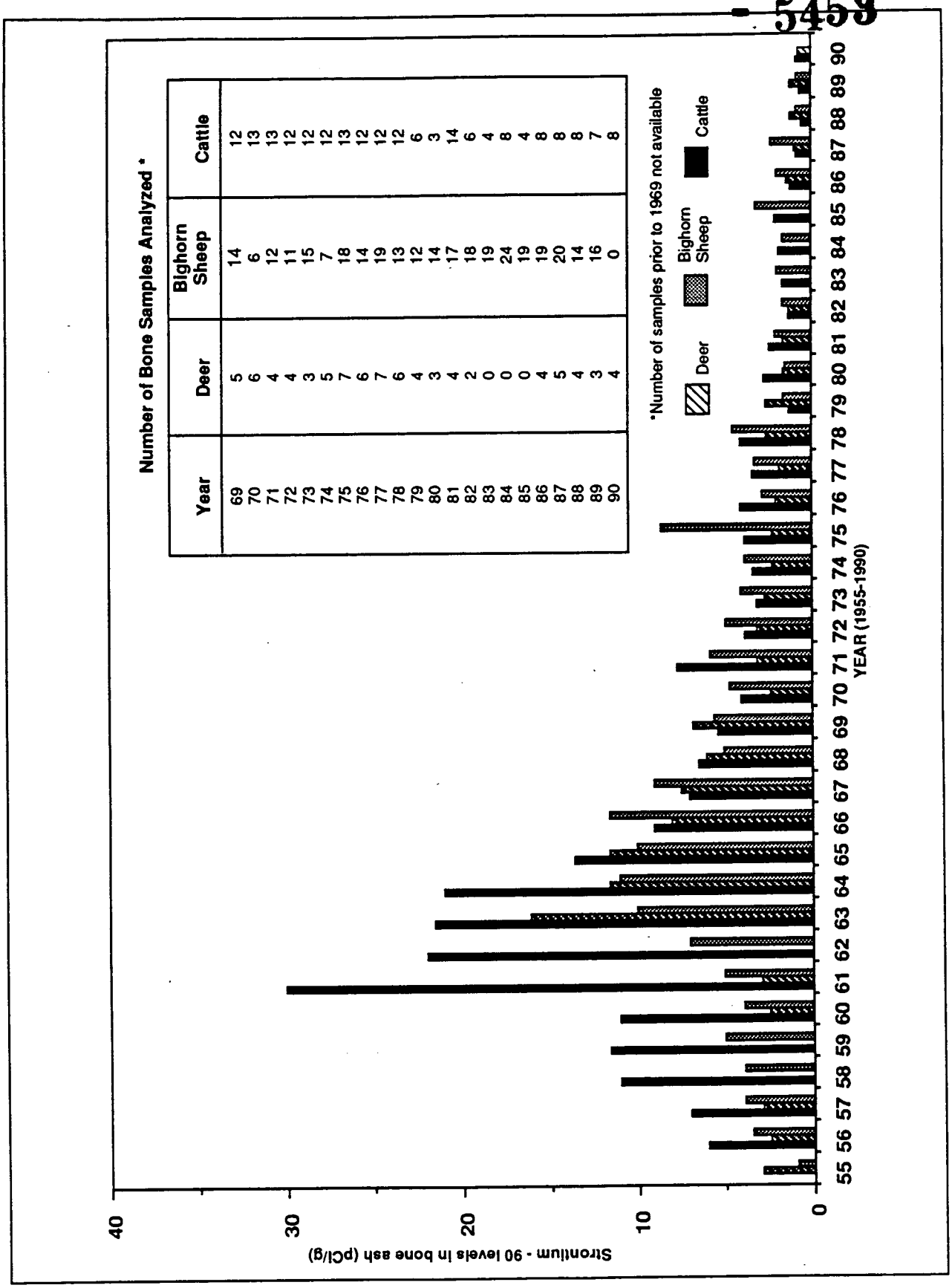


Figure 5.18 Average ^{90}Sr Concentrations in Animal Bone Ash - 1955-90

187

Table 5.29 Offsite Fixed Station TLD Results - 1990

Station Location	Measurement Period Issue Date	Measurement Period Collect Date	Measured Daily Exposure Equivalent (mR/day) Maximum	Minimum	Average	Gamma Exposure (mR/y)[a]
Arizona						
Colorado City	11/06/89	10/30/90	0.20	0.13	0.15	55
Jacob's Lake	11/06/89	10/30/90	0.27	0.18	0.22	80
Page	11/07/89	10/31/90	0.17	0.11	0.13	47
California						
Baker	11/07/89	11/01/90	0.22	0.18	0.20	73
Barstow	11/07/89	11/01/90	0.29	0.21	0.25	91
Bishop	11/14/89	11/03/90	0.28	0.20	0.24	88
Death Valley Junction	01/05/90	01/09/91	0.24	0.14	0.20	73
Furnace Creek	01/05/90	01/09/91	0.19	0.14	0.17	62
Independence	11/08/89	11/02/90	0.25	0.17	0.21	77
Lone Pine	11/08/89	11/02/90	0.25	0.18	0.21	77
Mammoth Geothermal	11/14/89	11/03/90	0.30	0.21	0.26	95
Mammoth Lakes	11/14/89	11/03/90	0.30	0.20	0.26	95
Olancha	11/08/89	11/02/90	0.25	0.18	0.22	80
Ridgecrest	11/08/89	11/02/90	0.25	0.16	0.20	73
Shoshone	11/07/89	11/01/90	0.19	0.13	0.16	58
Valley Crest	01/05/90	01/09/91	0.13	0.09	0.11	40
Nevada						
Alamo	11/01/89	10/30/90	0.25	0.18	0.21	77
Amargosa Center	01/04/90	11/27/90	0.20	0.17	0.19	69
Amargosa Valley	01/02/90	01/14/91	0.25	0.24	0.24	88
American Borate	01/02/90	01/14/91	0.32	0.25	0.29	106
Atlanta Mine	12/01/89	12/04/90	0.23	0.14	0.18	66
Austin	11/08/89	11/07/90	0.31	0.26	0.29	106
Battle Mountain	12/13/89	11/28/90	0.22	0.14	0.18	66
Beatty	01/04/90	01/09/91	0.35	0.27	0.30	110
Blue Eagle Ranch	01/03/90	01/08/91	0.19	0.13	0.16	58
Blue Jay	01/04/90	01/08/91	0.38	0.31	0.33	121
Cactus Springs	11/06/89	11/01/90	0.14	0.08	0.10	37
Caliente	11/01/89	10/29/90	0.26	0.19	0.21	77
Carp	11/01/89	10/29/90	0.24	0.16	0.19	69
Cherry Creek	11/29/89	12/05/90	0.30	0.18	0.23	84
Clark Station	01/03/90	01/08/91	0.32	0.28	0.30	110
Coaldale	11/07/89	11/06/90	0.26	0.22	0.24	88
Complex I	11/01/89	10/31/90	0.31	0.22	0.27	99
Corn Creek	11/06/89	11/01/90	0.10	0.05	0.07	26

(a) mR/y = Average mR/day x 365.25 days.

5453

Table 5.29 (Offsite Fixed Station TLD Results - 1990, cont.)

Station Location	Measurement Period Issue Date	Measurement Period Collect Date	Measured Daily Exposure Equivalent (mR/day) Maximum	Minimum	Average	Gamma Exposure (mR/y)[a]
Nevada, cont.						
Cortez Rd/Highway 278	12/12/89	11/28/90	0.32	0.21	0.25	91
Coyote Summit	11/01/89	10/30/90	0.36	0.24	0.30	110
Crescent Valley	12/12/89	11/28/90	0.22	0.15	0.18	66
Currant	01/04/90	01/09/91	0.29	0.26	0.28	102
Currie	11/29/89	12/05/90	0.31	0.20	0.25	91
Diablo Maintenance Station	01/05/90	01/03/91	0.39	0.32	0.35	128
Duckwater	01/04/90	01/08/91	0.28	0.23	0.25	91
Elgin	11/01/89	10/29/90	0.37	0.24	0.30	110
Elko	12/12/89	11/27/90	0.20	0.13	0.16	58
Ely	11/29/89	12/05/90	0.22	0.13	0.17	62
Eureka	01/04/90	01/15/91	1.97	0.24	0.70	256
Fallon	12/13/89	11/29/90	0.26	0.11	0.17	62
Flying Diamond Camp	11/01/89	10/31/90	0.21	0.13	0.17	62
Gabbs	11/07/89	11/06/90	0.15	0.14	0.15	55
Geyser Ranch	12/01/89	12/04/90	.29	0.18	0.22	80
Goldfield	11/09/89	11/13/90	0.22	0.19	0.21	77
Groom Lake	11/13/89	11/14/90	0.23	0.15	0.19	69
Hancock Summit	11/01/89	11/01/90	0.42	0.27	0.34	124
Hiko	11/01/89	10/30/90	0.19	0.12	0.15	55
Hot Creek Ranch	01/04/90	01/08/91	0.25	0.21	0.23	84
Indian Springs	11/06/89	11/01/90	0.12	0.07	0.09	33
Ione	11/07/89	11/06/90	0.24	0.20	0.22	80
Kirkeby Ranch	12/01/89	12/04/90	0.22	0.13	0.16	58
Koyne's Ranch	11/01/89	11/01/90	0.26	0.17	0.21	77
Las Vegas Airport	01/02/90	01/02/91	0.10	0.04	0.07	26
Las Vegas Airport - Test	01/02/90	01/02/91	0.18	0.01	0.11	40
Las Vegas (UNLV)	01/02/90	01/02/91	0.09	0.02	0.05	18
Las Vegas (DOI)	01/02/90	01/02/91	0.16	0.08	0.12	44
Las Vegas (DOI) - Test	01/02/90	01/02/91	0.10	0.01	0.07	26
Lavada's Market	01/04/90	01/14/91	0.29	0.22	0.26	95
Lida	11/01/89	11/13/90	0.24	0.20	0.22	80
Lovelock	12/13/89	11/28/90	0.21	0.11	0.16	58
Lund	11/30/89	12/06/90	0.23	0.13	0.18	66
Manhattan	11/08/89	11/07/90	0.32	0.27	0.29	106
Medlin's Ranch	11/01/89	11/01/90	0.31	0.22	0.26	95
Mesquite	11/02/89	10/29/90	0.15	0.11	0.12	44
Mina	11/07/89	11/06/90	0.23	0.18	0.21	77
Moapa	11/02/89	10/29/90	0.53	0.15	0.27	99
Mountain Meadows Ranch	01/03/90	01/03/91	0.19	0.15	0.17	62

(a) mR/y = Average mR/day x 365.25 days.

189

Table 5.29 (Offsite Fixed Station TLD Results - 1990, cont.)

Station Location	Measurement Period Issue Date	Measurement Period Collect Date	Measured Daily Exposure Equivalent (mR/day) Maximum	Minimum	Average	Gamma Exposure (mR/y)[a]
Nevada, cont.						
Nash Ranch	11/01/89	10/30/90	0.22	0.15	0.18	66
Nevada Low-Level Waste Site	01/04/90	01/10/91	0.32	0.28	0.30	110
Nyala	01/03/90	01/03/91	0.23	0.18	0.20	73
Overton	11/02/89	10/29/90	0.44	0.11	0.21	77
Pahrump	11/06/89	11/01/90	0.11	0.06	0.09	33
Penoyer Farms	11/01/89	10/31/90	0.35	0.23	0.29	106
Pine Creek Ranch	11/01/89	10/31/90	0.35	0.25	0.30	110
Pioche	11/01/89	10/29/90	0.21	0.16	0.18	66
Queen City Summit	01/05/90	01/03/91	0.37	0.33	0.35	128
Rachel	11/01/89	10/31/90	0.30	0.21	0.26	95
Reed Ranch	01/05/90	01/03/91	0.33	0.29	0.31	113
Reno	12/14/89	11/29/90	0.20	0.12	0.15	55
Round Mountain	11/08/89	11/07/90	0.29	0.23	0.26	95
Ruby Valley	12/12/89	11/27/90	0.32	0.19	0.24	88
Southern Desert Correctional Center	11/06/89	11/01/90	0.11	0.06	0.08	29
Shurz	12/14/89	11/29/90	0.30	0.17	0.21	77
Silver Peak	11/07/89	11/13/90	0.17	0.14	0.16	58
Springdale	01/04/90	01/11/91	0.37	0.27	0.30	110
Steward Ranch	12/01/89	12/04/90	0.31	0.20	0.27	99
Stone Cabin Ranch	01/03/90	01/03/91	0.32	0.28	0.30	110
Sunnyside	11/30/89	12/06/90	0.15	0.08	0.11	40
Tempiute	11/01/89	11/01/90	0.30	0.22	0.27	99
Tonopah	11/08/89	11/07/90	0.29	0.24	0.26	95
Tonopah Test Range	01/04/90	01/02/91	0.35	0.31	0.33	121
Twin Springs Ranch	01/03/90	01/03/91	0.33	0.27	0.30	110
Uhalde's Ranch	11/01/89	10/31/90	0.32	0.21	0.27	99
U.S. Ecology	01/04/90	01/11/91	0.33	0.29	0.31	113
Warm Springs #1	01/03/90	01/03/91	0.45	0.35	0.38	139
Warm Springs #2	01/03/90	01/03/91	1.12	0.99	1.07	391
Wells	12/12/89	11/27/90	0.24	0.14	0.18	66
Winnemucca	12/13/89	11/28/90	0.24	0.15	0.19	69
Young's Ranch	11/08/89	11/07/90	0.22	0.09	0.17	62
Utah						
Boulder	12/01/89	12/05/90	0.23	0.15	0.18	66
Bryce Canyon	12/01/89	12/05/90	0.21	0.13	0.16	58
Cedar City	12/04/89	11/28/9	0.18	0.11	0.14	51
Delta	01/08/90	01/30/91	0.21	0.17	0.19	69

(a) mR/y = Average mR/day x 365.25 days.

190

Table 5.29 (Offsite Fixed Station TLD Results - 1990, cont.)

Station Location	Measurement Period Issue Date	Measurement Period Collect Date	Measured Daily Exposure Equivalent (mR/day) Maximum	Minimum	Average	Gamma Exposure (mR/y)[a]
Utah, cont.						
Duchesne	01/10/90	01/29/91	0.18	0.14	0.16	58
Enterprise	12/01/89	11/27/90	0.36	0.23	0.29	106
Ferron	01/10/90	01/29/91	0.18	0.14	0.16	58
Garrison	11/29/89	12/05/90	0.21	0.12	0.16	58
Grantsville	01/09/90	01/30/91	0.19	0.14	0.17	62
Green River	11/07/89	10/31/90	0.20	0.14	0.16	58
Gunnison	12/01/89	12/06/90	0.15	0.11	0.13	46
Ibapah	11/29/89	12/05/90	0.27	0.19	0.23	84
Kanab	11/06/89	10/30/90	0.15	0.10	0.12	44
Loa	12/01/89	12/05/90	0.36	0.24	0.29	106
Logan	01/03/90	01/10/91	0.22	0.09	0.14	51
Lund	12/01/89	11/28/90	0.31	0.19	0.24	88
Milford	12/01/89	12/04/90	0.35	0.23	0.28	102
Monticello	11/07/89	10/31/90	0.26	0.17	0.20	73
Nephi	01/09/90	12/06/90	0.18	0.13	0.16	58
Parowan	12/01/89	12/04/90	0.20	0.12	0.16	58
Price	01/10/90	01/29/91	0.19	0.15	0.17	62
Provo	01/09/90	01/29/91	0.16	0.12	0.14	51
Salt Lake City	01/03/90	01/30/91	0.19	0.11	0.16	58
St. George	12/04/89	11/28/90	0.14	0.09	0.11	40
Trout Creek	11/29/89	12/05/90	0.23	0.13	0.18	66
Vernal	01/09/90	01/29/91	0.19	0.15	0.17	62
Vernon	01/08/90	01/30/91	0.26	0.16	0.20	73
Wendover	12/11/89	11/27/90	0.19	0.11	0.14	51
Willow Springs Lodge	01/09/90	01/30/91	0.17	0.13	0.15	55

(a) mR/y = Average mR/day x 365.25 days.

of potential NTS-related radioactivity, the means and ranges of measured ambient gamma exposures are very similar throughout the geographic area covered by this network.

Annual exposures at fixed environmental stations were evaluated to determine historical trends. Data for past years were taken from previous annual reports of the offsite monitoring program. Data for 1990 showed no statistically significant variation in annual ambient gamma exposure levels from those reported in previous years dating back to 1973. No statistically significant variation based on state or other location criterion was noted in the historic data. Figure 5.20 illustrates the average ± 2s annual exposures obtained at all fixed monitoring stations in each year since 1971.

Of 71 offsite residents monitored with personal TLDs, 20 showed zero detectable exposure above that measured at the associated reference background location. The apparent individual exposures of the rest

Table 5.30 Offsite Fixed Station TLD Statistics - 1990

	All States	Arizona	California	Nevada	Utah
Number of Fixed Stations Monitored:	134	3	13	89	29
Number of Days Each Station Monitored:					
Maximum	392	358	369	377	392
Average	365	358	360	363	370
Median	364	358	359	364	370
Minimum	331	358	354	327	331
Equivalent Exposure Rate (mR/day):					
Maximum	1.07	0.22	0.26	1.07	0.30
Average	0.22	0.17	0.21	0.23	0.18
Median	0.20	0.15	0.21	0.21	0.16
Minimum	0.05	0.13	0.11	0.05	0.10
Median Exposure in the Monitoring Period (mR/day x median days):					
	79.0	59.7	74.3	76.4	65.6
Range of Exposures in One Year (mR/day x 365.25)					
Maximum	391	80	95	391	106
Average	79.3	60.9	75.6	85.0	64.7
Median	73	55	77	77	58
Minimum	18	47	40	18	40

were slightly greater than the associated reference background. These ranged from 3.7 to 175.3 mrem absorbed dose equivalent for the year. Each of these represented total exposures obtained from several dosimeters worn during the year.

Apparent exposures to an individual dosimeter of less than 1.72 times the associated reference background are considered to be within the range of normal variation for the TLD system. Only one individual was determined by investigation of the apparent net individual exposures to represent an abnormal occurrence. This person was a worker at the Nevada Low Level Waste Site near Beatty, Nevada, and wore three different dosimetry badges. Because none of the other badges showed a detectable exposure, it was determined that somehow the badge and not the individual had been exposed. Although other badges showed higher than background levels, in no case did any individual or cumulative exposure exceed regulatory limits or ALARA-investigation levels. However, investigations are being conducted in each case where a significant above-background exposure was

192

5453

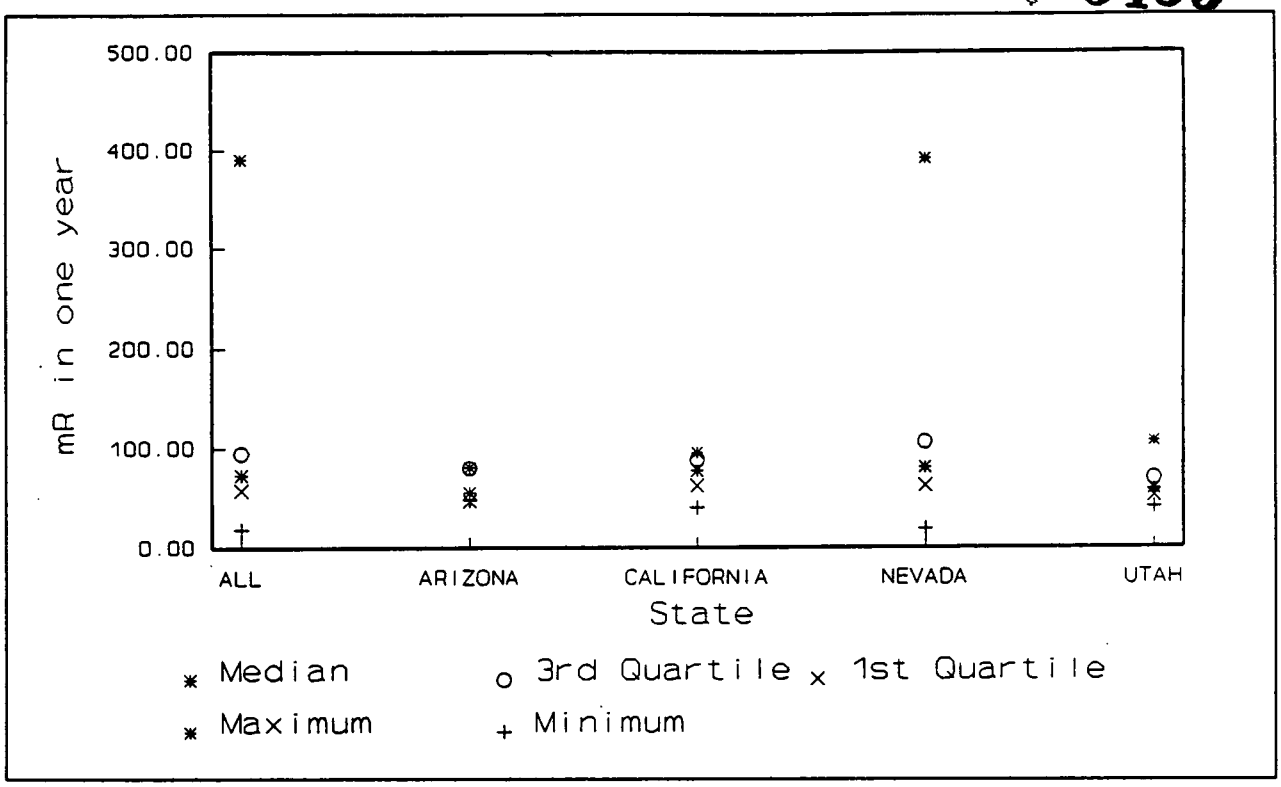


Figure 5.19 Range of Ambient Gamma Exposures at Offsite Fixed Stations by State - 1990

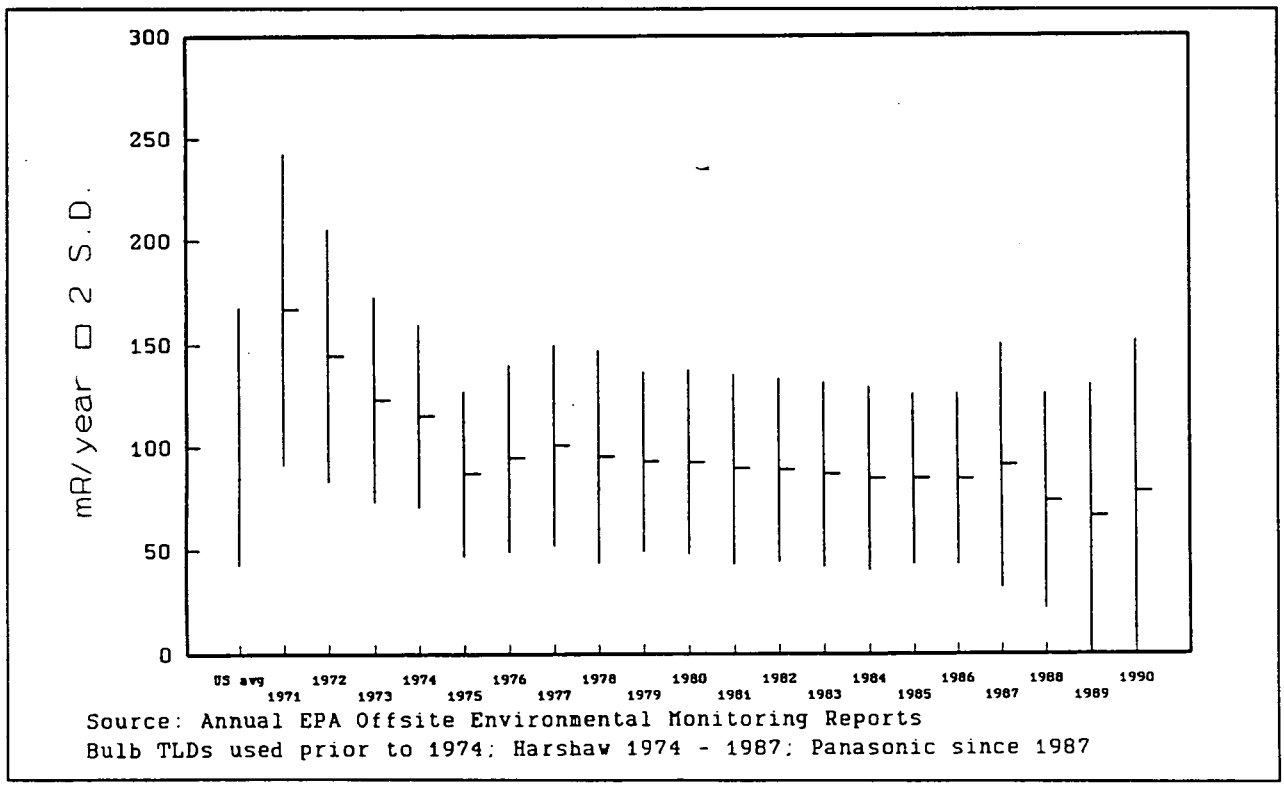


Figure 5.20 Historical Trends - TLD Exposures at Offsite Fixed Stations - 1971-90

193

noted in an attempt to determine any other factor(s) that may have resulted in the reported exposures. Table 5.31 lists the results of offsite personnel TLD monitoring for 1990, and Table 5.32 provides a statistical summary of those data. Figure 5.21 summarizes the TLD monitoring results for offsite residents living in California, Nevada, and Utah. There was no statistically significant difference between the states in the recorded minima, maxima, or means.

5.2.2.5 PRESSURIZED ION CHAMBER NETWORK

The stations of the external gamma exposure rate monitoring network, or Pressurized Ion Chamber (PIC) network, are shown in Section 4, Figure 4.12. Data for 1990 are displayed in Table 5.33 as the average μR/h and annual mR/year from each station. Figure 5.22 shows annual averages for each location in mR/year as compared to the maximum and minimum U.S. background (BEIR 1980). The averages of the 28 PICs varied from 50 mR/year (1.3×10^{-5} C·kg^{-1}·year^{-1}) at Las Vegas, Nevada, to 160 mR/year (4.1×10^{-5} C·kg^{-1}·year^{-1}) at Austin, Nevada. The U.S. background maximum and minimum values shown represent the highest and lowest values, respectively, of the combined terrestrial and cosmic components of environmental gamma radiation exposure.

The PIC network showed no unexplained deviations from background levels during 1990. The 1990 PIC data is consistent with previous year trends. No prolonged unexplained deviations from background levels occurred during the year.

COMPARING ROUTINE TLD RESULTS WITH DIRECT EXPOSURE MEASUREMENTS

When calculated TLD exposures were compared with results obtained from a collocated PIC, a uniform under-response of TLD versus PIC was noted. The TLDs consistently recorded calculated exposures of approximately one-half those recorded by PICs as shown by the correlation graph in Figure 5.23. This difference may be attributed to the following factors:

- The PIC measures ionization in air (the roentgen) while the TLD measures energy deposited in matter (the rad). Results of the two methods are not adjusted to account for this difference.

- The PIC is an exposure rate measuring device sampling every five seconds, while the TLD, as an integrating dosimeter, is analyzed approximately once each quarter. Some reduction in TLD results may be due to a small loss due to normal fading. (Studies by Panasonic have shown this loss to be minimal over the sampling period used.) A six-month fade study is currently being completed to confirm that fading is negligible.

- PICs are more sensitive to lower-energy gamma radiation than are the TLDs. A review of manufacturer's specifications for the PIC and TLD systems shows their responses to be almost linear above approximately 80 keV and above approximately 150 keV, respectively.

- The PIC units are calibrated by the manufacturer against ^{60}Co, while the TLDs are calibrated using ^{137}Cs. No adjustment is made to account for the differing energies at which the two systems are calibrated or the different shielding involved. Studies are planned for 1991 to determine the extent to which these factors influence PIC response.

- The use of TLDs for environmental monitoring requires several approximations, each of which contributes to the noted difference between the two systems.

For these reasons, it is important that neither the TLD nor the PIC be considered as a "definitive" device, but the two work as

Table 5.31 Offsite Resident TLD Results - 1990

Resident Identification Number	Associated Reference Background Location	Measurement Period Issue Date	Measurement Period Collect Date	Equivalent Dose Rate (mrem/day) Max.	Equivalent Dose Rate (mrem/day) Min.	Equivalent Dose Rate (mrem/day) Avg.	Annual Measured Dose (mrem/yr)[a]	Associated Reference Background Exposure (mR/yr)
Arizona								
No individuals residing in Arizona were monitored during the period covered by this report.								
California								
359	Death Valley Junction	01/04/90	01/10/91	0.32	0.09	0.21	78	51
304	Death Valley Junction	01/05/90	01/09/91	0.45	0.22	0.35	129	51
60	Shoshone	01/02/90	01/08/91	0.88	0.02	0.28	104	47
404	Shoshone	04/02/90	01/16/91	0.83	0.08	0.34	98	47
Nevada								
22	Alamo	01/10/90	01/03/91	0.30	0.09	0.17	61	66
426	Amargosa Valley	10/11/90	01/03/91	0.28	0.21	0.24	20	62
329	Austin	01/10/90	01/16/91	0.39	0.02	0.26	96	95
21	Beatty	01/04/90	01/10/91	0.45	0.05	0.22	82	99
38	Beatty	01/04/90	01/09/91	0.54	0.17	0.31	115	99
358	Beatty	01/04/90	01/11/91	5.40	0.11	0.75	279	99
9	Blue Eagle Ranch	01/03/90	01/11/91	0.85	0.07	0.24	90	47
2	Caliente	01/08/90	01/09/91	0.37	0.11	0.25	92	69
336	Caliente	01/08/90	01/02/91	0.31	0.07	0.16	57	69
10	Complex I	01/09/90	01/03/91	0.36	0.06	0.20	72	80
11	Complex I	01/09/90	01/03/91	0.36	0.06	0.17	61	80
25	Corn Creek	01/02/90	01/02/91	0.17	0.00	0.08	29	18
56	Corn Creek	01/02/90	01/02/91	0.24	0.01	0.11	40	18
14	Coyote Summit	01/09/90	01/04/91	0.26	0.04	0.17	61	88
15	Coyote Summit	01/09/90	01/04/91	0.28	0.03	0.17	61	88
47	Ely	01/08/90	01/09/91	0.27	0.05	0.17	62	47
233	Ely	01/08/90	12/06/90	0.31	0.07	0.16	53	47
302	Gabbs	01/09/90	01/15/91	0.46	0.03	0.18	67	51
7	Goldfield	01/16/90	01/17/91	0.44	0.04	0.21	77	69
19	Goldfield	01/17/90	01/17/91	0.38	0.03	0.19	69	69
40	Goldfield	01/12/90	01/17/91	0.77	0.03	0.19	70	69
424	Halloway Ranch	11/15/90	01/10/91	0.29	0.22	0.25	14	88
232	Hiko	01/09/90	01/04/91	0.28	0.12	0.19	68	44
3	Hot Creek Ranch	01/04/90	01/09/91	0.45	0.00	0.23	85	77
6	Indian Springs	01/02/90	01/07/91	0.67	0.01	0.22	81	26
37	Indian Springs	01/02/90	01/07/91	0.42	0.02	0.12	44	26
405	Indian Springs	04/02/90	01/07/91	0.28	0.08	0.17	48	26
381	Ione	01/09/90	01/15/91	0.58	0.03	0.24	89	73
300	Koyne's Ranch	01/09/90	01/03/91	0.24	0.02	0.12	43	62
49	Las Vegas (UNLV)	01/02/90	01/02/91	0.25	0.02	0.11	40	18
381	Ione	01/09/90	01/15/91	0.58	0.03	0.24	89	73

(a) mrem/yr = Average mrem/day multiplied by the number of days.

Table 5.31 (Offsite Resident TLD Results - 1990, cont.)

Resident Identification Number	Associated Reference Background Location	Measurement Period Issue Date	Measurement Period Collect Date	Equivalent Dose Rate (mrem/day) Max.	Equivalent Dose Rate (mrem/day) Min.	Equivalent Dose Rate (mrem/day) Avg.	Annual Measured Dose (mrem/yr)[a]	Associated Reference Background Exposure (mR/yr)
Nevada, cont.								
300	Koyne's Ranch	01/09/90	01/03/91	0.24	0.02	0.12	43	62
49	Las Vegas (UNLV)	01/02/90	01/02/91	0.25	0.02	0.11	40	18
297	Las Vegas (USDI)	01/02/90	01/02/91	0.30	0.01	0.10	37	29
326	Las Vegas (USDI)	01/02/90	01/02/91	0.20	0.00	0.09	33	29
376	Las Vegas (USDI)	01/02/90	01/02/91	0.19	0.02	0.09	33	29
377	Las Vegas (USDI)	01/02/90	01/02/91	0.21	0.02	0.10	37	29
398	Las Vegas (USDI)	03/05/90	01/02/91	0.99	0.09	0.32	97	29
399	Las Vegas (USDI)	03/05/90	01/02/91	0.29	0.03	0.14	42	29
400	Las Vegas (USDI)	03/05/90	11/06/90	0.26	0.01	0.13	32	29
401	Las Vegas (USDI)	03/05/90	11/06/90	0.79	0.04	0.26	64	29
402	Las Vegas (USDI)	03/05/90	01/02/91	0.81	0.03	0.29	88	29
403	Las Vegas (USDI)	03/05/90	01/02/91	0.97	0.02	0.25	76	29
342	Lavada's Market	01/04/90	10/11/90	0.24	0.09	0.17	48	80
380	Lavada's Market	01/04/90	01/03/91	0.32	0.00	0.19	69	80
379	Manhattan	01/10/90	01/16/91	0.52	0.01	0.22	82	99
307	Mina	01/09/90	01/15/91	0.39	0.04	0.20	74	66
18	Nyala	01/03/90	01/03/91	0.39	0.04	0.18	66	66
348	Overton	01/04/90	01/02/91	0.27	0.05	0.16	58	40
36	Pahrump	01/02/90	07/17/90	0.38	0.11	0.21	41	22
372	Pahrump	01/02/90	01/03/91	0.27	0.04	0.14	51	22
410	Pahrump	04/02/90	01/08/91	0.36	0.02	0.15	42	22
411	Pahrump	04/02/90	01/08/91	0.37	0.03	0.19	53	22
248	Penoyer Farms	01/09/90	01/03/91	0.37	0.13	0.21	75	84
293	Pioche	01/08/90	01/02/91	0.32	0.10	0.21	75	58
264	Rachel	01/09/90	01/04/91	0.54	0.16	0.27	97	77
334	Rachel	01/09/90	01/03/91	0.35	0.08	0.20	72	77
299	Round Mountain	01/10/90	01/16/91	0.35	0.03	0.21	78	84
341	Silver Peak	01/17/90	01/17/91	0.34	0.04	0.19	69	51
29	Stone Cabin Ranch	01/03/90	01/03/91	0.55	0.10	0.34	124	102
42	Tonopah	01/19/90	01/17/91	4.11	0.04	0.54	196	88
339	Tonopah	01/11/90	01/17/91	0.60	0.04	0.28	104	88
370	Twin Springs Ranch	01/03/90	01/03/91	0.38	0.11	0.25	91	99
Utah								
44	Cedar City	01/04/90	01/02/91	0.34	0.05	0.17	62	40
344	Delta	01/08/90	01/02/91	0.93	0.04	0.24	86	62
345	Delta	01/08/90	01/02/91	0.58	0.05	0.24	86	62
346	Milford	01/08/90	01/02/91	0.84	0.04	0.24	86	84
347	Milford	01/08/90	01/02/91	0.62	0.05	0.26	93	84
52	Salt Lake City	01/03/90	01/02/91	0.29	0.04	0.17	62	40
45	St. George	01/04/90	01/02/91	0.51	0.03	0.15	54	33

(a) mrem/yr = Average mrem/day multiplied by the number of days in the year.

Table 5.32 Offsite Resident TLD Statistics - 1990

	All States	Arizona	California	Nevada	Utah
Number of Individuals Monitored:	71	0	4	60	7
Number of Days Each Station was Monitored:					
Maximum	373		371	373	364
Average	341.2		350.0	338.4	360
Median	363		369	365	359
Minimum	56		289	56	359
Equivalent Daily Ambient Gamma Exposures (mR/day)					
Maximum	1.11		0.35	1.11	0.26
Average	0.25		0.31	0.25	0.21
Median	0.21		0.31	0.20	0.24
Minimum	0.09		0.27	0.09	0.15
Median Dose Equivalent in Monitoring Period (mrem/day x median days)					
	76.2		114.4	73.0	86.2
Range of Dose Equivalents in One Year (mrem/day x 365.25)					
Maximum	274		128	274	95
Average	78.1		107.7	76.3	76.7
Median	73		113	69	88
Minimum	29		77	29	55

complementary components of a comprehensive environmental monitoring system.

5.2.2.6 OFFSITE DOSIMETRY PROGRAM

During 1990 EPA obtained a total of 1500 gamma spectra from whole-body counting of 236 individuals of whom 120 were participants in the Offsite Dosimetry Program (see Section 4, Figure 4.13 for the location of the participating families). In general the spectra were representative of normal background and showed only naturally occurring ^{40}K. No transuranic radionuclides were detected in any lung counting data.

Bioassay results for the Offsite Dosimetry Program showed that the concentration of tritium in single urine samples collected at random periods of time varied from below the MDC to 5.5 x 10^{-7} µCi/mL (20 Bq/L, see Table 5.34). The average value for 115 samples analyzed for tritium in urine was 1.0 x 10^{-7} µCi/mL (3.7 Bq/L). Only four percent of the concentrations were above the MDC, and none of those values above the MDC were over applicable limits. The highest value, 5.5 x 10^{-7} µCi/mL, was only 0.02 percent of the Annual Limit of Intake for the general public.

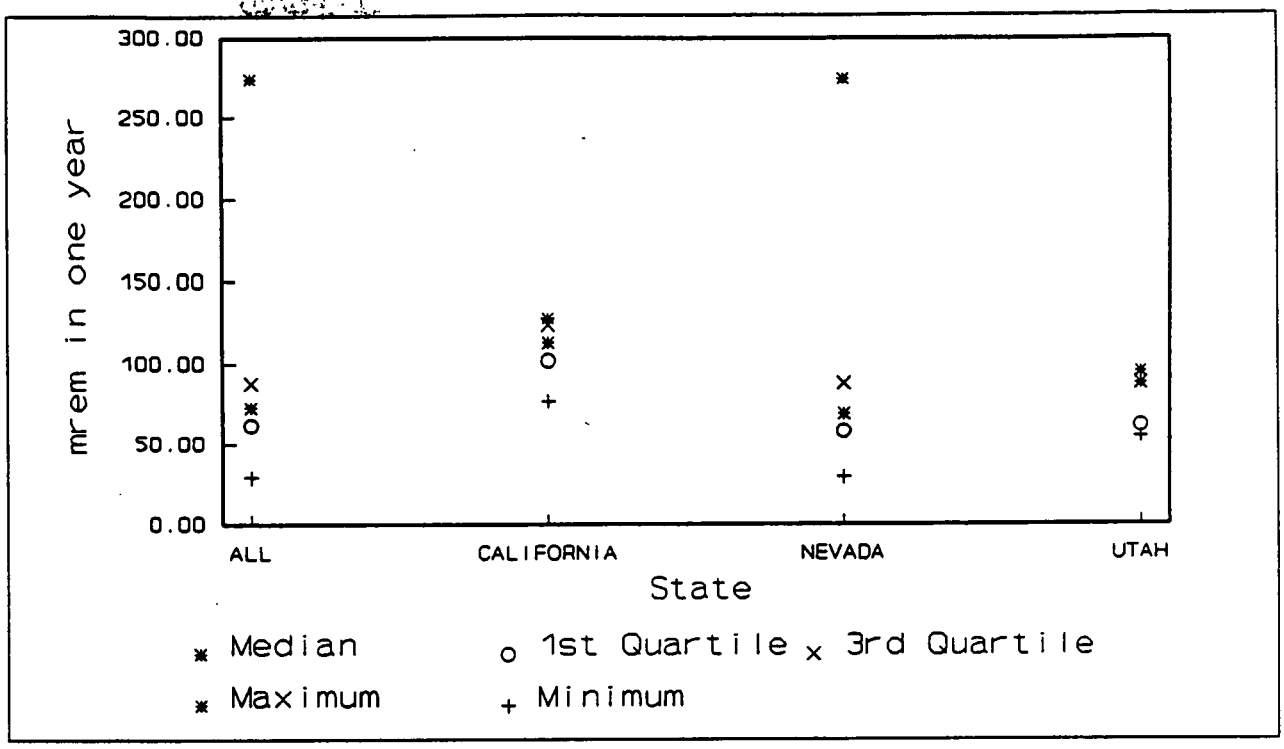


Figure 5.21 Range of Ambient Gamma Exposures of Offsite Residents by State - 1990

The higher-than-MDC ^{3}H values seen in individual urine samples from the offsite population occur routinely. There appears to be no correlation between the higher-than-MDC ^{3}H levels and the ^{3}H found in air samples at any statistically acceptable confidence level. Biological indicators of exposure have been shown to be much more sensitive than instruments as they concentrate the activity over time. However, these samples cannot be used as other than indicators of exposure because they are single random samples.

As reported in previous years, medical examinations of the offsite families revealed a generally healthy population. The blood examinations and thyroid profiles showed no symptoms which could be attributed to past or present NTS testing operations. External exposure data as measured by TLDs are presented in Section 5.2.2.4.

The plot of the average tritium in urine from the Offsite Dosimetry Program, Figure 5.24, shows the values from 1981 through 1990.

As no planned releases from NTS occurred in 1990, no additional bioassay sampling was performed.

5.2.2.7 MILK SURVEILLANCE NETWORK

Although all samples collected for the MSN (see Section 4, Figure 4.8, for sampling locations) and SMSN (Figure 4.9) were analyzed for gamma-emitting radionuclides, only naturally occurring ^{40}K was detected for either network in any sample. (See Section 5, Table 5.35 for detectable results from the MSN.) No tritium above the minimum detectable concentration (MDC) was found in any of the samples from locations on the MSN. Tritium above the MDC was found in one location on the SMSN (Boise, Idaho). No ^{89}Sr above the MDC was found in any of the MSN or SMSN samples. Strontium-90 above the MDC was measured in (1) four samples from two different locations during the year on the MSN and (2) 17 samples from the SMSN. These samples were from locations where ^{90}Sr had been detected previously. Results for the SMSN are

198

Table 5.33 Pressurized Ion Chamber Readings - 1990

Station Location	Number of Weekly Values	Exposure Rate[a] in µR/h[b] Minimum	Maximum	Avg. ± 1s	mR/year[c]
Alamo, NV	53	13	14	13 ± 0.3	115
Amargosa, NV	52	11	11	11 ± 0.2	96
Austin, NV	53	14	20	19 ± 1.2	160
Beatty, NV	53	16	17	17 ± 0.3	150
Caliente, NV	53	14	15	14 ± 0.4	127
Cedar City, UT	53	9.5	11	10 ± 0.4	88
Complex I, NV	53	15	17	16 ± 0.4	140
Delta, UT	53	11	13	11 ± 0.4	100
Ely, NV	53	12	14	13 ± 0.4	110
Furnace Creek, CA	53	9.4	11	10 ± 0.3	87
Goldfield, NV	53	11	16	15 ± 1.2	130
Indian Springs, NV	53	8.7	9.5	9.0 ± 0.2	79
Las Vegas, NV	53	5.5	6.2	5.7 ± 0.2	50
Lathrop Wells, NV	53	14	15	14 ± 0.3	120
Medlin's Ranch, NV	53	15	17	16 ± 0.2	140
Milford, UT	53	16	18	17 ± 0.5	150
Nyala, NV	53	12	14	13 ± 0.3	110
Overton, NV	53	8.7	9.8	9.2 ± 0.2	81
Pahrump, NV	53	7.4	8.2	7.7 ± 0.2	68
Pioche, NV	53	11	13	12 ± 0.5	100
Rachel, NV	53	12	18	16 ± 1.5	140
St. George, UT	53	8.5	9.5	8.9 ± 0.3	78
Salt Lake City, UT	53	10	11	11 ± 0.2	95
Shoshone, CA	53	11	13	12 ± 0.4	100
Stone Cabin Ranch, NV	53	16	19	17 ± 0.8	152
Tonopah, NV	53	16	18	16 ± 0.4	140
Twin Springs Ranch, NV	53	16	19	17 ± 0.6	148
Uhalde's Ranch, NV	53	15	18	17 ± 0.7	149

(a) Weekly averages.
(b) Multiply µR/h by 2.6×10^{-10} to obtain $C \cdot kg^{-1} \cdot h^{-1}$.
(c) Multiply mR/year by 2.6×10^{-7} to obtain $C \cdot kg^{-1} \cdot y^{-1}$.

included in Appendix D, "Summary of Results for the Offsite Standby Milk Surveillance Network - 1990."

Analytical results from the MSN are available from the beginning of the network, allowing some results to be compared over time. Figure 5.25 shows that the levels of ^{90}Sr in Las Vegas, Salt Lake City, and New Orleans milk samples have decreased since the 1960s, when atmospheric weapons testing was conducted in locations worldwide. The analyses shown on the figure were performed on samples from the Pasteurized Milk Network that is operated by the EPA's National Air and Radiation Environmental

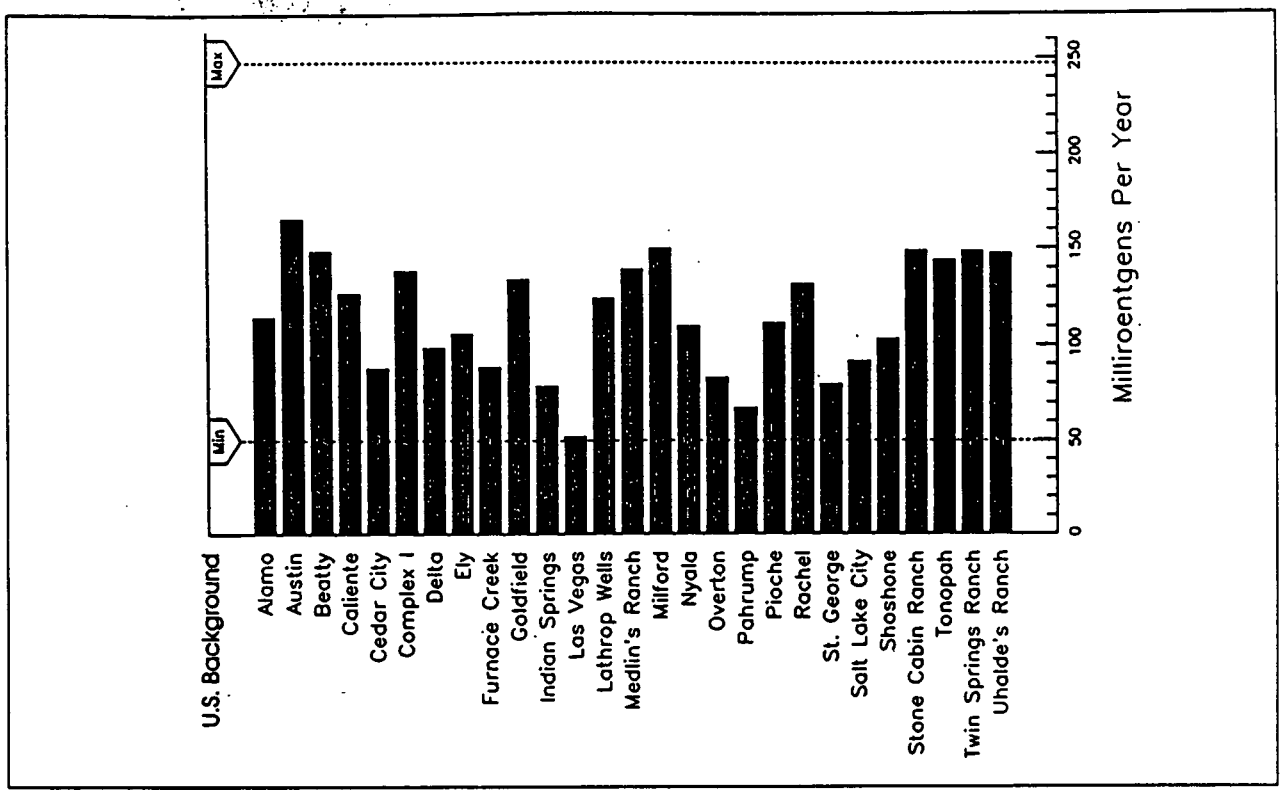


Figure 5.22 Annual PIC Averages by Station In Milliroentgens per Year - 1990

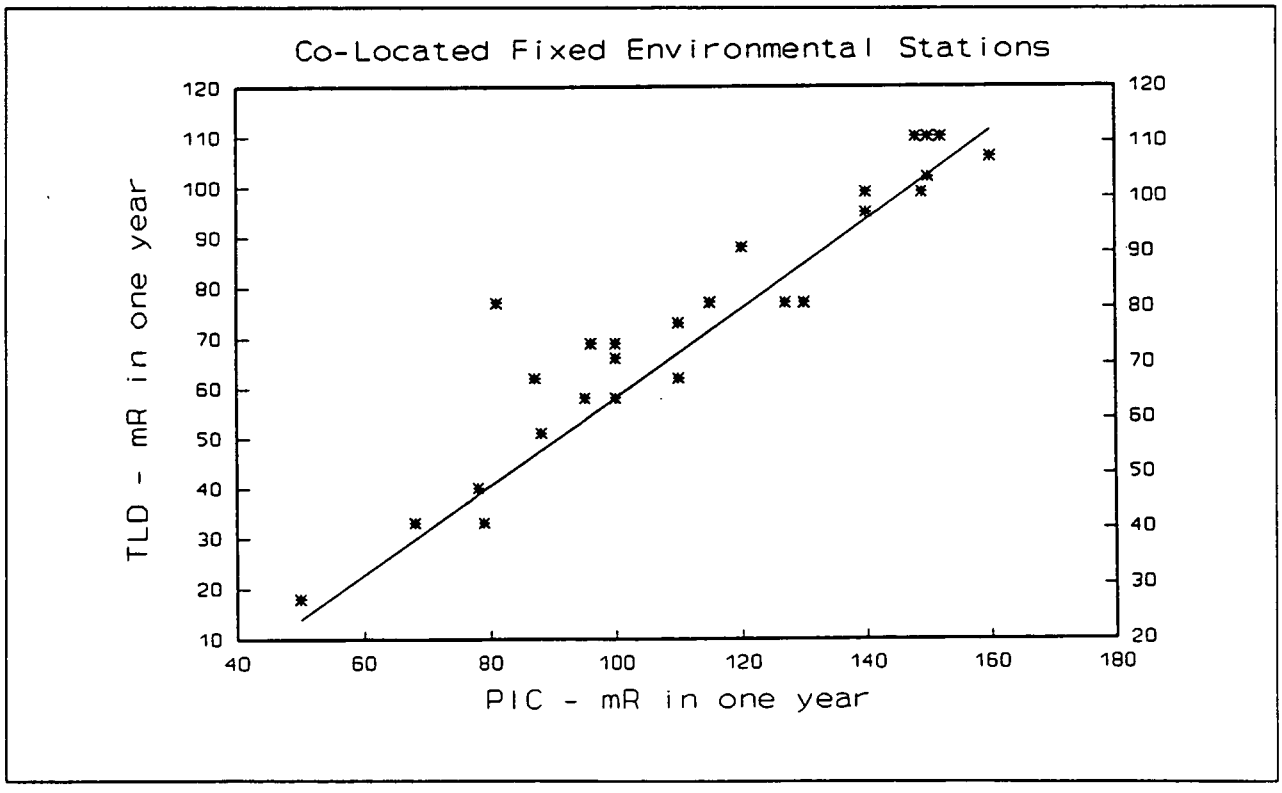


Figure 5.23 Correlating TLD and PIC Results - 1990

200

Table 5.34 Tritium in Urine, Offsite Dosimetry Program - 1990

Sampling Location	Collection Date 1990	(Concentration ± 1s) x 10^{-9} µCi/mL[a] (MDC)
Shoshone, CA	06/21	270 ± 99 (320)
	06/21	140 ± 96 (310)
	06/21	180 ± 88 (280)
	06/21	93 ± 95 (310)
Alamo, NV	02/08	84 ± 93 (300)
	02/18	99 ± 93 (300)
Beatty, NV	01/26	10 ± 93 (300)
	01/31	130 ± 95 (310)
	01/31	160 ± 96 (310)
	02/14	120 ± 94 (300)
	02/14	80 ± 94 (300)
	02/23	67 ± 95 (310)
	02/23	-76 ± 95 (310)
	05/03	46 ± 90 (300)
	05/03	44 ± 90 (300)
	05/03	-4 ± 90 (300)
	05/03	-8 ± 91 (300)
	05/03	110 ± 92 (300)
	05/03	30 ± 91 (300)
	08/10	80 ± 71 (230)
	08/10	-84 ± 68 (220)
	08/31	120 ± 75 (240)
	08/07	42 ± 74 (240)
	08/07	20 ± 75 (240)
	08/07	140 ± 72 (240)
Caliente, NV	07/23	49 ± 73 (240)
	07/23	110 ± 73 (240)
Currant, NV, Blue Eagle Ranch	03/14	370 ± 97 (310)[b]
	03/14	160 ± 92 (300)
	03/14	60 ± 91 (300)
Ely, NV	04/27	230 ± 92 (300)
	04/27	75 ± 91 (300)
	07/16	13 ± 72 (240)
	07/16	94 ± 73 (240)
	12/12	200 ± 110 (360)
	12/12	140 ± 100 (340)
Goldfield, NV	05/16	210 ± 93 (300)
	05/16	260 ± 93 (300)
	05/16	-72 ± 94 (310)
	05/16	29 ± 94 (300)
Indian Springs, NV	04/10	62 ± 91 (300)
	04/10	180 ± 95 (300)
	07/10	150 ± 73 (240)
	07/10	160 ± 72 (230)
	07/10	120 ± 73 (240)
	12/17	82 ± 100 (350)
	12/17	78 ± 100 (360)
Las Vegas, NV	01/24	60 ± 92 (300)
	01/24	140 ± 93 (300)
	02/08	270 ± 97 (310)
	03/07	160 ± 98 (320)
	03/07	-38 ± 97 (320)
Amargosa Valley, NV	01/26	-18 ± 91 (300)
Amargosa Center, NV	01/10	66 ± 92 (300)
	08/06	120 ± 73 (240)
	08/06	-32 ± 72 (240)
	08/14	-45 ± 74 (240)
	08/14	14 ± 72 (240)

(a) Multiply by 0.037 to obtain Bq/L.
(b) Concentration is greater than the MDC.

201

Table 5.34 (Tritium in Urine, Offsite Dosimetry Program - 1990, cont.)

Sampling Location	Collection Date 1990	(Concentration ± 1s) x 10^{-9} µCi/mL[a] (MDC)
Lund, NV	01/26	-12 ± 92 (300)
	01/26	80 ± 92 (300)
McGill, NV	01/08	89 ± 93 (300)
	01/08	8 ± 91 (300)
Nyala, NV	06/14	-120 ± 100 (340)
	06/14	47 ± 100 (330)
	06/14	-13 ± 98 (320)
	12/10	-69 ± 100 (360)
Overton, NV	04/10	310 ± 93 (300)[b]
	04/10	22 ± 91 (300)
	04/10	-64 ± 90 (300)
	04/10	-49 ± 91 (300)
	04/10	51 ± 91 (300)
	04/10	170 ± 92 (300)
	05/04	300 ± 93 (300)
	05/04	100 ± 92 (300)
	05/04	100 ± 91 (300)
	05/04	550 ± 97 (300)[b]
	05/04	83 ± 91 (300)
Pahrump, NV	03/07	180 ± 92 (300)
	06/19	300 ± 100 (320)
	06/19	220 ± 98 (320)
	06/25	160 ± 99 (320)
	06/25	360 ± 99 (320)[b]
Pioche, NV	02/20	150 ± 98 (320)
	02/20	180 ± 95 (300)
	02/20	200 ± 95 (300)
	02/20	10 ± 93 (300)
	02/20	29 ± 96 (320)
	08/09	160 ± 73 (240)
	08/09	-66 ± 71 (240)
	08/09	40 ± 72 (240)
	08/09	83 ± 72 (230)
	08/09	-130 ± 70 (240)
Rachel, NV	03/02	150 ± 97 (320)
	03/02	88 ± 95 (310)
	03/02	-57 ± 94 (310)
	03/02	-65 ± 96 (320)
	03/02	-89 ± 95 (310)
	06/01	4 ± 94 (300)
Warm Springs, NV Hot Creek Valley	12/10	28 ± 100 (360)
Cedar City, UT	02/16	160 ± 95 (300)
	02/16	200 ± 95 (300)
	02/16	120 ± 94 (310)
	02/16	10 ± 93 (300)
	02/16	21 ± 94 (300)
	06/08	97 ± 99 (320)
	06/18	-130 ± 98 (320)
	06/19	17 ± 99 (320)
	11/30	120 ± 100 (360)
	11/30	61 ± 100 (360)
	11/30	160 ± 110 (360)
	11/30	100 ± 100 (350)
	11/30	160 ± 110 (360)
	11/30	140 ± 100 (360)
Milford, UT	02/09	120 ± 93 (300)
	02/09	59 ± 93 (300)

(a) Multiply by 0.037 to obtain Bq/L.
(b) Concentration is greater than the MDC.

202

5453

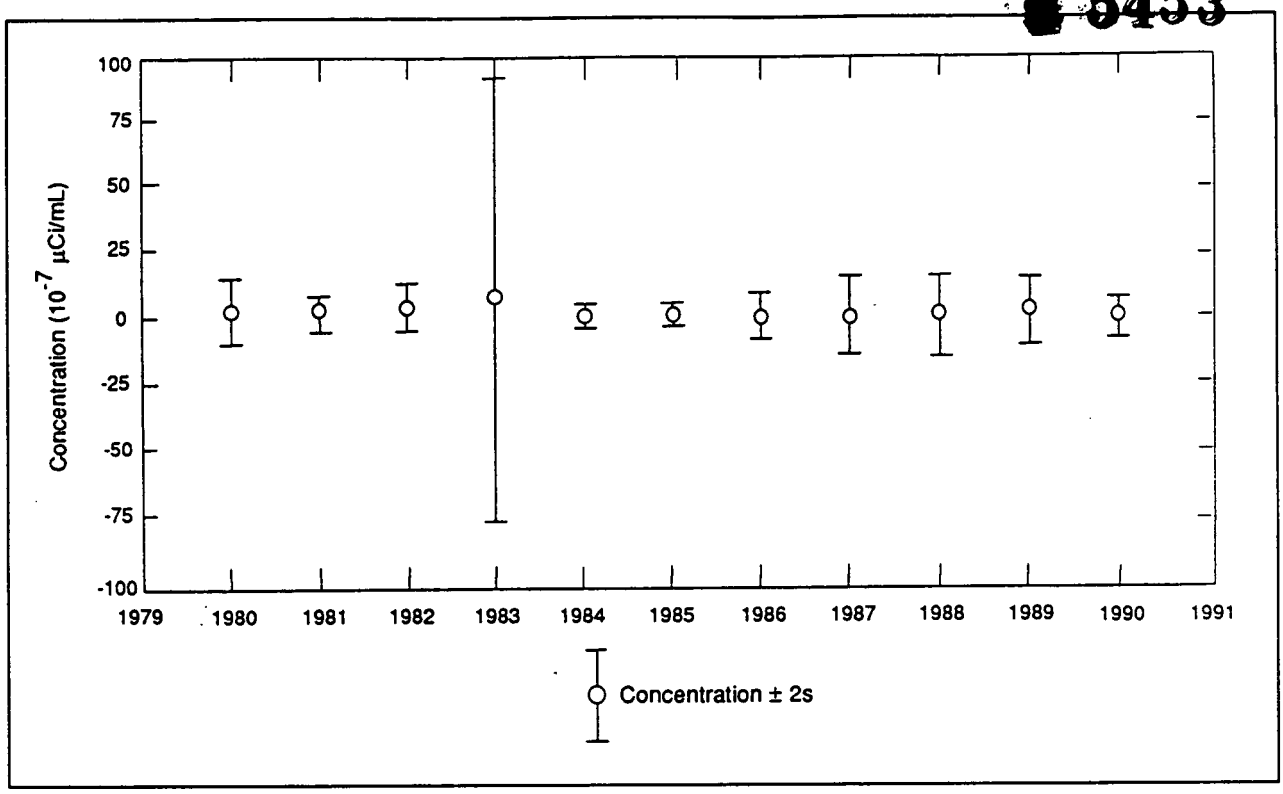


Figure 5.24 Mean and Standard Deviation for the Concentration of Tritium in the Urine of Offsite Residents - 1979-90

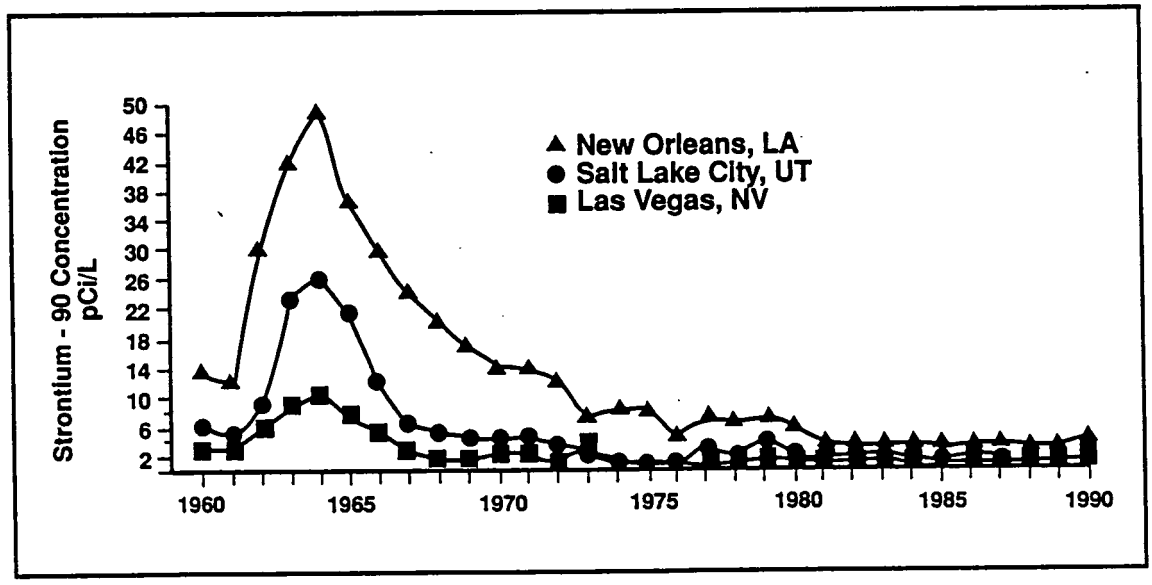


Figure 24. Strontium-90 Concentration in Pasteurized Milk Network Samples.

Figure 5.25 ^{90}Sr in Pasteurized Milk Network Samples - 1960-90

Table 5.35 Milk Surveillance Network Results - 1990[a]

Sampling Location	Collection Date	(Concentration ± 1s) x 10^{-9} µCi/mL[b] (MDC) ^{3}H	^{89}Sr	^{90}Sr
Benton, CA				
Irene Brown Ranch	01/05	100 ± 120 (400)	N/A	0.23 ± 0.59 (2.2)
	04/02	45 ± 140 (460)	N/A	-0.10 ± 0.39 (1.)
	07/19	-40 ± 120 (420)	N/A	0.19 ± 0.41 (1.6)
	10/04	260 ± 140 (450)	-0.1 ± 2 (2.7)	0.63 ± 0.41 (1.5)
Hinkley, CA				
Desert View Dairy	01/03	-45 ± 120 (400)	N/A	0.06 ± 0.51 (1.9)
	04/02	-140 ± 130 (430)	N/A	0.05 ± 0.34 (1.4)
	07/18	-13 ± 120 (400)	1.0 ± 1.1 (1.5)	0.54 ± 0.35 (1.3)
	10/02	260 ± 170 (550)	0.4 ± 1.9 (2.5)	0.48 ± 0.39 (1.5)
Ridgecrest, CA				
Cedarsage Farm	01/03	-85 ± 120 (400)	N/A	-0.36 ± 0.51 (2.0)
	04/02	-16 ± 120 (420)	N/A	-0.32 ± 0.37 (1.5)
	07/18	-55 ± 120 (420)	-1 ± 1 (1.6)	0.50 ± 0.32 (1.4)
	10/03	210 ± 150 (500)	N/A	0.23 ± 0.38 (1.6)
Alamo, NV				
Courtney Dahl Ranch	03/07	220 ± 120 (410)	N/A	0.69 ± 0.52 (1.8)
	05/02	280 ± 140 (440)	0.3 ± 1.3 (2.1)	0.26 ± 0.31 (1.3)
	08/15	180 ± 120 (370)	0.8 ± 1.9 (3)	0.46 ± 0.38 (1.5)
	11/01	-24 ± 140 (480)	N/A	-0.19 ± 0.39 (1.6)
Austin, NV				
Young's Ranch	03/15	250 ± 120 (390)	N/A	1.1 ± 0.35 (1.4)
	06/06	180 ± 120 (420)	0.5 ± 1.5 (2.0)	0.87 ± 0.39 (1.4)
	09/13	220 ± 120 (370)	N/A	0.09 ± 0.37 (1.5)
	12/12	160 ± 140 (480)	N/A	0.77 ± 0.38 (1.4)
Blue Jay, NV				
Blue Jay Springs, Jim Bias Ranch	03/08	330 ± 120 (400)	N/A	1 ± 0.39 (1.4)
	09/06	5 ± 110 (380)	N/A	0.57 ± 0.41 (1.5)

(a) Samples were collected monthly when possible. For those months not listed in the table, either no sample was available or gamma spectrometric analysis indicated only naturally occurring ^{40}K.
(b) Multiply the result by 0.037 to convert to Bq/L.
N/A = Not analyzed.

Table 5.35 (Milk Surveillance Network Results - 1990[a], cont.)

Sampling Location	Collection Date	(Concentration ± 1s) x 10^{-9} µCi/mL[b] (MDC) ^{3}H	^{89}Sr	^{90}Sr
Caliente, NV				
June Cox Ranch	02/05	130 ± 120 (390)	N/A	0.15 ± 0.43 (1.6)
	05/07	150 ± 130 (440)	0.6 ± 1.5 (2.1)	0.99 ± 0.36 (1.3)
	08/06	100 ± 120 (380)	-0.7 ± 2.2 (3.1)	0.74 ± 0.39 (1.5)
	11/01	110 ± 140 (480)	0.2 ± 1.7 (2.7)	-0.13 ± 0.39 (1.7)
Currant, NV				
Blue Eagle Ranch	03/07	92 ± 120 (400)	N/A	0.63 ± 0.35 (1.4)
	06/11	160 ± 130 (430)	-0.3 ± 1.2 (1.8)	0.55 ± 0.34 (1.4)
Manzonie Ranch	03/07	310 ± 130 (420)	N/A	0.90 ± 0.35 (1.4)
Dyer, NV				
Ozel Lemon	03/09	110 ± 120 (400)	N/A	0.90 ± 0.40 (1.6)
	09/06	160 ± 120 (370)	N/A	0.02 ± 0.39 (1.5)
	12/06	200 ± 160 (510)	N/A	0.29 ± 0.55 (1.8)
Ely, NV				
McKay, Robert and Carla	02/05	220 ± 120 (400)	N/A	0.66 ± 0.74 (2.5)
	05/07	330 ± 150 (500)	-0.6 ± 1.4 (2.1)	0.76 ± 0.33 (1.4)
	08/06	140 ± 110 (370)	-2.6 ± 2.4 (3.5)	1.1 ± 0.43 (1.7)
	12/05	320 ± 170 (550)	N/A	0.22 ± 0.50 (1.8)
Goldfield, NV				
Frayne Ranch	09/14	180 ± 110 (360)	N/A	0.91 ± 0.42 (1.6)
Susie Scott Ranch	06/07	230 ± 120 (400)	1.8 ± 1.6 (2.0)	0.41 ± 0.40 (1.5)
Indian Springs, NV				
Susan Carr Ranch	02/05	-29 ± 120 (400)	N/A	0.85 ± 0.38 (1.4)
Amargosa Valley				
John Deer Ranch	06/06	-34 ± 130 (440)	0.9 ± 1.4 (1.9)	0.33 ± 0.36 (1.4)
Logandale, NV				
Leonard Marshall	02/08	220 ± 120 (390)	N/A	0.24 ± 0.37 (1.5)
	05/02	310 ± 130 (430)	0.7 ± 1.4 (2.2)	0.38 ± 0.30 (1.3)
	08/06	180 ± 110 (360)	0.0 ± 2.6 (4.2)	0.34 ± 0.44 (1.8)
	11/01	170 ± 180 (580)	0.7 ± 2.7 (4.1)	-0.11 ± 0.58 (2.2)

(a) Samples were collected monthly when possible. For those months not listed in the table, either no sample was available or gamma spectrometric analysis indicated only naturally occurring ^{40}K.
(b) Multiply the result by 0.037 to convert to Bq/L.
N/A = Not analyzed.

Table 5.35 (Milk Surveillance Network Results - 1990[a], cont.)

Sampling Location	Collection Date	(Concentration ± 1s) x 10^{-9} µCi/mL[b] (MDC) ^{3}H	^{89}Sr	^{90}Sr
Lund, NV				
Ronald J Horsley Ranch	02/06	-28 ± 120 (400)	N/A	0.26 ± 0.40 (1.6)
	05/18	200 ± 130 (440)	-0.4 ± 1.1 (1.8)	0.97 ± 0.32 (1.3)
	08/07	56 ± 97 (320)	1.3 ± 2.7 (3.5)	0.48 ± 0.56 (1.9)
	11/01	220 ± 160 (540)	0.1 ± 1.7 (2.8)	-0.02 ± 0.40 (1.7)
Mesquite, NV				
Hafen Dairy	06/28	-6 ± 130 (430)	0.0 ± 1.3 (2.0)	0.56 ± 0.33 (1.3)
	09/28	240 ± 150 (490)	N/A	0.30 ± 0.37 (1.5)
Mesquite, NV				
Speda Brothers Dairy	01/04	10 ± 120 (410)	N/A	0.35 ± 0.37 (1.5)
	03/26	230 ± 130 (420)	N/A	0.32 ± 0.36 (1.5)
Moapa, NV				
Rockview Dairies, Inc.	01/04	140 ± 120 (420)	N/A	1.1 ± 0.35 (1.4)
	03/26	120 ± 130 (440)	N/A	0.40 ± 0.34 (1.5)
	07/02	-180 ± 120 (420)	0.0 ± 2 (2.7)	0.96 ± 0.49 (1.7)
	10/04	180 ± 150 (500)	2.2 ± 1.9 (2.7)	0.03 ± 0.40 (1.5)
Nyala, NV				
Sharp Ranch	03/07	120 ± 120 (400)	N/A	0.37 ± 0.39 (1.6)
	06/12	71 ± 120 (420)	-0.4 ± 1.3 (1.8)	0.91 ± 0.37 (1.4)
	10/11	42 ± 140 (480)	-0.7 ± 1.7 (2.3)	0.96 ± 0.40 (1.5)
	12/05	380 ± 140 (480)	N/A	0.71 ± 0.40 (1.4)
Pahrump, NV				
Pahrump Dryair	01/02	-120 ± 120 (380)	N/A	0.71 ± 0.50 (1.7)
	04/02	-50 ± 120 (420)	N/A	0.39 ± 0.43 (1.6)
	07/17	-160 ± 120 (400)	-0.2 ± 2 (2.6)	0.36 ± 0.53 (1.9)
	10/01	160 ± 140 (480)	N/A	0.03 ± 0.40 (1.7)
Shoshone, NV				
Harbecke Ranch	02/05	280 ± 130 (420)	N/A	1.3 ± 0.46 (1.5)
	05/07	140 ± 130 (430)	-0.1 ± 1.6 (2.2)	1.8 ± 0.40 (1.4)[c]
	08/06	270 ± 110 (360)	-1.6 ± 2.2 (2.7)	2.1 ± 0.49 (1.6)[c]
	11/01	290 ± 160 (520)	0.2 ± 2.2 (2.7)	2.5 ± 0.52 (1.7)[c]

(a) Samples were collected monthly when possible. For those months not listed in the table, either no sample was available or gamma spectrometric analysis indicated only naturally occurring ^{40}K.
(b) Multiply the result by 0.037 to convert to Bq/L.
N/A = Not analyzed.

206

Table 5.35 (Milk Surveillance Network Results - 1990[a], cont.)

Sampling Location	Collection Date	(Concentration ± 1s) x 10^{-9} µCi/mL[b] (MDC) ^{3}H	^{89}Sr	^{90}Sr
Cedar City, UT				
Brent Jones Dairy	01/03	180 ± 120 (420)	N/A	1.1 ± 0.39 (1.4)
	03/26	88 ± 130 (440)	N/A	0.55 ± 0.36 (1.5)
	07/02	-33 ± 120 (420)	0.2 ± 1.4 (2.0)	0.80 ± 0.36 (1.4)
	10/04	320 ± 150 (480)	2.7 ± 2.5 (3.4)	0.10 ± 0.50 (1.8)
Ivins, UT				
David Hafen Ranch	01/04	100 ± 120 (400)	N/A	1.0 ± 0.42 (1.5)
	03/26	300 ± 140 (450)	N/A	2.6 ± 0.48 (1.5)[c]
	07/02	-98 ± 120 (420)	0.0 ± 1.3 (1.8)	0.84 ± 0.34 (1.3)
	10/04	260 ± 140 (460)	N/A	0.76 ± 0.49 (1.8)

(a) Samples were collected monthly when possible. For those months not listed in the table, either no sample was available or gamma spectrometric analysis indicated only naturally occurring ^{40}K.
(b) Multiply the result by 0.037 to convert to Bq/L.
(c) Concentration is greater than the MDC.
N/A = Not analyzed.

Laboratory in Montgomery, Alabama. No results for 1988 or 1989 were available for Salt Lake City. Results from the New Orleans samples have been consistently higher over the years and reflect a greater soil inventory of radiostrontiums from atmospheric testing as a result of weather patterns and precipitation.

207

6.0 DOSE ASSESSMENT

5453

William G. Phillips and Stuart C. Black

The extensive offsite environmental surveillance system operated around the NTS by the EPA Environmental Monitoring System Laboratory, Las Vegas (EMSL-LV), measured no radiological exposures that could be attributed to recent NTS operations. Calculation of potential dose to offsite residents, based on onsite source emission measurements provided by DOE and calculated by the EPA's AIRDOS-PC model, resulted in a maximum calculated dose of 6 x 10^{-3} mrem (6 x 10^{-5} mSv) to a hypothetical resident of Crystal, Nevada, 52 kilometers south of the NTS Control Point (CP-1). Monitoring network data indicated a 1990 dose of 123 mrem from normal background radiation occurring at Crystal. The calculated population dose to the approximately 7700 residents living within 80 kilometers of the CP-1 was 1.5 x 10^{-2} person-rem (1.5 x 10^{-4} person-sievert).

6.1 ESTIMATED DOSE FROM NTS ACTIVITIES

The estimated effective dose equivalent to the offsite population due to NTS activities was based on the total release of radioactivity from the NTS in 1990 as listed in Section 5, Table 5.1. The dose from other NTS faciltites such as the laboratories in Mercury and Area 25, Area 6 Decontamination Laundry, Areas 3 and 5 waste management sites, and Area 27 Assembly Building totaled less than 10^{-5} mrem using AIRDOS-PC centered on each facility. As no radioactivity of recent NTS origin was detectable offsite by the various monitoring networks, no measurable exposure to the population living around the NTS was expected. To confirm this expectation, a calculation of estimated dose was performed using EPA's AIRDOS-PC model. The individuals exposed were considered to be all of those living within a radius of 80 kilometers of the NTS CP-1, a total of 7700 individuals. The hypothetical individual with the maximum calculated dose from airborne NTS radioactivity would have been continuously present at Crystal, Nevada, 52 kilometers south of CP-1. That maximum dose was 6 x 10^{-3} mrem (6 x 10^{-5} mSv). The population dose from airborne emissions within 80 kilometers was 1.5 x 10^{-2} person-rem (1.5 x 10^{-4} person-Sv), calculated by AIRDOS-PC using the appropriate distance and sector for each population group.

During calendar year 1990 there were four sources for possible radiation exposure to the population of Nevada, as listed below. All except the first source were measurable by the offsite monitoring networks. These sources were:

- Operational releases of radioactivity from the NTS, including those from drill-back and purging activities.
- Radioactivity that was accumulated in migratory animals during their residence on the NTS.
- Worldwide distributions of fallout radioactivity such as ^{90}Sr in milk, ^{85}Kr in air, etc.
- Background radiation due to natural sources such as cosmic radiation, natural radioactivity in soil, and ^{7}Be in the air.

208

The estimated dose equivalent exposures from these sources to people living near the NTS are calculated separately in the following subsections.

Table 6.1 summarizes the annual effective dose equivalents from operations at the NTS during 1990 using AIRDOS-PC and the radionuclides released as listed in Table 5.1.

6.2 ESTIMATED DOSE FROM WORLDWIDE FALLOUT

From the monitoring networks described in previous sections of this report, the following concentrations of radioactivity were found:

- Tritium (^{3}H); 6 x 10^{-13} µCi/mL of air (22 mBq/m^3).
- ^{85}Kr; 26 x 10^{-12} µCi/mL of air (1 Bq/m^3).
- ^{90}Sr; 6 x 10^{-10} µCi/mL in milk (22 mBq/L).
- ^{137}Cs; 38 pCi/kg in deer kidney (1.4 Bq/kg).
- $^{239+240}Pu$; 0.201 pCi/kg (7 mBq/kg) in beef liver and 0.102 pCi/kg (4 mBq/kg) in deer meat.

The annual dose is estimated from these findings by using the following assumptions and dose conversion factors:

- The adult breathing rate is 8400 m^3/year.
- Milk intake (for a 10-year old) is 160 L/year.

Table 6.1 Summary of Annual Effective Dose Equivalent from NTS Operations during 1990

	Maximum Dose at NTS Boundary[a]	Maximum dose to an Individual[b]	Collective Dose to Population within 80 km of NTS CP-1
Dose	8.9 x 10^{-3} mrem (8.9 x 10^{-5} mSv)	6 ± 0.5 x 10^{-3} mrem (6 x 10^{-5} mSv)	1.5 x 10^{-2} person-rem (1.5 x 10^{-4} person-Sv)
Location	Site boundary 30 km south of NTS CP-1 at 191°	Crystal, Nevada, 52 km south of NTS CP-1	7700 people within a 80-km radius of NTS CP-1
NESHAP Standard	-----	10 mrem per year (0.1 mSv per year)	-----
Percentage of NESHAP	-----	6 x 10^{-2}	-----
Background	123 mrem (1.2 mSv)	123 mrem (1.2 mSv)	947 person-rem (9.5 person Sv)
Percentage of Background	7.2 x 10^{-3}	5 x 10^{-3}	2 x 10^{-3}

(a) The maximum boundary dose is to a hypothetical individual who remains in the open continuously during the year at the NTS boundary located 30 km from CP-1 in the direction 191° south.

(b) The maximum individual dose is to an individual outside the NTS boundary at a residence where the highest dose-rate occurs as calculated by AIRDOS-PC (Version 3.0) using NTS effluents listed in Section 5, Table 5.1 and assuming all tritiated water input to containment ponds was evaporated.

- Consumption of beef liver is 0.5 lb/week (11.5 kg/year).

- An average deer has 100 lb (45 kg) of meat.

The dose conversion factors are derived from Appendix C of NCRP Commentary No. 3 (1989). These are:

- ^{3}H; 1.3 x 10^{-7} mrem/pCi.

- ^{90}Sr; 1.3 x 10^{-4} mrem/pCi.

- ^{137}Cs; 4.6 x 10^{-5} mrem/pCi.

- ^{85}Kr; 1.1 x 10^{-5} mrem/year per pCi/m^3.

- $^{239+240}Pu$; 9 x 10^{-4} mrem/pCi.

As an example calculation, the following is the result for ^{3}H exposure from breathing HTO:

- 0.6 pCi/m^3 x 8400 m^3/year x 1.3 x 10^{-7} mrem/pCi = 6.6 x 10^{-4} mrem.

Also:

- ^{90}Sr; 0.6 pCi/L x 160 L/year x 1.3 x 10^{-4} mrem/pCi = 0.012 mrem.

- ^{85}Kr; 26 pCi/m^3 x 1.1 x 10^{-5} mrem/year per pCi/m^3 = 3 x 10^{-4} mrem.

- $^{239+240}Pu$; 0.201 pCi/kg x 11.8 kg/year x 9 x 10^{-4} mrem/pCi = 2.1 x 10^{-3} mrem.

Therefore, exposure to worldwide fallout results in an annual dose equivalent equal to the sum of the three preceding exposures or 1.5 x 10^{-2} mrem (1.5 x 10^{-4} mSv).

6.3 ESTIMATED DOSE FROM RADIOACTIVITY IN AN NTS DEER

The highest measured concentrations of radionuclides in deer tissues occurred in deer collected on the NTS. There was 38 pCi/kg of ^{137}Cs in a kidney sample and 0.1 pCi/kg of $^{239+240}Pu$ in a muscle sample.

In the unlikely event that one such deer was collected by a hunter in offsite areas, the hunter's intake could be calculated. Assuming two pounds (0.9 kg) of kidney and 100 lb (45 kg) of meat with the radionuclide concentrations listed above, the dose equivalent would be:

- 38 pCi/kg (Cs) x 0.9 kg x 4.6 x 10^{-5} mrem/pCi = 1.6 x 10^{-3} mrem.

- 0.1 pCi/kg (Pu) x 45 kg x 9 x 10^{-4} mrem/pCi = 4 x 10^{-3} mrem.

Thus, approximately 6 µrem (6 x 10^{-5} mSv) would be delivered to one individual consuming the stated quantity of meat assuming no radioactivity was lost in food preparation.

6.4 DOSE FROM BACKGROUND RADIATION

In addition to external radiation exposure due to cosmic rays and gamma radiation from naturally occurring radionuclides in soil (^{40}K, uranium, and thorium daughters, etc.), there is a contribution from ^{7}Be that is formed in the atmosphere by cosmic ray interactions with oxygen and nitrogen. The annual average ^{7}Be concentration measured by the offsite air surveillance network was 0.11 pCi/m^3. With a dose conversion factor for inhalation of 2.6 x 10^{-7} mrem/pCi, this equates to 2.4 x 10^{-4} mrem, a negligible quantity when compared with the pressurized ion chamber network measurements that vary from 50 to 170 mR/year, depending on the location.

6.5 SUMMARY

The individual with the calculated (modeled) highest exposure to NTS effluent during 1990 was a hypothetical person living in Crystal, Nevada, where the NTS exposure, plus that due to worldwide fallout, plus

background would add to ($6 \times 10^{-3} + 1.5 \times 10^{-2} + 123$) mrem = 123 mrem (1.2 mSv). Both the NTS and worldwide distributions contributed a negligible amount of exposure compared to natural background. If one of these people were to collect and consume an NTS deer, that estimated dose equivalent would increase by 6×10^{-3} mrem, a negligible amount.

7.0 NONRADIOLOGICAL MONITORI[redacted]

Charles W. Burhoe, Richard B. Hunter, and Glen A. Clark

Environmental nonradiological monitoring of NTS operations involved only onsite monitoring as there were no nonradiological discharges to the offsite environment. Onsite drinking water distribution systems were monitored for Safe Drinking Water Act compliance; sewage influents to onsite lagoons were monitored for Clean Water Act compliance and state of Nevada permit requirements; polychlorinated biphenyl (PCB) monitoring was conducted for Toxic Substance Control Act compliance; asbestos monitoring was conducted for asbestos removal and renovation projects; and environmental media were sampled for hazardous characteristics and constituents in the vicinity of hazardous waste management sites on the NTS. Flora, fauna, and special environmental conditions were also monitored for trends and impacts.

7.1 ENVIRONMENTAL SAMPLES

7.1.1 SAFE DRINKING WATER ACT

Water sampling was conducted for analysis of bacteria, volatile organic compounds (VOCs), inorganic constituents, and water quality as required by the Safe Drinking Water Act and state of Nevada regulations. All samples were collected according to accepted practices and sent to federal- or state-approved laboratories for analysis.

7.1.1.1 BACTERIOLOGICAL SAMPLING

All drinking water distribution systems on the NTS were sampled by Reynolds Electrical & Engineering Co., Inc. (REECo). Common sampling points were rest-room and cafeteria sinks. The samples were submitted for analysis of coliform bacteria to the state-approved Associated Pathologists Laboratories in Las Vegas, Nevada. Bacteriological testing was conducted according to Nevada Administrative Code (NAC) 445.247 and 40 Code of Federal Regulations (CFR) Part 141. These require that all water systems servicing less than 1000 nontransient persons be tested once a month. Systems serving more persons must be tested more frequently.

Residual chlorine (RC) and pH levels were determined at the collection point by using colorimetric methods approved by the state. The results were recorded in REECo's laboratory drinking water sample logbook, and the chlorine residual level was recorded on an analysis form.

Using the "most probable number" technique, if the coliform bacteria colony count exceeded 2.2 colonies per 100-mL sample, or, using the "membrane filter" technique, if the coliform bacteria colony count exceeded zero, the system would have been declared unsafe and closed. In order to reopen the system, samples collected for three consecutive days had to have a coliform count that was in line with state requirements.

Sample results for 1990 distribution systems water quality parameters are listed in Table 7.1, along with applicable state of Nevada permit numbers. RC results (0.1 to 2.0 parts per million [ppm]) and pH results (6.8 to 8.4) were all within permit criteria. No coliform counts exceeded the reference level.

212

Table 7.1 Monthly Monitoring Results for NTS Potable Water Systems - 1990[a]

Area/ Building	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
					PERMIT 360-12C							
Area 22	Desert Rock Weather Station											
RC	0.5	--	0.3	0.4	0.3	0.4	0.4	0.1	0.2	0.1	0.1	0.1
pH	7.2	--	7.2	8.0	8.2	8.1	8.0	8.4	8.2	8.2	8.1	8.1
Coliform	0	--	0	<2.2	0	0	0	0	0	0	0	0
Area 23	Building 652, Mercury											
RC	0.6	0.6	0.6	--	0.5	--	--	0.6	--	0.5	0.6	0.6
pH	7.2	7.2	8.0	--	7.4	--	--	7.4	--	7.6	7.4	7.4
Coliform	0	0	0	--	0	--	--	0	--	0	0	0
Area 23	Cafeteria, Mercury											
RC	0.5	0.6	0.6	0.6	0.5	0.6	0.5	0.6	0.6	0.5	0.6	0.5
pH	7.1	7.6	7.9	7.5	7.6	7.3	7.3	7.4	7.6	7.6	7.4	7.4
Coliform	0	0	0	<2.2	0	0	0	0	<2.2	0	0	0
Area 23	Bowling Alley, Mercury											
RC	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.5	0.6	0.5
pH	7.2	7.4	8.0	7.5	7.6	7.3	7.3	7.4	7.6	7.6	7.4	7.4
Coliform	0	0	0	<2.2	0	0	0	0	0	0	0	0
Area 23	Building 652A											
RC	--	--	--	0.5	--	0.6	0.5	--	0.6	--	--	--
pH	--	--	--	7.5	--	7.3	7.3	--	7.6	--	--	--
Coliform	--	--	--	<2.2	--	0	0	--	0	--	--	--
					PERMIT NY-4098 12NC							
Area 25	Site Maintenance											
RC	0.3	0.6	0.5	0.6	0.3	0.5	0.6	0.8	0.8	0.8	0.5	0.8
pH	7.3	7.8	8.1	7.6	7.2	7.3	7.3	7.3	7.7	7.8	7.8	7.7
Coliform	0	0	0	0	0	0	0	0	0	<2.2	0	0
					PERMIT NY-4099 12NC							
Area 2	Field Operations											
RC	0.4	0.5	0.4	0.6	0.5	0.6	0.4	0.4	0.2	0.3	0.3	0.3
pH	7.2	7.5	7.2	7.5	8.2	7.2	7.2	7.2	7.5	7.2	7.3	7.4
Coliform	0	0	0	0	0	0	0	0	0	0	0	0
Area 2	Rest Room											
RC	--	--	0.4	--	--	--	--	--	--	--	--	--
pH	--	--	7.1	--	--	--	--	--	--	--	--	--
Coliform	--	--	<2.2	--	--	--	--	--	--	--	--	--
Area 12	Cafeteria											
RC	0.7	0.4	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.5	0.3	0.6
pH	7.3	7.4	7.4	7.4	7.8	7.4	7.5	7.2	7.5	7.4	7.4	6.8
Coliform	0	<2.2	0	0	0	0	0	0	0	0	0	0

(a) RC - residual chlorine in parts per million (ppm); coliform colony count is in number/100 mL.

213

Table 7.1 (Monthly Monitoring Results for NTS Potable Water Systems - 1990[a], cont.)

Area/ Building	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Area 12	Building 30											
RC	--	0.5	--	--	--	--	--	--	--	--	--	--
pH	--	7.4	--	--	--	--	--	--	--	--	--	--
Coliform	--	<2.2	--	--	--	--	--	--	--	--	--	--
Area 12	Building 12-909											
RC	0.6	--	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.5	0.3	0.6
pH	7.2	--	7.3	7.3	8.0	7.4	7.5	7.2	7.5	7.4	7.4	7.0
Coliform	0	--	0	0	0	0	0	0	0	0	0	0
PERMIT NY 5000-12NC												
Area 6	Building 6 - Control Point 65											
RC	--	<0.1	--	0.6	0.1	--	--	--	--	--	0.5	0.4
pH	--	7.5	--	8.2	7.4	--	--	--	--	--	7.6	7.6
Coliform	--	0	--	0	0	--	--	--	--	--	<2.2	0
Area 6	Fire Station											
RC	0.5	--	0.6	--	--	0.4	0.4	0.5	0.6	0.5	0.5	0.4
pH	7.2	--	7.6	--	--	7.4	7.4	7.6	7.6	7.4	7.6	7.6
Coliform	0	--	0	--	--	0	0	0	0	0	<2.2	0
Area 6	Building 70											
RC	--	<0.1	--	0.6	--	0.4	0.4	0.5	0.6	0.5	--	--
pH	--	7.2	--	7.8	--	7.4	7.6	7.6	7.6	7.4	--	--
Coliform	--	0	--	0	--	0	0	0	0	0	--	--
Area 6	Building 106											
RC	0.5	--	--	--	--	--	--	--	--	--	--	--
pH	7.2	--	--	--	--	--	--	--	--	--	--	--
Coliform	0	--	--	--	--	--	--	--	--	--	--	--
Area 6	Building 160											
RC	--	<0.1	0.6	0.3	0.1	0.4	0.4	0.5	0.6	0.4	0.6	0.5
pH	--	7.4	7.6	7.6	7.4	7.4	7.6	7.6	7.6	7.2	7.6	7.6
Coliform	--	0	0	0	0	0	0	0	0	0	<2.2	0
Area 6	Building 162											
RC	0.5	--	0.6	--	0.1	--	--	--	--	--	--	--
pH	7.1	--	7.6	--	7.4	--	--	--	--	--	--	--
Coliform	0	--	0	--	0	--	--	--	--	--	--	--
Area 27	Cafeteria											
RC	0.8	6.0	0.3	0.7	0.1	1.0	0.3	2.0	0.8	0.6	1.0	1.0
pH	7.3	8.0	7.2	7.6	8.0	8.0	8.2	7.8	7.7	8.0	7.6	7.6
Coliform	0	0	0	0	0	0	0	0	0	0	0	0
PERMIT NY-5084-12NC												
Area 1	Building 1-101											
RC	0.3	0.3	0.4	0.6	0.4	0.8	0.6	0.5	0.5	0.6	0.6	0.7
pH	7.1	7.6	7.6	7.4	7.4	7.4	7.4	7.1	7.4	7.6	7.6	7.2
Coliform	0	0	0	0	0	0	0	0	0	0	0	0

(a) RC - residual chlorine in ppm; coliform colony count is in number/100 mL.

214

Each truck which hauled potable water from NTS wells to work areas was sampled. A total of 1306 water truck samples were collected during 1990, of which 1301 contained no coliform colonies per 100-mL sample. One truck had two samples taken on the same day with coliform counts that measured 4 and 15 colonies per 100 mL. Three consecutive follow-up samples contained no colonies per 100 mL. Also, three samples were shown to be invalid coliform bacteria samples; one was eliminated as a valid sample due to overgrowth by other bacteria, and two were not used because the bottles had been cracked before analysis. Follow-up samples taken from the suspected trucks indicated that the water was not contaminated. The invalid samples were most likely caused by sampling or analysis error.

7.1.1.2 Chemical Analysis

Chemical analysis for organic and inorganic compounds was conducted in accordance with NAC 445 and 40 CFR 141. The sample collection points were at each of the nine potable water wells on the NTS shown in Section 4, Figure 4.3.

7.1.1.3 Volatile Organic Compound Analysis

Samples for VOCs were collected in March 1990 in accordance with 40 CFR 141.40. All community and noncommunity water systems were required to be sampled by January 1, 1991, for VOCs. The samples were sent to Alpha Analytical, Inc., in Sparks, Nevada, an EPA- and state-approved laboratory. Volatile organic compounds were not detected in any of the samples collected.

7.1.1.4 Inorganic Compound Analysis and Water Quality

Samples for inorganic compounds and water quality were collected in May 1990 in accordance with 40 CFR 141.11 and NAC 445. These samples were sent to the state of Nevada laboratory for analysis. Sample results, along with state standards, are listed in Table 7.2. A graph of all constituents as a percentage of the appropriate standard appears in Section 3, Figure 3.1.

Well 4 in Area 6 had a nitrate level of 18.2 ppm, 8.2 ppm above the National Primary Drinking Water Standard. Additional samples were collected at Well 4 which confirmed standard violations (see Table 7.3). Since the Area 6 Control Point Complex was supplied by this well, samples were taken to establish concentration levels at the supply points. Two samples, one taken each day a replicate sample from Well 4 was taken, reflected levels of 0.6 ppm and 1.2 ppm in Building CP-2. These were well below the 10 ppm standard.

Wells J-12 and J-13 in Area 25 had a fluoride levels of 2.04 ppm and 2.40 ppm, respectively, both of which exceeded the state of Nevada Secondary Standard of 2.0 ppm. Additional samples were collected which confirmed standard violations (see Table 7.3).

Well C and Well C-1 in Area 6 had a total dissolved solids (TDS) level of 640 ppm and 650 ppm, respectively, both of which exceeded the state of Nevada Secondary Standard of 500 ppm. Additional samples for Well C were collected which confirmed the standard violations (see Table 7.3). Due to delays in obtaining sample results, resampling for Well C-1 will be conducted in 1991.

Well 5C in Area 5 had a pH of 8.91, which exceeded the state of Nevada Secondary Standard of a pH between 6.5 and 8.5. Three additional samples for pH were collected at the well which confirmed the standard violation (see Table 7.3).

Notices for posting entitled "Elevated pH in Mercury Water Supply," "Elevated Nitrate Concentration in Area 6 Water Supply,""Elevated TDS Concentration in Area 6 Water Supply," and "Elevated Fluoride Concentration in Area 25 Water Supply"

Table 7.2 Water Chemistry Analysis for Potable Water Wells at the NTS - 1990

Constituents	WELLS									STANDARDS	
	Army	5C	4	C	C1	J-12	J-13	8	16D	SDWA	State Limits[b]
T.D.S.[a]	312	395	288	644	647	211	231	154	412	--	500
Hardness	201	5	90	311	313	46	41	27	305	--	--
Calcium	44	2	23	75	76	15	13	9	81	--	--
Magnesium	22	0	8	30	30	2	2	1	25	--	--
Sodium	39	136	50	126	127	40	50	31	29	--	--
Potassium	5	6	5	14	14	5	4	3	7	--	--
Sulfate	55	28	39	69	69	23	20	16	58	--	250
Chlorine	15	9	11	34	34	6	6	7	10	--	250
Nitrate	1.9	7.3	18.2	0.1	0.1	8.9	8.3	5.6	0.0	10	--
Alkalinity	214	260	134	476	476	98	118	62	294	--	--
Bicarbonate	261	268	163	581	581	120	144	76	359	--	--
Carbonate	0	24	0	0	0	0	0	0	0	--	--
Fluoride	1.07	1.03	0.85	1.15	1.16	2.04	2.40	0.85	0.60	4.0	2.0
Arsenic	0.008	0.032	0.007	0.005	0.007	0.009	0.011	<0.003	<0.003	0.05	--
Iron	0.00	0.00	0.49	0.10	0.02	0.01	0.23	0.02	0.005	--	0.3
Manganese	0.00	0.00	0.02	0.01	0.00	0.00	0.02	0.00	0.00	--	0.05
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	--	1
Zinc	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.01	--	5
Barium	0.09	0.00	0.00	0.13	0.13	0.00	0.00	0.00	0.16	--	1
Boron	0.1	0.4	0.1	0.5	0.5	0.0	0.1	0.0	0.1	--	--
Silicia	22	59	67	32	33	64	72	52	31	--	--
Color	3	3	3	3	3	3	3	3	3	--	15
Turbidity	0.2	0.2	2.6	0.3	0.4	0.3	0.9	0.4	0.5	N/A	N/A
pH	7.96	8.91	8.18	7.31	7.19	7.86	7.84	7.72	7.52	6.5	6.5/8.5
Elect. Conduct.	555	596	408	1066	1066	290	323	203	679	--	--
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	--
Chromium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05	--
Lead	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05	--
Mercury	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.002	--
Selenium	<0.001	0.001	0.001	0.001	<0.001	0.001	0.001	0.001	0.002	0.01	--
Silver	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.05	--
MBASs	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	--	0.5
Gross Alpha	<3	<3	4	4	6	<3	<3	<3	<3	5[c]	--
Gross Beta[d]	5	<3	6	12	11	4	<3	<3	6	--	--

(a) Analysis for T.D.S. through Silicia and Cadmium through MBAs are measured in parts per million. Color through Electrical Conductivity are measured in standard units for each individual constituent; Gross Alpha and Gross Beta are measured in picocuries/liter (pCi/L).

(b) State primary standards are adopted directly from the SDWA standards. All standards listed are state established secondary standards.

(c) Gross alpha samples above the SDWA limit were analyzed for ^{226}Ra; all results were below ^{226}Ra limits (see Section 5.2.1.6).

(d) Gross beta is calculated according to total millirem exposure per year.

Table 7.3 Sampling Results that Exceeded Drinking Water Standards - 1990

Well	Standard	Sample	Date	Results
J-12	Fluorides	1	06/12/90	2.05 ppm
		2	06/29/90	2.05 ppm
J13	Fluorides	1	06/12/90	2.42 ppm
		2	06/29/90	2.34 ppm
Well 5C	pH	1	09/11/90	8.88
		2	09/19/90	8.94
		3	09/25/90	8.85
Well 4	Nitrates	1	09/25/90	18.4 ppm
		2	10/01/90	17.9 ppm
Well C	TDS	1	09/25/90	640 ppm
		2	10/01/90	640 ppm
		3	10/08/90	634 ppm

were sent to the appropriate potable water user for each standard violation. These notices identified the (1) violations, (2) areas affected, and (3) potential health effects. The state of Nevada will be contacted to determine the required corrective actions.

7.1.2 CLEAN WATER ACT

7.1.2.1 NTS OPERATIONS

In accordance with the state of Nevada operating permits (OPs) for the sewage lagoon systems on the NTS (OPs Nos. NV87059, NV87060, NV87069, and NV87076), regular influent sampling schedules have been established. Specific standards have not been established for these systems.

Twelve sewage lagoons were in operation at the end of 1990. During 1990 seven lagoon systems were modified to comply with state regulations. One lagoon system in Area 12 was replaced with a septic tank/leach field system, and another in Area 11 was replaced with an evapo-transpiration bed. Four lagoons did not have sufficient inflow to monitor. These sampling locations were designated as the Area 6-DAF, Area 2, Area 25 Engine Test Stand, and Area 25 Test Cell "C" lagoons. Another lagoon system will be put into operation during 1991 in Area 6. Three lagoons that were closed during 1989 were dried, scraped, and back-filled as laid out in state-approved drawings during 1990.

State-required monitoring was conducted at sewage lagoons for flow rate, pH, biological oxygen demand (BOD), and total suspended solids (TSS). The flow rate and pH were estimated or measured onsite, and the BOD and TSS were determined by the City of Henderson Laboratory, in Henderson, Nevada, a state-approved laboratory (see Table 7.4).

Continuous monitoring of flow rates was conducted at the Areas 6 (Yucca Lake), 12, and 23 lagoon systems. Flow rates were

Table 7.4 pH, BOD, and TSS in NTS Sewage Lagoon Influents - 1990

	1st Quarter			2nd Quarter			3rd Quarter			4th Quarter			State
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Limits
pH													
Yucca Lake	---	---	7.0	7.0	---	---	---	---	8.0	---	---	8.0	6.0 to 9.0
Area 6, CP-6	---	---	7.0	---	---	7.5	---	---	7.0	---	---	7.5	6.0 to 9.0
Area 6, CP-72	---	---	7.0	---	---	7.0	---	---	7.0	---	---	7.5	6.0 to 9.0
Area 12	---	6.5	7.0	---	---	6.5	---	---	7.0	---	---	7.0	6.0 to 9.0
Area 22, Gate	7.5	7.0	7.0	7.0	7.0	7.5	7.5	7.0	7.5	8.0	8.0	7.5	6.0 to 9.0
Area 23	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.5	8.0	8.5	6.0 to 9.0
Area 25, Reactor Control	---	---	7.0	---	---	7.0	---	---	8.0	---	---	Dry	6.0 to 9.0
Area 25, Central Support	---	---	7.0	---	---	7.0	---	---	7.5	---	---	7.0	6.0 to 9.0
FLOW RATE (in millions of gallons per day)													
Area 6, Yucca Lake	0.0096	0.0036	0.006	0.0089	0.0103	0.0135	0.0091	0.0098	0.0021	0.0085	0.0126	0.0104	0.01
Area 6, CP-6	---	---	---	---	---	---	0.0057	0.0071	0.0025	0.0045	0.0025	0.0050	0.0078
Area 6, CP-72	---	---	---	---	---	---	0.0005	0.0006	0.0002	0.0002	0.0003	0.0004	0.0006
Area 12	0.068	0.0338	0.095	0.0693	0.0712	0.0529	0.0491	0.0561	0.0491	0.0566	0.0348	0.0365	0.072
Area 22, Gate	---	---	---	---	---	---	0.0014	0.0133	0.0015	0.0012	0.0019	0.0013	0.0019
Area 23	0.068	0.115	0.142	0.1962	0.1659	0.1780	0.1687	0.1776	0.1821	0.1425	0.1279	0.1221	0.227
Area 25, Reactor Control	0.0006	0.0006	---	0.0018	0.0012	0.0001	Dry	0.0001	0.0002	0.0002	0.0001	Dry	0.0015
Area 25, Central Support	---	---	---	---	---	---	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0036
BOD (mg/L)													
Area 6, Yucca Lake	---	---	---	813	---	---	---	---	---	215	---	---	No Standard
Area 12	---	---	---	---	---	609	---	---	273	---	---	521	No Standard
Area 23	115	129	207	232	140	216	206	178	264	311	188	361	No Standard
Area 25, Reactor Control	---	---	---	---	24	---	---	---	---	Dry	---	---	No Standard
TSS (mg/L)													
Area 6, Yucca Lake	---	---	---	348	---	---	---	---	---	260	---	---	No Standard
Area 12	---	---	---	---	---	380	---	---	212	---	---	296	No Standard
Area 23	276	236	224	192	356	184	344	544	424	840	536	416	No Standard
Area 25, Reactor Control	---	---	---	---	15	---	---	---	---	Dry	---	---	No Standard

--- = No sampling required. Dry = No flow.

determined from periodic measurements at the Area 25 Reactor Control sewage lagoon. ISCO flow meters were used to monitor these flows. All other lagoons require an estimated flow rate. At the Area 6 Yucca Lake Facility the flow rates for May, June, November, and December exceeded the state of Nevada limit for the lagoon system of 0.01 million gallons per day. These results were reported to the state, and a request to increase the permitted flow rate will be submitted during 1991.

The pH was determined for the Areas 22 and 23 lagoon systems every month and for all other systems every quarter. The pH is determined through use of either a pH meter or colorimetric test strips. For BOD and TSS, the sewage lagoon system permits require biannual sampling at the Area 6 Yucca Lake and Area 25 Reactor Control lagoon systems, quarterly sampling at the Area 12 lagoon system, and monthly sampling at the Area 23 lagoon system. Automatic samplers to collect BOD and TSS samples were installed in the Areas 12 and 23 systems during 1990, and another sampler will be installed in the Area 6 Yucca Lake system during 1991.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA) SAMPLING

In addition to state-required monitoring, samples were collected for constituents relating to RCRA to verify that hazardous materials were not being discharged into the lagoon system. These samples were submitted to an EPA Contract Laboratory Program laboratory (Datachem Laboratory, Salt Lake City, Utah). Analyses were conducted for VOCs, metals, and base/neutral/acid (BNA) compounds. Cyanide analyses were performed by REECo's Industrial Hygiene Department (IHD) Laboratory. The number of samples taken for each type of analysis is listed in Table 7.5.

All lagoon systems were sampled for RCRA constituents during the first quarter, and Areas 6 (Yucca Lake), 12, and 23 were sampled again in the third quarter. Samples were taken at one primary and all secondary

Table 7.5 Number of RCRA Samples Analyzed - 1990

Sample Type Analysis	Soil	Water	Sediment	Oil	Other	Total
Volatile Organic Compounds	93	9	3	50		155
Semi-Volatile Organics	78	3	7	18	11	117
ICP Metals		1	2	1	3	7
EPTox Metals	47	13	22	11	25	118
EPTox Lead	3					3
TCLP Metals	43	2	1	1		47
pH	5	20		1	17	43
Flashpoint	7	23		53	11	94
Underground Diesel or Gasoline Tanks	55					55
Other	52	15		29	4	100
Total	383	86	35	164	71	739

219

5453

Table 7.6 RCRA Constituents in NTS Sewage Lagoons - 1990

Analysis	Results April	Results August[a]
Area 23 - North Central Primary Lagoon		
Cyanide	N/D	N/S
BNA	Bis (2-ethylhexyl) phthalate - 3.7 µg/L	N/S
VOC	N/D	N/S
Metals	Barium - 0.6 mg/L	N/S
Area 23 - North East Primary Lagoon		
Cyanide	N/S	N/D
BNA	N/S	Bis (2-ethylhexyl) phthalate - 2.9 µg/L
VOC	N/S	N/D
Metals	N/S	N/D
Area 23 - East Secondary Lagoon		
Cyanide	N/D	N/D
BNA	N/D	N/D
VOC	N/D	N/D
Metals	Barium - 0.7 mg/L	N/D
Area 23 - Central Secondary Lagoon		
Cyanide	N/D	N/S
BNA	N/D	N/S
VOC	N/D	N/S
Metals	N/D	N/S
Area 23 - West Secondary Lagoon		
Cyanide	N/D	N/S
BNA	Bis (2-ethylhexyl) phthalate - 8.5 µg/L	N/S
BNA	Bis (2-ethylhexyl) phthalate - 2.9 µg/L	N/S
VOC	Toluene - 3.8 µg/L	N/S
Metals	Barium - 0.5 mg/L	N/S
Gate 100 - Primary Lagoon		
Cyanide	N/D	N/S
BNA	N/D	N/S
VOC	N/D	N/S
Metals	Barium - 0.6 mg/L	N/S
Area 6 CP - Primary Lagoon		
Cyanide	N/D	N/S
BNA	Bis (2-ethylhexyl) phthalate - 4.9 µg/L	N/S
BNA	Bis (2-ethylhexyl) phthalate - 4.2 µg/L	N/S
VOC	N/D	N/S
Metals	N/D	N/S

Note: BNA and VOC are analyses for base/neutral/acid and volatile organic chemicals, respectively. BNA, VOC, and metal analyses were performed by Datachem Laboratory in Salt Lake City, Utah. Cyanide analyses were performed by REECo.

(a) VOC analysis for August, 1990 were conducted using the TCLP method of analysis which does not include all VOCs.

N/D = None detected. N/S = Not sampled.

220

Table 7.6 (RCRA Constituents in NTS Sewage Lagoons - 1990, cont.)

Analysis	Results April	Results August[a]
Area 6 Yucca Lake - Primary Lagoon		
Cyanide	N/D	N/D
BNA	Phenol - 340 µg/L	Diethyl phthalate - 6.8 µg/L
BNA	Phenol - 370 µg/L	Di-n-butyl phthalate - 28 µg/L
BNA	Diethyl phthalate - 3.7 µg/L	Acetophenone - 11 µg/L
BNA	Diethyl phthalate - 3.6 µg/L	
BNA	Bis (2-ethylhexyl) phthalate - 4.8 µg/L	
BNA	Bis (2-ethylhexyl) phthalate - 3.2 µg/L	
VOC	N/D	N/D
Metals	Barium - 0.8 mg/L	Barium - 0.6 mg/L
Metals		Chromium - 0.15 mg/L
Area 12		
Cyanide	N/D	N/D
BNA	N/D	Phenol - 2.5 µg/L
BNA	N/D	Bis (2-ethylhexyl) phthalate - 3.2 µg/L
BNA	N/D	Benzyl alcohol - 21 µg/L
VOC	Toluene - 7.9 µg/L	N/D
VOC	Toluene - 7.9 µg/L	
Metals	Barium - 1.0 mg/L	Barium - 1.1 mg/L

Note: BNA and VOC are analyses for base/neutral/acid and volatile organic chemicals, respectively. BNA, VOC, and metal analyses were performed by Datachem Laboratory in Salt Lake City, Utah. Cyanide analyses were performed by REECo.

(a) VOC analysis for August 1990 were conducted using the TCLP method of analysis which does not include all VOCs.

N/D = None detected.

ponds. The results are presented in Table 7.6. VOC trip blanks were submitted with the samples. Two samples bottles were submitted for BNA and VOC analysis. The results of both BNA and VOC samples were included where sample results were positive. These results were reported to the state of Nevada, and action guidance is pending state consideration at the end of 1990.

SOLID WASTE DISPOSAL

All operation and maintenance manuals for the sanitary landfills at the NTS have been approved by the state of Nevada. (Permits are not issued for sanitary landfills by the state.) Monitoring of these landfills was limited to recording daily refuse amounts by weight. All waste disposed of in the Area 23 landfill was weighed at the Gate 100 weighing station.

Table 7.7 contains the amount of waste disposed of in the Areas 6 and 9 sanitary landfills. These estimates are based on the weight of the cargo as provided by the truck drivers.

7.1.2.2 NON-NTS SAMPLING RESULTS

Water pH samples taken to satisfy the sampling and reporting requirement of the Massachusetts Water Resources Authority permit for the Woburn Cathode Ray Tube Operations facility showed results of between six and seven for each semi-annual sample

Table 7.7 Quantity of Waste Disposed of in Sanitary Landfills - 1990

Month	Quantity (in pounds) Area 6	Area 9	Area 23
January	140,628	333,735	634,300
February	121,820	553,076	355,935
March	148,400	694,499	298,270
April	190,150	306,101	188,890
May	171,822	728,458	166,672
June	110,147	2,459,837	129,270
July	95,030	1,219,567	117,410
August	110,660	2,502,469	126,360
September	71,900	1,235,200	136,275
October	77,120	989,779	169,922
November	69,905	291,048	145,190
December	66,875	422,218	148,539

taken. No other sampling and reporting was required by any non-NTS facility.

7.1.3 TOXIC SUBSTANCES CONTROL ACT (TSCA)

The TSCA regulates, among other things, the use, transfer in commerce, and disposal of PCBs in electrical equipment. PCBs were commonly used as dielectric fluid in transformers in the 1960s and 1970s until brought under regulation by TSCA in the late 1970s.

Over the preceding several years, the NTS has characterized all known electrical equipment, including transformers and capacitors, for PCB content. These characterized electrical equipment were subsequently marked as "PCB," i.e., having levels greater than 500 parts per million; "PCB-contaminated," i.e., having levels between 50 and 500 parts per million; and "non-PCB," i.e., having levels below 50 parts per million and managed in accordance with the Toxic Substances Control Act.

During 1990, 217 transformer and waste oil samples were analyzed by the IHD Laboratory to determine PCB concentrations. PCB analyses were also performed on 12 soil samples and 24 swipe samples.

Transformer and waste oil results are as follows: 130 samples were measured at less than 5 ppm (the limit of quantitation), 77 samples were between 5 and 500 ppm, and 10 samples showed concentrations in excess of 500 ppm. Ten soil samples analyzed were less than the quantitation limit of 0.16 ppm, and two other soil samples were less than 1 ppm. Twenty-four swipe samples ranged from none detected to 32,000 µg/100 cm^2. The IHD Laboratory also analyzed 139 (55 percent) blank and spike samples as part of the laboratory quality control program (see Section 11 for more details of the IHD Laboratory program).

7.1.4 NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS

During 1990, 657 bulk and air samples were collected and analyzed by the IHD Laboratory in conjunction with asbestos removal and renovation projects at the NTS. Of the 607 bulk samples collected, 162 showed positive asbestos levels and 445 were negative. One hundred fifty-six (26

222

percent) bulk quality assurance samples were also analyzed. A total of 50 general area air samples were collected and analyzed along with 21 (42 percent) quality assurance samples. Tables 11.1 and 11.3 in Section 11 contain the quality control data.

7.1.5 RESOURCE CONSERVATION AND RECOVERY ACT

Table 7.6 provides the number of samples analyzed in 1990 for waste management and environmental compliance activities. All of the volatile and semi-volatile organic compound analyses were performed by outside commercial laboratories. Ninety-seven (56 percent) of the ICP[a] metals, EPTox[b] metals, and TCLP[b] metals analyses were performed by the REECo IHD Laboratory, and 75 (44 percent) were performed by outside commercial laboratories. Fourteen (25 percent) of the underground storage tank diesel or gasoline analyses were performed by REECo and 41 (75 percent) were performed by outside commercial laboratories.

A total of 260 (33 percent) blank and spike samples were analyzed in the IHD Laboratory in addition to the analyses reported in the table as part of the Laboratory quality control program.

7.1.6 FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT

An audit of the pesticide spraying facility was conducted by a DOE industrial hygienist who requested two corrective actions: a back-flow preventer on the water faucet next to the facility and a sign indicating that pesticides are not to be mixed at the facility. Requisitions have been submitted for these items.

7.1.7 SPECIAL STUDIES

A total of 129 tests were conducted at the Liquified Gaseous Fuels Spill Test Facility (LGFSTF) in 1990. As indicated in Table 7.8, in all cases monitored, no detectable concentrations of the spilled chemical were found one mile (1600 meters) away from the boundary of the NTS. In addition, no odors attributable to the chemicals being tested were detected by monitoring personnel.

7.2 ENVIRONMENTAL CONDITIONS

In 1990 the flora and fauna on the NTS continued to be strongly affected by drought. The weather in 1990 was dry, with precipitation at the NTS lower than any year since recording of precipitation data began in 1962. Precipitation measured at Yucca Flat in 1990 totaled 54.4 mm (2.14 inches). Until 1990 the lowest precipitation measured at Yucca Flat was 55.4 mm (2.18 inches) in 1989. Rainfall was unusually sparse until July, after which infrequent small showers allowed some plant growth. The effects of the continued drought were seen on all phases of flora and fauna monitoring and are exemplified in the results from the control baseline study plot in Yucca Flat. Results are also presented from the monitoring of disturbed areas created by two above-ground tests during the 1950s at the NTS and flora and fauna monitoring from areas downwind of the LGFSTF.

(a) "ICP metals" refers to samples analyzed on an inductively coupled plasma spectrometer for the presence of certain metals.

(b) "EPTox metals" and "TCLP metals" refers to samples that have been subjected to the "extraction procedure toxicity" test and the EPA-approved "toxicity characteristic leaching procedure," respectively.

5453

Table 7.8 Summary of Liquified Gaseous Chemical Spill Tests - 1990

Chemical Spilled/Date	Number of Tests	Mitigation[a]	Number Monitored	Results
Chlorosulfonic Acid				
04/03/90	2	None	2	Negative
04/05/90	1	None	1	Negative
Oleum				
04/04/90	3	None	2	Negative
Sulfur trioxide				
04/07/90	5	None	5	Negative
Trochlorosilane				
05/07/90	4	None	4	Negative
	2	Urethane foam	2	Negative
05/10/90	3	None	3	Negative
	2	Silvex foam	2	Negative
	2	3M foam	2	Negative
	3	MSA Ultra-foam	3	Negative
05/12/90	3	Ansul foam	3	Negative
Silicon tetrachloride				
05/11/90	5	None	5	Negative
	2	Silvex foam	2	Negative
	2	None	2	Negative
05/13/90	3	None	3	Negative
05/14/90	5	None	5	Negative
Chlorine				
06/22 - 06/25/90	18	Water spray and aqueous foam	18	Negative
08/16/90	4	None	4	Negative
08/17/90	3	None	3	Negative
08/18/90	8	None	8	Negative
08/20/90	5	None	0	
08/21/90	5	None	0	
Monomethylamine				
08/25/90	5	None	5	Negative
08/26/90	5	None	0	
08/27/90	5	None	0	
08/28/90	4	None	4	Negative
Cyclohexane				
09/07/90	4	None	4	Negative
09/08/90	6	None	0	
09/10/90	6	None	0	
09/11/90	4	None	0	

(a) In some cases the mitigating agent is added to the chemical before spilling.

224

- 5458

7.2.1 FLORA

Results of flora monitoring on baseline plots in 1990 showed declines in perennials and annual plant populations. Most perennial plants on the NTS remained dormant through the end of June, then leaved out sparsely in response to thundershowers. Many plants died between the summers of 1989 and 1990. There was differential survival among species; the bunch grasses and herbaceous perennial species suffered the highest mortality.

Data available from an undisturbed baseline plot located in the southwest portion of Yucca Flat (4050 feet [1200 meters] in elevation) showed a decline of approximately six percent in the number of live plants from 1989 to 1990 (Table 7.9). But the overall effects of the drought can be seen in the 46 percent, four-year decline in the number of live plants from 1987 to 1990. Two more species appear to have completely died out in 1990; *Oryzopsis hymemoides*, a bunch grass, and *Sphaeralcea ambigua*, a soft-stemmed short-lived shrub. This brings the total to four species which have completely died out; *Sitanian jubatum*, a bunch grass, and *Mirabilis pudica*, a below-ground rhizomatous herb, died out in 1989. Of the woody shrubs, the most severely affected were two small species, *Acamptopappus shockleyi* and *Artemisia spinescens*. The dominant species *(Ephedra nevadensis, Grayia spinosa*, and *Lycium andersonii*) did not significantly change in number. The estimated live volumes of perennial plants (Table 7.10) behaved similarly, dropping 37 percent since 1987, with the greatest observed decline in live volume occurring from 1989 to 1990. Again, the dominant species showed the least damage.

Similar situations were observed with the perennial plants at other baseline plots on the NTS in 1990. On the edge of Frenchman Playa (at a 3100-foot [940-meter]

Table 7.9 Counts of Live Perennial Plants by Species on a 100 m^2 Baseline Plot in Southwestern Yucca Flat, 1987-1990, and Percent Change from 1987 to 1990

Species	1987	1988	1989	1990	Percent Change
Acamptopappus shockleyi	44	34	26	13	-70
Arabis pulchra	0	1	0	0	0
Artemisia spinescens	49	47	38	21	-57
Atriplex canescens	36	38	38	41	+14
Ceratoides lanata	65	58	53	54	-17
Ephedra nevadensis	22	18	21	21	-5
Erioneuron pulchellum	28	17	0	2	-93
Grayia spinosa	40	35	34	44	+10
Hymenoclea salsola	11	9	8	10	-9
Lycium andersonii	20	15	18	20	0
Menodora spinescens	1	1	1	1	0
Mirabilis pudica	7	4	0	0	-100
Oryzopsis hymenoides	8	6	5	0	-100
Sitanian jubatum	28	8	0	0	-100
Sphaeralcea ambigua	71	26	2	0	-100
Stipa speciosa	6	10	5	8	+33
Tetradymia axillaris	2	2	2	2	0
Totals	438	329	251	237	-46

225

Table 7.10 Estimated Live Volumes (Liters/100 m^2) of Perennial Plants on a Baseline Plot in Southwestern Yucca Flat, 1987-1990, and Percent Change from 1987 to 1990

Species	1987	1988	1989	1990	Percent Change
Acamptopappus shockleyi	592	344	381	16	-97
Arabis pulchra	0	1	0	0	0
Artemisia spinescens	732	537	575	47	-94
Atriplex canescens	2085	1535	1264	921	-56
Ceratoides lanata	798	461	611	378	-53
Ephedra nevadensis	5007	5320	5015	4482	-10
Erioneuron pulchellum	1	2	0	0	-98
Grayia spinosa	2948	3195	3015	1598	-46
Hymenoclea salsola	420	196	188	44	-90
Lycium andersonii	4073	3511	2681	2521	-38
Menodora spinescens	1	1	1	0	-60
Mirabilis pudica	5	1	0	0	-100
Oryzopsis hymenoides	41	10	2	0	-100
Sitanian jubatum	11	2	0	0	-100
Sphaeralcea ambigua	34	20	0	0	-100
Stipa speciosa	2	3	3	2	+9
Tetradymia axillaris	1732	1583	1869	1636	-6
Totals	18,482	16,722	15,604	11,646	-37

elevation), one community lost 91 percent of its plants and 97 percent of live volume between 1989 and 1990. In Jackass Flats (at a 3100-foot [940-meter] elevation), a baseline plot lost 56 percent of its plants and 65 percent of its live volume. A plot on Pahute Mesa (at a 6200-foot [1900-meter] elevation), however, lost only 4 percent of its plants and 14 percent of its live volume. Ephemeral plant populations were very sparse, as in 1989. Ten of 19 sites sampled had no live annuals in a sample area of 1000 m^2 (11,000 ft^2). In lower-altitude habitats there were occasional small herbaceous perennials measured with the ephemerals, particularly *Euphorbia albomarginata* (a rhizomatous perennial spurge). On Pahute Mesa there were moister conditions, and a drill pad (U19e) sampled in May 1990 had 1242 ± 249 ephemeral plants per square meter (mean ± standard error of the mean [sem], also referred to as the "standard error" [se]). Those included 952 ± 238 *Salsola iberica* (Russian thistle) and 276 ± 51 *Bromus tectorum*, both introduced weeds, and 14 ± 6 individuals of three native species.

Following summer thundershowers, certain areas of the NTS had populations of small summer annuals including *Euphorbia micromera* in Rock Valley, Mid Valley, and parts of Frenchman Flat. A sparse population of *Amaranthus fimbriatus* occurred in Mid Valley in August, and roadside weeds were abundant in scattered areas throughout the NTS.

7.2.2 FAUNA

Results from surveys of baseline plots in 1990 showed declines in both reptile and small mammal populations. On the baseline plot in southwestern Yucca Flat, a decline in the numbers of the adult *Uta stansburiana* was observed from 1989 to 1990 (Table 7.11). This was expected based on the low numbers of juveniles in 1989. The estimate

Table 7.11 Estimated Densities of the Lizard *Uta stansburiana* in Summer 1990 on the Yucca Flat Baseline Plot, NTS

	Number/hectare ± 2 se[a]			
	1987	1988	1989	1990
Adults	33 ± 6	42 ± 13	55 ± 11	20 ± 6
Hatchlings	123 ± 18	101 ± 34	11 ± 5	53 ± 25

(a) The error terms are the estimated 2 sem in accordance with Seber (1982).

of 53 hatchlings in 1990 suggests reproduction occurred at a near-normal rate but from a reduced adult population.

Estimates of spring mammal populations on the baseline plot in Yucca Flat, as determined by mark and recapture techniques, are presented in Table 7.12. Although the most common species of kangaroo rat *(Dipodomys merriami)* increased to 1988 population levels, the other two widespread species of small mammal (Great Basin kangaroo rat, *Dipodomys microps*, and the little pocket mouse, *Perognathus longimembris*) continued to decline and were at about half the 1988 densities. (These data were recalculated using a greater trapping distance for edge traps, and densities are therefore slightly changed from the 1989 report.)

Monitoring of feral horse populations on the NTS continued in 1990. Sixty-five individual horses have now been identified through use of photographs. No new horses were identified after May, indicating that all horses on the NTS had been identified. Ten foals were observed, of which eight had disappeared by fall. Only one adult identified in 1989 was not seen in 1990. Man-made water sources are available to the horse bands, and the loss of foals can therefore be attributed to either poor forage conditions or predators. In 1990 a second deer census was conducted using spotlighting methods during three nights on Pahute and Rainier Mesas. This census indicated the presence

Table 7.12 Estimated Spring 1990 Densities of Mammals on the Yucca Flat Baseline Plot, NTS

	Number/hectare ± 2 se[a]		
Species	1988	1989	1990
Dipodomys merriami (Merriam's kangaroo rat)	5.0 ± 0.2	3.4 ± 0.0	5.0 ± 1.3
Dipodomys microps (Great Basin kangaroo rat)	5.2 ± 0.8	2.7 ± 0.7	2.3 ± 1.0
Perognathus longimembris (Little pocket mouse)	19.0 ± 1.8	9.0 ± 1.6	8.2 ± 4.7

(a) The error terms are the estimated 2 sem.

5453

of approximately 700 animals, down from approximately 1400 animals observed in 1989.

In July 1990 an estimate of the NTS raven population was made. A total of 230 raven were spotted in concentrations near work sites and landfills. This provided a lower limit to the raven population size on the NTS.

In March 1990 REECo received a permit from the U.S. Fish and Wildlife Service to capture, mark, weigh, and attach transmitters to desert tortoises *(Gopherus agassizii)* and to salvage dead animals and remains. The permit was issued for the purpose of scientific research into tortoise populations and habitats in order to enhance survival of the species. During 1990, 16 free-roaming tortoises were captured, weighed, marked, and released on the NTS, bringing the total marked since 1987 to 64 individuals. In addition, 16 tortoises inhabiting fenced areas in Rock Valley were recaptured and measured in 1990. These animals have been recaptured twice a year, when possible, for the last 27 years. No evidence of upper respiratory disease syndrome was observed in any of the above-mentioned tortoises.

7.2.3 MONITORING OF DISTURBED AREAS

Biological monitoring studies were conducted in 1990 on two blast areas created during above-ground tests in the 1950s (T2 in Area 2 and T4 in Area 4) and adjacent undisturbed control areas. These blast areas, left essentially undisturbed for 33 years, had reduced species richness in shrub cover and animal densities, and the low density of the vegetation was exacerbated by the drought.

The vegetation on these blast areas has consisted largely of bunch grasses during the latter part of the 1980s. Results of the assessment of vegetation are in Table 7.13. In the control areas and on the T2 blast area, essentially all the bunch grasses died. On the T4 blast area, approximately half the plants were alive, most of them young seedlings of *Stipa speciosa* (desert needlegrass) and *Sphaeralcea ambigua* (desert globemallow). On control areas roughly half the shrubs were dead, largely from drought. In the spring there were no live annual plants in either control or blast areas.

Lizard numbers on the blast areas were much lower than those seen on control areas, likely due to predation and the absence of shrubs which provide cover. Both the number of species and total numbers of small mammals were reduced in the blast areas (Table 7.14), although *Dipodomys merriami* (Merriam's kangaroo rat) was found in equal densities (8 ± 1 per

Table 7.13 Perennial Plant Species and Numbers of Live and Dead Shrubs and Grasses on Two 1950s Blast Areas and Adjacent Control Areas, NTS - 1990

	Number of Live Species	Number/100 m^2			
		Grasses		Shrubs	
		Live	Dead	Live	Dead
T4 Blast Area	4	97	36	282	307
T4 Control	9	2	108	63	72
T2 Blast Area	0	0	1264	0	7
T2 Control	8	1	167	79	88

Table 7.14 Number of Species and Individual Animals Trapped on 1.1 Hectare Plots on Two Ground Zeroes and Control Areas on Yucca Flat - 1990

	Number of Species	Number of Animals
T2 Blast Area	3	13
T2 Control	5	36
T4 Blast Area	1	11
T4 Control	4	18

hectare) on T4 ground zero (GZ) and its control area.

7.2.4 FLORA AND FAUNA DOWNWIND FROM THE LIQUIFIED GASEOUS FUELS SPILL TEST FACILITY

Biological studies were carried out by the University of California, Los Angeles, during the initial evaluation of the LGFSTF in 1981 and again in 1986 and 1987 during initial operations. The studies were continued by the Basic Environmental Compliance and Monitoring Program (BECAMP) group from 1988 to 1990. Populations of perennial plants were characterized in 1981, and changes in those populations nearest the LGFSTF were monitored from 1986 to 1990. Small granivorous rodents (kangaroo rats and pocket mice) were trapped periodically to monitor survival and population changes along two arcs, three and five kilometers downwind from the LGFSTF.

Aside from some damage from vehicle traffic out to five kilometers from the LGFSTF, the only evidence of damage to flora and fauna consisted of hydrogen fluoride surface damage to plants on raised mounds in the Frenchman playa near the LGFSTF. Beyond the edge of the playa the plant and animal data suggested a large effect of climate patterns that would mask any subtle effects of the LGFSTF spills. The plants and animals nearest the LGFSTF were too distant from the facility to have been affected by the tests that occurred between 1986 and 1990.

Nevertheless, the results of these studies are quite valuable in terms of monitoring the effects of natural forces on plants and animals. Only one other site in Yucca Flat has been monitored annually under the BECAMP program. The data from the LGFSTF census has given a much clearer idea of the effects of drought on the perennials and small mammals than could be seen in other Mojave Desert areas of the NTS. The 1981 baseline data were also invaluable for indicating the growth of shrubs from 1981 to 1986. Almost no perennial plant data were taken on the NTS between 1975 and 1986, and earlier data were taken at locations that were not permanently marked.

8.0 RADIOACTIVE AND MIXED WASTE DISPOSAL

5453

Mary E. Thompson

Two radioactive waste disposal facilities are operated on the NTS; the Area 5 Radioactive Waste Management Site (RWMS) and the Area 3 Bulk Waste Management Facility (BWMF). During 1990 the RWMS received low-level and mixed wastes generated at other DOE facilities. Waste is disposed of in shallow pits, trenches, and intermediate-depth, large-diameter augured shafts. Transuranic (TRU) wastes are stored in surface containers pending shipment to the Waste Isolation Pilot Plant (WIPP) in New Mexico. The Area 3 BWMF is used for disposal of low-level waste that cannot be packaged for disposal at the Area 5 RWMS. Environmental monitoring included air sampling, water sampling, tritium migration studies, and vadose zone monitoring for hazardous constituents. Environmental monitoring results for 1990 indicated that no measurable radioactivity from waste disposal operations was detectable away from the area of the waste facilities.

8.1 WASTE DISPOSAL OPERATIONS

The Radioactive Waste Management Project was established at the NTS in January 1978. Six trenches in Area 5 were opened for the disposal of radioactive waste materials from the NTS and from non-NTS facilities of the DOE. Disposal in shallow pits, trenches, large-diameter augured shafts, and subsidence craters is now accomplished at two different sites thirteen miles apart; the RWMS in Area 5 and the BWMF in Area 3.

Hazardous waste disposal Resource Conservation and Recovery Act (RCRA) operations at the NTS require the shipment of nonradioactive hazardous materials to licensed disposal facilities offsite. No disposal of hazardous materials was performed at the NTS except as constituents of the mixed waste received from the Rocky Flats Plant.

8.1.1 AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE

The RWMS occupies approximately 700 acres (1700 hectares) of the Frenchman Flat basin in the southeastern part of the NTS. It is located in Area 5, 14 miles (9 kilometers) north of the NTS main gate. Area 5 includes much of the Frenchman Flat playa, where nuclear tests were conducted in the 1950s to determine effects of nuclear weapons on miscellaneous targets.

The Frenchman Flat basin is bounded on the north by the Massachusetts Mountains, Black Ridge and Mt. Salyer to the west, the Buried Hills and Ranger Mountains to the east, and Mercury Ridge to the south. The general surface geology in the area is alluvial sediment. The basin is filled with up to 1000 feet (300 meters) of these sediments, which have collected there from the surrounding mountains. The disposal site is located on a relatively flat alluvial fan extending southward from the Massachusetts Mountains, which lie approximately two miles (1.2 kilometers) away. In the disposal site vicinity, the slope of the terrain is two percent. To the west, the general slope is about three percent. Two shallow dry washes cut through the site from the northwest. An earthen dike has been constructed along the northern border of the RWMS to prevent water flow into the disposal area from this direction.

230

There are no permanent sources of surface water or water wells at the RWMS; domestic water supplies for the site are trucked in. The distance to groundwater is approximately 800 feet (250 meters), and preliminary modeling studies have shown the travel time from the surface to be thousands of years.

The RWMS contains the low-level waste (LLW) management unit, which is comprised of the LLW disposal unit, the TRU waste storage cell, and the Greater Confinement Disposal (GCD) unit. Of the 732 acres (1800 hectares) of the RWMS, 92 acres (230 hectares) are fully fenced, posted with warning signs, and in current use for LLW waste disposal operations.

The Mixed Waste Management Unit (MWMU) is located just north of the RWMS and will be part of routine disposal operations. This area, covering approximately 24 acres (59 hectares), will contain 18 landfill cells to be used for mixed waste disposal. In April 1990 operations were limited to NTS-generated mixed waste disposal. Offsite generated mixed waste disposal ceased at that time pending receipt of an approved generators application as required by NVO-325, Nevada Test Site Defense Waste Acceptance Criteria, Certification, and Transfer Requirements.

The RWMS (as well as the BWMF) accepts only waste materials which are defense related. All waste must meet the requirements of DOE Order 5820.2A, "Radioactive Waste Management," the NTS-specific criteria in NVO-325, and relevant DOT regulations. The site itself is operated in full compliance with applicable EPA regulations and DOE Orders.

Wastes are usually received in DOT Type A containers such as heavy plywood boxes or 55-gallon steel drums. These are neatly stacked, and the location of each package within the stack is recorded in case retrieval is necessary. An eight-foot (2.5-meter) cap of clean soil, which extends four feet (1.2 meters) above the grade, is eventually placed over the waste materials to isolate the packages from the biosphere and the environment in general.

Most of the shipments received are tritium- and plutonium-contaminated materials; however, special equipment and facilities are available for handling high specific-activity gamma emitters which are received on occasion. Reusable Type B transportation containers are used to ship these materials. An inner container holding the radioactive material is removed from the shipping cask and placed in GCD shafts.

8.1.2 AREA 3 BULK WASTE MANAGEMENT FACILITY

The second disposal site is the BWMF in Area 3, which lies at an elevation of 4050 feet (1230 meters) and covers approximately 50 acres (120 hectares). It is located in a large valley bounded by mountains and the Nellis Air Force Base Bombing and Gunnery Range. Its climate and topography is similar to that of the site in Area 5. Further details regarding the BWMF are available in DOE report DOE/NV/10327-39 (Gonzalez 1988).

Waste materials which could not be packaged were disposed of at the BWMF, but only LLW was accepted. Much of the waste material buried there is contaminated soil and metal remaining onsite from the atmospheric testing of nuclear weapons at the NTS. During 1990 these materials were collected from individual test or disposal areas, transported to Area 3 by truck, and unloaded in subsidence craters caused by collapse of the overburden into the cavities formed by underground nuclear detonations. As layers of waste material have been added, waste has been covered with uncontaminated soil until the crater is filled.

Two craters, U3ax and U3bl, were filled in this manner. Between 1974 and 1990 almost 279,000 cubic yards (213,000 cubic

5453

meters) of contaminated material were consolidated at this location. An eight-foot (2.5-meter) cap of clean soil extending four feet (1.2 meters) above the grade was placed over the craters to isolate them and the waste they contain. In compliance with RCRA, a closure plan for this location has been submitted to the state of Nevada. Approval was pending at the end of December 1990.

8.2 WASTE DISPOSAL ENVIRONMENTAL MONITORING

The Reynolds Electrical & Engineering Co., Inc., (REECo) Environmental Surveillance Branch was responsible for collection of samples and verifying sample results. Standard operating procedures were maintained by the REECo Environment and Health Division, Health Physics Department (HPD). The REECo HPD Laboratory Operations Section was responsible for the analysis of the samples. (See Section 4 for sampling methods and Section 10 for laboratory quality assurance measures.)

8.2.1 AIR MONITORING

At the RWMS airborne particulate material was collected at nine sites along the perimeter fence and from six sites within the fence. At the BWMF four samplers were deployed along the perimeter fence. These air samplers operate at an air flow rate of 22 gallons (100 liters) per minute and are changed weekly.

The sampling media consisted of four-inch (10-cm), glass-fiber filters and charcoal cartridges that were analyzed for gamma activity and gross beta. Members of the naturally occurring ^{238}U and ^{232}Th decay chains and ^{40}K were the most frequently detected but in very low concentrations, typically below the detection limits of the analytical instrumentation. The results from air samples collected at the RWMS were not statistically different than the annual NTS average, indicating that no detectable radioactivity was emitted from the RWMS.

The primary potential airborne contaminant at the RWMS is tritium. Due to its tendency to migrate with soil moisture, tritium represents the greatest possibility for human exposure at the RWMS. Seven megacuries (2.5×10^{17}) have been buried at the RWMS, and special monitoring was performed at locations that were judged to be of higher risk to operating personnel.

Samplers for tritium oxide were located with the particulate samplers. The tritium samplers consisted of a column of silica gel, a pump for drawing air through the desiccant, and a dry-gas meter to measure the sample volume. Samples were collected routinely every two weeks, during which time approximately 12 cubic yards (10 cubic meters) of air were sampled. None of the airborne tritium concentrations measured at the RWMS exceeded the Derived Concentration Guides or were statistically different from the NTS network annual average. (See Section 5.1.1, "Radiological Monitoring Results," Figures 5.1, 5.2, and 5.3 for the RWMS 1990 air sampling annual average results and tritiated water vapor annual results.)

8.2.2 EXTERNAL GAMMA EXPOSURES

Thermoluminescent dosimeters (TLDs) were deployed at 24 locations around the RWMS, including six TLDs around the TRU waste storage pad and one each in Pit Nos. 3 and 4 approximately 100 feet (30 meters) from the waste stacks. These were collected quarterly. The graph in Figure 8.1 shows that the gamma exposure rates of the different areas at the RWMS are generally not statistically different from each other. The Strategic Materials Storage (SMS) Area TLDs are located in a known radiological area and therefore display higher gamma exposure rates.

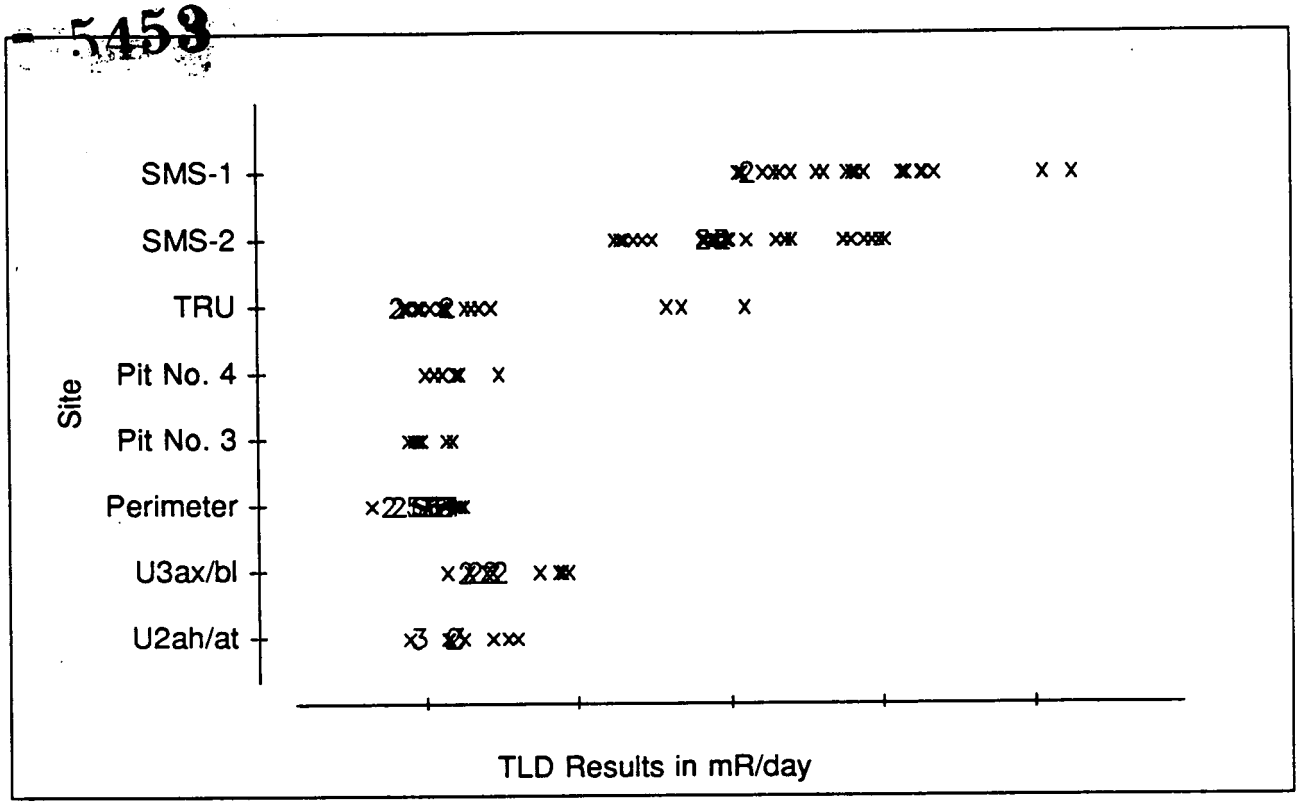


Figure 8.1 Statistical Comparison of Gamma Exposure Rates

8.2.3 WATER SAMPLING

There were six opportunities to collect precipitation water samples at both disposal sites during 1990. When samples could be collected following a precipitation event they were taken from areas of high traffic, whenever possible, and analyzed for gamma emitters. No activity above background levels was found in any of the samples taken during 1990.

8.2.4 STRATEGIC MATERIALS STORAGE AREA

Waste material from Mound Laboratory, Miamisburg, Ohio, containing approximately 290 curies (10.7×10^{12} Bq) of uranium and thorium is in temporary storage in an isolated location at the RWMS pending final disposal there. The materials were packaged in wooden boxes which in turn were stored in 28 steel cargo containers. These containers were passively ventilated through holes in the container walls. This was done to prevent the buildup of ^{222}Rn and daughters (^{218}Po, ^{214}Pb, and ^{214}Bi). In addition to the airborne alpha emitters present, accumulation of these daughters constitutes a gamma hazard. Ventilation reduces the hazards from penetrating radiations and is in keeping with the philosophy of keeping doses as low as reasonably achievable (ALARA).

The containers are located inside a fenced area that is posted with warning signs. These containers have not been opened because of the airborne contamination known to be present in them. TLDs were placed at 18 locations on the fence which surrounds the cargo containers. These were exchanged quarterly. Quarterly measurements of possible neutron emissions were made for three quarters in 1990 using track-etch methodology with plastic foils. No neutron exposures were detected, so this monitoring was discontinued.

8.2.5 VADOSE ZONE MONITORING FOR MIXED WASTE DISPOSAL

Since mixed waste consists of both hazardous and radioactive components, the

monitoring method used must address both components. For this purpose a vadose zone monitoring system consisting of neutron logging, soil air sampling, and gamma logging is under development for the RWMS.

Because water movement through the unsaturated zone is the major vehicle for the transport of waste components, neutron logging will be used for the long-term monitoring of soil moisture conditions within and beneath the disposal unit. Analysis of soil air samples will detect the presence and concentration of volatile organic compounds (VOCs). A gas chromatograph will be used for analyzing the VOCs. Gamma logging will be used to identify radioactive components in the soil.

Baseline data are currently being obtained by neutron logging, gas chromatography, and gamma spectroscopy at 24 stations located on 28-foot (8.5-meter) centers in Pit No. 3, the interim status mixed waste cell. This test area is providing data for use in computer model studies for the design of the final monitoring system.

8.2.6 TRANSURANIC WASTE STORAGE

The TRU waste storage cell was used for interim storage of certified TRU waste materials from Lawrence Livermore National Laboratory (LLNL). The waste materials were packaged in steel drums and steel boxes and stored in large steel cargo containers pending shipment to the WIPP in New Mexico.

Neutron dosimeters were placed on the door handles of each container at the beginning of the second quarter of 1990. In the second and third quarters of 1990, exposures at 46 TRU storage containers were calculated. Geometric means and standard deviations were estimated using the PROC LIFREG program of SAS 6.03. The second quarter estimated geometric means and geometric standard deviation were, respectively, 0.60 mrem/day (0.60 x 10^{-2} mSv/day) and 3.33 mrem/day (3.33 x 10^{-2} mSv/day). In the third quarter, the geometric mean was 1.05 mrem/day (1.05 x 10^{-2} mSv/day) and the geometric standard deviation was 3.61 mrem/day (3.61 x 10^{-2} mSv/day).

8.2.7 TRITIUM MIGRATION STUDIES AT THE AREA 5 RWMS

Subsurface tritium migration studies of four sites at the Area 5 RWMS have been conducted by personnel from the University of California, Berkeley. The first site was used for a study of the transport of tritium from buried waste to the atmosphere by plant transpiration. In 1976 radioactive waste containing 3.5 million curies (130 x 10^{15} Bq) of tritium was buried in one location in Trench T4. Tritium migration studies have been conducted at that trench from 1983 through 1990. A vegetative sampling area was established over the buried containers. Initially the plot had an *Alta fescue* grass cover that was followed by a native plant cover of various *Atriplex* and creosote bushes. Based on foliage sampling, transpiration of tritium increased from 0.024 Ci/year in 1983 to 5.6 Ci/year in 1990 (0.9 to 210 x 10^{9} Bq). The latter value represents a yearly loss of 1.6 x 10^{-4} percent of the amount buried.

The second study site was Pit No. 1, where sixteen 55-gallon barrels containing a total of 248 kCi (9.2 x 10^{15} Bq) of tritium were overpacked in a used engine container and then buried 20 feet (six meters) below the floor of the pit. A 2.4-inch (6-mm) longitudinal gap was left between the upper and lower halves of the overpack. Soil atmosphere samplers were distributed around the overpack to measure the migration rate of tritium. Studies of the tritium leak rate from the barrels and the concentration of the tritium in the soil air near the waste were conducted from 1983 through 1990. As in the first study mentioned above, the release rate of tritium appears to be doubling annually. The total release during 1990 is estimated to be 30 mCi (1.1 x 10^{9} Bq).

The third site for the tritium migration study is the GCD Test shaft. The GCD Test shaft is used as a supplemental disposal method to

5453

234

augment shallow land disposal (SLD). The SLD method is not suitable for the disposal of certain materials which might constitute special hazards to the public or the environment. As a result, the concept of deeper burial in augured shafts was developed. A total of 594 kCi (22 x 10^{15} Bq) of tritium were disposed of at a depth ranging from 67 to 89 feet (20 to 27 meters) below the grade. As other radionuclides were present, their decay produced sufficient heat to melt Teflon sample tubing, and this may have driven off the tritiated water faster than would otherwise have occurred. Soil moisture tritium sampling was similar to that used in Pit No. 1 except that higher flow rates were needed due to water vapor diffusion through the Teflon sampling lines. Sampling of soil air indicated very little lateral migration of the tritium.

The fourth site of the tritium migration study was in connection with a GCD hole in which 2.2 MCi (82 x 10^{15} Bq) of tritium were disposed of in a 9.8-foot (3-meter) diameter by 120-foot (36-meter) deep borehole. The waste was emplaced during the period from May 1985 through May 1987. The top layer of waste was placed 67 feet (20 meters) below the grade, and the hole was then back-filled with soil. Soil atmosphere samples were located in the borehole at various intervals. The present release rates are low but, based on the results reported above, may increase significantly with time.

Details of the methods and results and a discussion of the tritium migration studies are given in a draft topical report prepared by the University of California, Los Angeles (UCLA), and REECo personnel (Schulz et al. 1990). Information gathered so far indicates the need for having accurate site-specific soil tritium migration data in order to predict more accurately the tritium release rates to the atmosphere or migration downward towards the water table.

9.0 GROUNDWATER PROTECTION 5453

Stuart C. Black, Ronald L. Hershey,
and William G. Phillips

DOE/NV instituted a Long-Term Hydrological Monitoring Program (LTHMP) in 1972 to be operated by the EPA under an Interagency Agreement. Groundwater was monitored on and around the NTS, at seven sites in other states, and at two off-NTS locations in Nevada in 1990 to detect the presence of any radioactivity that may be related to nuclear testing activities. No radioactivity was detected in the groundwater sampling network around the NTS. Tritium escaped in 1965 from the LONG SHOT test on Amchitka Island and contaminated the groundwater, and, during cleanup and disposal operations, shallow groundwater at the Tatum Dome Test Site in Mississippi was contaminated by tritium. The levels at both these sites are decreasing and were well below the National Primary Drinking Water Regulation levels during 1990. NTS supply wells were monitored for gross alpha and beta activity as well as tritium levels.

Because wells that were drilled for water supply or exploratory purposes are used in the present monitoring program rather than ones drilled specifically for groundwater monitoring, an extensive program of well drilling for groundwater characterization has been started. The design of the program is for installation of approximately 90 wells at strategic locations on and near the NTS.

A special study was conducted at the Tatum Dome Test Site in 1990 that included vegetation, soil, animal, and milk sampling in addition to the routine groundwater monitoring. No test-related radioactivity was found outside the Tatum Dome Test Site.

Other activities in this program included studies of groundwater transport of contaminants (radionuclide migration studies) and nonradiological monitoring for water quality assessment and Resource Conservation and Recovery Act requirements.

9.1 DOE/NV GROUNDWATER AT TESTING SITES

9.1.1 NTS GROUNDWATER

The NTS has three primary water-bearing units: the lower carbonate aquifer, the volcanic aquifer, and the valley-fill aquifer The water table occurs variously in the latter two units and is confined to the NTS in the carbonate aquifer. The depth to the saturated zone is highly variable but is generally at least 152 meters (500 feet) below the land surface and is often more than 305 meters (1000 feet). The hydrogeologic units at the NTS occur in three groundwater subbasins in the Death Valley Groundwater Basin (see Section 2, Figure 2.9, for a diagram of these systems). The actual subbasin boundaries are poorly defined, but the basin hydrology is summarized in the following paragraph.

Groundwater beneath the eastern part of the NTS is in the Ash Meadows Subbasin and

286

discharges along a spring line for evapotranspiration in Ash Meadows south of the NTS. Most of the western NTS is in the Alkali Flat-Furnace Creek Subbasin that discharges for evapotranspiration at Alkali Flat and by spring near Furnace Creek Ranch. Groundwater beneath the far northwestern corner of the NTS may be in the Oasis Valley Subbasin that discharges by evapotranspiration in Oasis Valley. Some underflow past all of the subbasin discharge areas probably travels to springs in Death Valley. Regional groundwater flow is from the upland recharge areas in the north and east toward discharge areas in Ash Meadows and Death Valley, southwest of the NTS. Due to large topographic changes across the area and the importance of fractures to groundwater flow, local flow directions may be radically different from the regional trend. (ERDA 1977)

9.1.2 NON-NTS GROUNDWATER

No current operations are conducted at any non-NTS DOE/NV facility which affects the quality of the groundwater. Activities at non-NTS test areas are principally limited to groundwater surveillance and monitoring.

9.1.3 GROUNDWATER PROTECTION POLICY

An environmental protection policy statement for DOE/NV has been written. A specific reference to groundwater protection at DOE/NV-managed sites is included which states, "The principal objective of the DOE/NV groundwater protection policy is to minimize the potential environmental impacts of underground testing. To ensure minimization of impacts, while fulfilling the requirements of the testing program, procedures will be developed and implemented to optimize the location and construction of tests in order to maximize environmental protection while minimizing adverse impacts on the testing mission of DOE/NV. An ongoing program to monitor and assess the effectiveness of groundwater protection efforts will be established so that resources are allocated based on current understanding of the effectiveness of groundwater protection programs."

Presently, the above-referenced procedures for groundwater protection have not been developed. However, some general strategies for implementing the policy have been undertaken. These include:

- Identification of regulatory and other applicable groundwater protection requirements.
- Implementation of a groundwater characterization program.
- Requesting a proposal for a remedial investigation and feasibility study (RI/FS) on the NTS.
- Implementation of pollution prevention and waste minimization programs for sources other than underground detonations to minimize the amount of contaminants that could potentially affect groundwater at the NTS.
- Evaluation of physical and administrative controls implemented to protect groundwater to ensure that protection requirements are met.

Natural hydrogeological barriers to groundwater contamination from NTS operations, such as the thick vadose zone mentioned above, are enhanced by operational procedures and actions to limit potential sources of contamination. Waste control, treatment, and cleanup actions, coupled with underground test location restrictions, are used to minimize the likelihood of contamination. Onsite and offsite groundwater monitoring programs are used to document long-term water quality changes that might occur. In 1989 an extensive hydrogeology characterization project (through a contract with the Desert Research Institute, University of Nevada System) was initiated to further enhance the

understanding of the NTS groundwater system and its movement toward offsite areas.

The NTS has several natural features that protect the groundwater from contamination. The average annual precipitation level ranges from about nine inches at high elevations to less than six inches in the valleys. The arid conditions at the NTS are a result of this limited rainfall combined with a potential average annual evapotranspiration of over 120 inches of water. This leaves very little water available to leach surface contaminants into the soil or transport them through the vadose zone toward the groundwater tables. The soils have very low infiltration rates, isolating much of this water near the surface. The net vertical water movement between the water table and the surface is so small that it has not yet been measured accurately. The aquitards separating the aquifers provide partial barriers to vertical migration. In the event that contamination occurs from underground nuclear tests or other sources, the characteristic NTS and regional hydrogeology shows extremely slow groundwater movement toward distant offsite areas where public use might occur.

9.1.4 AREAS OF KNOWN CONTAMINATION

Table 9.1 is a listing of the locations on the NTS and at off-NTS sites from which groundwater samples have been taken containing detectable levels of man-made radioactivity. Potential contamination sites are discussed below.

A preliminary survey of underground and surface contamination at the NTS was conducted by the DOE in 1987. The survey delineated known and potential sources of groundwater contamination at the NTS, including underground nuclear testing areas and surface facilities. Information from this document and from DOE/NV's "Site Specific Plan for Environmental Restoration and Waste Management, Five Year Plan," was used to describe the known areas of groundwater contamination at the NTS. Detonations of nuclear devices are conducted underground to contain the detonation products. Underground emplacement of nuclear devices is accomplished either by drilling a vertical hole or mining a horizontal tunnel.

The majority of underground tests resulting from vertical drill-hole device emplacement have occurred in Yucca Flat, Frenchmen Flat, Pahute Mesa, and Shoshone Mountain. Testing in tunnels has occurred under Rainier Mesa. To date approximately 580 announced underground nuclear tests have been conducted. The principal by-products from these tests are heavy metals and a wide variety of radionuclides with differing half-lives and decay products. Detonations within or near the regional water table are considered to have contaminated the local groundwater with radionuclides, principally tritium.

When a nuclear device is detonated in a vertical shaft, all the material in the immediate vicinity of the detonation is vaporized and a cavity is formed. As pressures decrease in the cavity after detonation, fractured rock from above begins to collapse into the cavity forming a rubble chimney that usually extends to the surface, where it forms a circular depression known as a subsidence crater. (See Section 2, Figure 2.5, for a graphic representation of this occurrence.) Detonations at Rainier Mesa occur in horizontal shafts excavated in the tuff aquitard. Recharging waters from the surface of Rainier Mesa may move through contaminated zones and transport radioactive material to the regional water table.

Surface activities associated with underground testing and the secondary missions of the NTS, including disposal of defense-related low-level radioactive and mixed wastes, spill testing of hazardous liquified gaseous fuels, testing of radioactive

Table 9.1 Water Samples Containing Man-Made Radioactivity[a]

Sampling Location	Radionuclide	Concentration x 10^{-9} µCi/mL
NTS Onsite Network		
Well UE-18t	^{3}H	210
Project GNOME, New Mexico		
Well LRL-7	^{3}H	1.4×10^{4}
	^{137}Cs	180
Well USGS-4	^{3}H	1.5×10^{5}
Well USGS-8	^{3}H	1.2×10^{5}
	^{137}Cs	64
Project GASBUGGY, New Mexico		
Well EPNG 10-36	^{3}H	230
	^{137}Cs	13
Project RIO BLANCO, Colorado		
Well CER No. 1, Black Sulfur	^{3}H	340
Project Dribble, Mississippi		
Well HMH-1	^{3}H	4.0×10^{3}
Well HMH-2	^{3}H	8.1×10^{3}
Well HMH-5	^{3}H	1.8×10^{3}
Well HMH-16	^{3}H	550
Well HM-L	^{3}H	1.1×10^{3}
Well HM-S	^{3}H	9.4×10^{3}
Half Moon Creek Overflow	^{3}H	450

(a) Only ^{3}H concentrations greater than one percent of the National Primary Drinking Water Regulation are shown (greater than 2×10^{-9} µCi/mL).

materials, and other such activities, also pose potential soil and groundwater contamination problems. The types of contaminants found on the surface of the NTS include radionuclides, organic compounds, metals, hydrocarbons, and residues from plastics, epoxy, and drilling muds. A wide variety of surface facilities, such as injection wells, leach fields, sumps, waste storage facilities, tunnel ponds and muck piles, and storage tanks, have contaminated local soil and the shallow unsaturated zone at the NTS.

Because of the great depths to groundwater and the arid climate, the potential for mobilization of surface and shallow subsurface contamination is minimal. However, contaminants entering carbonate bedrock from Rainier Mesa tunnel ponds, contaminated wastes injected into deep wells, and wastes dumped into subsidence craters may reach the regional water table.

9.1.5 GROUNDWATER PROGRAMS

The groundwater monitoring protection plan for the DOE/NV is divided into four different programs: groundwater protection, groundwater characterization, groundwater monitoring, and groundwater remediation. Brief descriptions of these programs follow.

- The groundwater protection program addresses criteria for the placement of underground nuclear tests to minimize environmental and groundwater impacts as well as surface activities that may potentially contaminate the soil column.
- The groundwater characterization program delineates the procedures and criteria for the installation and testing of groundwater characterization wells and the collection of data to support the 1980 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) RI/FS.
- The groundwater monitoring program states the general criteria for a groundwater monitoring network that may be designed after completion of the groundwater characterization program and the RI/FS.
- The groundwater remediation program describes activities for remediating groundwater and potential groundwater contamination sources.

9.1.5.1 GROUNDWATER PROTECTION

The potential sources for DOE/NV-facility groundwater contamination are the underground cavities created by nuclear detonations. Some of the tests in vertical drilled holes have been detonated below the water table. However, most of the contaminants produced by the detonation are contained in the fused rock in the wall of the cavity that formed as the vaporized material condensed and solidified.

SUBSURFACE ACTIVITIES

The potential for groundwater contamination resulting directly from nuclear device detonations is now being minimized in several ways. These modifications in activity include:

- Testing is limited to three main areas; Pahute Mesa, Rainier Mesa, and Yucca Flat to localize the contamination sources to a few areas.
- Tests are normally detonated in extremely dry formations, well above the regional carbonate aquifer, increasing the potential migration time to the water table and consequent possible horizontal migration in regional groundwater flow.
- Areas with high potential for flooding or infiltration, such as dry washes, are avoided.
- Exploratory holes below the depth at which the device is placed are grouted or stemmed to prevent open pathways to deeper formations.

SURFACE ACTIVITIES

As part of the groundwater protection program, potential sources of land contamination from conventional hazardous waste are being reduced. At the NTS, leach fields are being replaced with evaporation ponds, and ponds are being lined. Underground storage tanks are being removed or upgraded. Solvents are being replaced with biodegradable substitutes. Other chemical wastes are shipped offsite for commercial disposal. Use of injection wells and French drains is being discontinued.

The radioactive and mixed-waste disposal facilities are mainly shallow land burial areas. No free liquid wastes are accepted, extensive flood protection is provided, and closure designs strongly emphasize limiting deep soil infiltration. These sites will most likely remain too dry for significant migration

and consequent groundwater contamination to occur.

A waste minimization plan to regulate the volume and toxicity of hazardous, mixed, and radioactive wastes is being developed and implemented by Reynolds Electrical & Engineering Co., Inc. (REECo) and the DOE Defense Waste Branch (DWB). This plan includes the characterization of waste streams to identify waste materials and alternate production methods to minimize waste volumes. This information will also be used to develop new technologies to avoid, eliminate, and/or reduce waste generation.

A pollution prevention awareness program is also being incorporated into the waste minimization plan. Presently, waste streams are discharged to injection wells, leach fields, lagoons, ponds, and sumps. Injection of liquid wastes into wells greatly increases the potential for contamination of groundwater by shortening the pathway to the water table and supplying the medium to transport contaminants. Pumping liquid wastes into leach fields and unlined surface structures such as ponds and lagoons introduces contaminants into the unsaturated zone and supplies the mechanisms necessary to transport contaminants to the local groundwater table.

Discharges of liquid wastes to injection wells and leach fields are being eliminated. Lagoons, ponds, and sumps are being lined with impermeable materials that will allow liquid wastes to evaporate, rather than seep into the ground. Residual contaminants are being periodically removed from these surface structures. Dumping of liquid and solid, radioactive, and hazardous wastes into subsidence craters is also being eliminated. Long-term measures will be instituted to remediate contaminated areas, control migration of wastes, and/or isolate wastes from the accessible environment.

Because of the arid climate and the great depths to groundwater from the land surface, any contaminants found in the near-surface environment will probably not reach the water table unless associated with large volumes of liquids (injection wells, ponds, etc.). Hazardous wastes found in the soils will be remediated as required by state of Nevada and federal regulations. Most radioactive materials produced from nuclear testing, including tritium, cannot be treated. Thus, mixed wastes and radioactive wastes presently located in the near surface will either be isolated from the accessible environment by *in situ* stabilization using engineered barriers to restrict migration or removed and placed in properly designed and permitted waste repositories.

Extensive monitoring systems surrounding isolated wastes will be designed and constructed to provide early warning of contaminant migration. Dry wastes isolated in the unsaturated zone will be monitored with instruments that detect waste transport in the liquid and gaseous phases. Monitoring systems for liquid-waste storage areas, lagoons, and ponds will also use soil-moisture and soil-gas monitoring instruments as well as monitoring wells.

All water supply wells presently at the NTS were sampled in 1990 for radionuclide contamination and hazardous contaminants where appropriate. It is the DOE/NV's policy to implement all near-term and long-term measures according to appropriate state of Nevada and federal environmental regulations.

Typical up-gradient and down-gradient monitoring wells were not employed for monitoring groundwater during 1990 in the vicinity of the Mixed Waste Disposal Facility in Area 5 or other places because of the great depth and extremely long potential migration time from any contamination sites to the groundwater. Vadose zone monitoring was conducted in the unsaturated zone under the waste disposal pits to obtain much more timely information on any possible movement of waste constituents toward the groundwater table.

9.1.5.2 GROUNDWATER CHARACTERIZATION

The hydrogeologic regime in the vicinity of the NTS is not well understood. As part of the groundwater protection program, a groundwater characterization program is presently being implemented to better understand the location, quality, quantity, and movement of groundwater at the NTS. Information gained from the groundwater characterization program will be used to investigate and develop groundwater remediation and monitoring programs. These programs will be initiated to detect subsurface migration of radioactive contaminants generated from underground testing in the Frenchman Flat, Yucca Flat, Pahute Mesa, and Rainier Mesa areas.

To ensure the adequacy of hydrogeologic data, site characterization will be performed prior to designing the remediation and altering the present monitoring program. The function of the site characterization process will be to collect sufficient information to identify and characterize potential pathways for contaminant migration. This information is required to optimize the locations of monitoring wells.

Currently, DOE/NV is implementing a long-term groundwater characterization program with the purpose of refining knowledge of the groundwater-flow and solute-transport systems on the NTS. The program is expected to require from three to five years, with drilling of the first well starting in May 1991. The wells drilled for the groundwater characterization program will be positioned as to maximize the geologic and hydrologic information available from each boring. Geologic information gained during drilling will be used to optimize testing of different hydrologic units and to determine well-screen intervals. Hydrogeologic information will be used to determine the directions and rates of groundwater flow in three dimensions, determine spatial and temporal variations in the directions and rates of groundwater flow, and quantify parameters that control these factors.

Formation samples taken during construction will be tested to determine physical and chemical properties. The wells will also be pumped to determine aquifer properties such as transmissivity, boundary locations, and leakage through aquitards. Water samples will be chemically analyzed to indicate flow paths and travel times. Water table elevations, together with the hydraulic information from laboratory testing of the media samples and the pumping test, will allow much more accurate predictions of vertical and areal migration velocities. Water samples from these wells will also be tested for radionuclides during the monitoring phase of the program.

9.1.5.3 GROUNDWATER MONITORING

A groundwater monitoring program may be implemented at the NTS as part of the overall RI/FS and groundwater protection program. Presently, groundwater sampling programs are being conducted by REECo on the NTS and by EPA on and in the vicinity of the NTS. Information from these sampling programs, the groundwater characterization program, and special studies will be used to evaluate potential monitoring and remedial actions at the NTS that will satisfy federal and state requirements. The proposed NTS groundwater monitoring well network may include existing water supply wells, characterization wells, and monitoring wells specifically designed to monitor groundwater contamination.

DOE/NV currently operates the LTHMP in cooperation with the EPA. The NTS program was developed gradually from available wells drilled to support studies associated with the nuclear weapons testing program. The locations of these wells reflect their initial purpose as exploratory holes, hydrologic test wells, and water supply wells, and are not located as well as monitoring wells specifically designed to monitor migration of contamination might be. The present

sampling well network is used to determine whether or not radionuclide contamination associated with underground nuclear testing has entered the sampled wells. In the event that a groundwater monitoring well network is required as a result of the RI/FS at the NTS, certain criteria for the placement and design of monitoring wells as required by EPA must be considered. The monitoring networks for these areas will be designed to intercept all formations that have the potential for acting as pathways for radionuclide migration and transport of nonradioactive contaminants. A smaller surficial network may be required for Jackass Flats to detect and monitor existing and possible future releases of contaminants from surface-based facilities. Until the RI/FS is completed, the exact nature of monitoring and/or remedial actions will not be known. The water sources normally sampled are shown in Table 9.2.

9.1.5.4 GROUNDWATER REMEDIATION

Currently, DOE/NV conducts an Environmental Restoration Program at the NTS that includes sites associated with above- and below-ground tests, safety tests, and industrial activities. The Environmental Restoration Program also includes sites and equipment that must be decontaminated and decommissioned. Because the sites being considered by the Environmental Restoration Program are inactive, the program has been planned in accordance with the requirements of CERCLA, the Superfund Amendments and Reauthorization Act (SARA), and the EPA. Other regulatory guidelines that may cover remedial activities include the Resource Conservation and Recovery Act, Safe Drinking Water Act, and state of Nevada Underground Storage Tank Program. However, conditions at the NTS negate the implementation of some remedial actions commonly used in other areas of the country.

The nature of wastes and materials released and the types of activities conducted at the NTS, such as nuclear weapons testing, are unique. Consequently, cleanup of groundwaters cannot always be achieved using technologies that are currently available. Also, remedial controls typically used at other sites to manage groundwater contaminant plumes are not cost effective because of the great depths to groundwater at the NTS. Thus, remediation of underground testing areas will consist of a strategy to determine the extent of contamination and, possibly, a monitoring system that will identify any movement of contamination off the NTS. Actual remedial actions will be developed from information gained during RI/FS activities.

The strategy for the Environmental Restoration Program and RI/FS activities includes:

- Identifying inactive, contaminated facilities and sites.
- Assessing these facilities and sites to determine the nature and extent of contamination.
- Confining and containing existing contamination to the extent necessary for minimizing its further spread.
- Providing for negotiated agreements with regulatory authorities and defining the requirements and schedule for cleanup of contaminated facilities and sites.
- Ensuring that cleanup is carried out in strict compliance with these agreements.
- Providing long-term monitoring to ensure continuing compliance.

Locations which are currently candidates for remedial action were shown in Table 9.1.

9.1.5.5 SPECIAL STUDIES

The major focus of the Hydrology/ Radionuclide Migration Program (HRMP) is to gain a better understanding of groundwater flow directions and velocities and radionuclide migration in order to address the environmental and safety

Table 9.2 Summary of Long-Term Hydrological Monitoring Program Information

Location Name	State	Number and Sources Sampled	Purpose of Nuclear Tests	Remarks
NTS (Onsite)	Nevada	29 wells	Weapons/effects tests, etc.	Collected monthly or semi-annually
NTS (Offsite)	Nevada and California	25 wells 7 springs	Weapons/effects tests, etc.	Collected monthly
Fallon	Nevada	4 wells 1 spring	Vela Uniform	Project SHOAL
Blue Jay	Nevada	4 wells 1 spring	Calibration test	Project FAULTLESS, Central Nevada Test Area
Amchitka Island	Alaska	5 wells 1 spring 2 surface		Background samples
Amchitka Island	Alaska	1 well 6 surface	Warhead test	Project CANNIKIN
Amchitka Island	Alaska	4 wells 8 surface	Vela Uniform	Project LONG SHOT
Amchitka Island	Alaska	18 wells 1 surface	Calibration test	Project MILROW
Rio Blanco	Colorado	5 wells 9 surface	Plowshare test	Project RIO BLANCO
Grand Valley	Colorado	6 wells 3 springs 1 surface	Plowshare test	Project RULISON
Baxterville	Mississippi	40 wells 7 surface	Vela Uniform	Project Dribble
Gobernador	New Mexico	5 wells 3 springs 2 surface	Plowshare test	Project GASBUGGY
Malaga	New Mexico	10 wells	Multi-purpose test	Project GNOME

aspects of continued underground nuclear testing at the NTS. The HRMP includes a series of ongoing groundwater studies on both a regional and local scale. Brief descriptions of the individual studies are presented below.

GEOCHEMICAL AND ISOTOPIC MODELS

Several major activities are presently being conducted. A comprehensive discrete-state compartment (DSC) model of the NTS groundwater system using deuterium as a tracer has been constructed and the input parameters identified. The steady-state model has been calibrated and independently checked. Two transient-state scenarios mimicking a cooler and wetter climate have also been calibrated. Mean ages for each cell of the different scenarios were calculated and a sensitivity analysis was performed. Presently, the DSC model results are being compared to a previous model that used ^{14}C data. The models are being evaluated in terms of recharge, groundwater flow, and discharge. Stable isotopic data of rain water and groundwater are also being evaluated to investigate groundwater recharge and flow. Finally, a feasibility study is being conducted to test the viability of stable isotopic ratios of soil vapor to predict those of liquid water in the soil zone.

YUCCA FLAT HYDROLOGY

Unusually high hydraulic pressures are observed in Yucca Flat that present problems with respect to nuclear testing by increasing engineering and material costs and causing concern for radionuclide migration. This long-term project is designed to collect hydraulic information necessary to understand the high pressure zone in Yucca Flat. Presently, fluid levels in existing holes and exploratory holes are being monitored.

RECHARGE AND RUNOFF STUDIES

One of the fundamental questions concerning the groundwater system at the NTS relates to the conditions under which recharge occurs. Presently, high-elevation areas of Pahute Mesa and Rainier Mesa are being monitored for soil moisture, soil temperature, and *in situ* water content. Alluvial-wash environments are being evaluated for their recharge potential. Selected sites are also being monitored for precipitation, air temperature, relative humidity, soil temperature, soil moisture, and equivalent soil moisture of snow.

DRILLING AND TESTING

Drilling activities under HRMP are designed to gather geologic, hydraulic, and water chemistry data to better understand groundwater flow and potential contaminant transport. A site (UE3e#4) was selected by the HRMP committee, and drilling and construction of a well was completed with drilling reaching a total depth of 2372 feet. Tritium activity in the returned drilling fluid and from the gamma-ray geophysical log and gamma activity in the recovered core suggests possible pathways of radionuclide migration at depths of 1775, 2160, and 2230 feet. Slow water-level recovery rates in the borehole indicated that the adjacent formations were of low permeability. Three monitoring wells were installed in the open borehole with 20-foot screened intervals centered at depths of 1630, 1900, and 2160 feet. Water levels measured in these wells suggest a strong, vertically upward hydraulic gradient at this location. Tritium activities collected during well development suggested a tritium source from a fracture at 2160 feet. Representative groundwater samples have not been collected because of well completion problems.

WELL VALIDATION PROGRAM

To quantify the movement of groundwater beneath the NTS and help develop a monitoring strategy to detect the possible migration of hazardous and radioactive substances, detailed testing of existing wells and boreholes and proposed monitoring wells is being conducted. Wells presently

5453

used for groundwater sampling are poorly characterized with regard to lithology, aquifer penetrated, vertical hydraulic gradients, and vertical variations in water quality. Testing strategies to characterize existing well parameters have been developed and implemented. Detailed geophysical logs and borehole flow-meter logs were conducted at boreholes UE18r and HTH-1, and water samples were collected from UE18r, HTH-1, and HTH-3. In each of these unpumped boreholes, natural vertical flow, induced by vertical hydraulic gradients, was detected. The presence of vertical flow suggests that depth-to-water measurements do not represent the actual hydraulic head present in any of the open intervals of the borehole sampled. The presence of vertical flow invalidates the assumption that only horizontal flow occurs, which is traditionally used in estimating groundwater flow and contaminant transport potential.

NEAR-FIELD HYDROLOGIC STUDY

The near-field hydrologic system is important because it controls the transfer of water and radionuclides from the shot cavity to the regional hydrologic system; therefore, it can strongly affect the environmental impact of underground testing. Post-shot hydrologic monitoring strategies are being conducted to evaluate transport processes including installation of temperature and pressure probes at the BULLION event site.

RADIONUCLIDE GEOCHEMISTRY STUDIES

The geochemical behavior of radionuclides in the subsurface is being investigated. Model elements representing radionuclides are being used to evaluate adsorption and desorption isotherms on different surfaces including inorganic surfaces, colloidal silica and calcite, and organic colloidal material.

NONRADIONUCLIDE GEOCHEMISTRY STUDIES

Selected groundwaters from the NTS are being collected to provide background information on the occurrence and distribution of metals and organic compounds in water supply wells, tunnel discharges, and shot cavities. These analyses will aid in the prediction of geochemical behavior of contaminants in groundwater.

CAMBRIC STUDIES

In 1965 the CAMBRIC nuclear test was conducted in Frenchman Flat, Area 5. A re-entry borehole (RNM-1) was drilled into the cavity in 1974 along with a satellite well (RNM-2S) 91 meters away. Water has been continually pumped from the satellite well since 1974 to induce a hydraulic gradient from the cavity to the satellite well. Groundwater samples have been collected from these wells to evaluate radionuclide migration away from the cavity. All radionuclides at the cavity have decreased with time, with tritium and ^{85}Kr concentrations decreasing at similar rates. However, tritium levels have decreased slightly less than those of ^{85}Kr at RNM-2S. The apparent loss of krypton relative to tritium may be the result of sorption of krypton onto geologic material or the release of gaseous krypton to the unsaturated zone. Tritium concentrations in the cavity have decreased more rapidly relative to ^{90}Sr and ^{137}Cs. Desorption and/or dissolution of ^{90}Sr and ^{137}Cs from materials in the cavity may keep their concentrations higher than that of tritium, which exists as part of the water molecule. Effluent from RNM-2S is discharged into a ditch near the pumped well. Radionuclide migration in the unsaturated zone is being investigated at the ditch. Over the past 13 years approximately two-thirds of the water entering the ditch has re-infiltrated into the subsurface. Analysis of subsurface hydrologic properties is being conducted including matric potential, moisture content, and saturated hydraulic conductivity of drill cores taken near the CAMBRIC ditch.

RADIONUCLIDE DISTRIBUTION STUDIES

Some water samples from wells on the NTS have, over time, exhibited spikes of tritium which may have been the result of

atmospheric or underground nuclear detonations. In order to evaluate these observed variations over time, parallel sampling of selected wells currently sampled in the LTHMP is being conducted and tracking of radionuclide samples collected during drilling of emplacement holes is being performed.

9.2 NTS LONG-TERM HYDROLOGICAL MONITORING PROGRAM

At the inception of nuclear device testing on the NTS, the primary concern was with atmospheric fallout, so surface water sampling and analysis was emphasized. This was continued after 1954 with the signing of the Memorandum of Understanding between the U.S. Atomic Energy Commission (AEC) and the U.S. Public Health Service (PHS). Samples were collected only during the periods of testing and were analyzed for gross alpha and gross beta.

Beginning in 1958 the emphasis shifted to groundwater sources and a routine sampling regime. There were 21 sampling locations around the NTS, mostly groundwater and potable water supplies with few surface water locations. This permanent network was supplemented with other surface water collections during each test series. Samples were collected bimonthly and were again analyzed for gross alpha and gross beta activity. In 1960 the PHS obtained multi-channel analyzers, so analysis for specific radionuclides became possible, and gamma spectra were obtained on some of the water samples. The routine water surveillance network had increased to 30 stations by 1962, with samples collected monthly, and continued increasing, principally by adding surface sources such as stock tanks and irrigation reservoirs, to more than 90 stations by 1968.

In 1972 the Nevada Operations Office (NV) of the AEC instituted the LTHMP to be operated by the EPA's Environmental Monitoring Systems Laboratory in Las Vegas, Nevada (EMSL-LV), which was the successor agency to the PHS. The LTHMP was instituted because NV realized its responsibility for obtaining, and having available for dissemination, data for all locations where nuclear devices have been tested that was appropriate and adequate to:

- Assure public safety.
- Inform the public, the news media, and the scientific community relative to radiological contamination.
- Document compliance with existing federal, state, and local anti-pollution requirements.

To achieve these goals, the NV established a Hydrologic Monitoring Advisory Committee whose purpose was to review the LTHMP data, establish or modify the locations to be sampled, and establish the frequency of sample collection and the target radionuclides. The initial sampling locations were at off-NTS test sites in Nevada, Mississippi, New Mexico, and Colorado that were visited annually for water sample collection. The LTHMP was gradually expanded to include all stations in the network by 1975. Each of the off-NTS test sites included in the LTHMP is discussed later in this section.

LTHMP samples are currently collected monthly from some of the onsite wells and semi-annually from others. These samples are analyzed for gamma emitters and tritium. Samples are collected monthly from the wells in the near offsite area of the NTS network for analysis by gamma spectroscopy, and tritium analysis is performed semiannually on samples from these locations.

At the start of the LTHMP, the first samples from a new location were analyzed for 15 stable elements; anions, nitrates, ammoniacal nitrogen, silica; uranium, plutonium and strontium isotopes; and ^{226}Ra.

At each location where a sample was collected, measurements of pH, temperature, conductivity, and the sampling depth were made. In 1979 the stable chemical analyses were discontinued, except on special request, but strontium, uranium, plutonium, and ^{226}Ra analyses are still performed for all new sampling locations. The present makeup of the LTHMP for the NTS is displayed in Figure 9.1 for the onsite wells and in Figure 9.2 for the offsite wells. If the offsite sampling locations are compared with the groundwater flow pattern shown in Section 2, Figure 2.9, the upgradient/downgradient pattern is evident. The results of sample analyses by EMSL-LV are discussed in Section 9.2.1.

Some of the NTS wells that are part of the LTHMP are also sampled and analyzed independently as part of the onsite groundwater monitoring network operated by REECo for DOE/NV. That network includes 14 wells and 7 natural springs. The NTS water distribution system is the potentially critical pathway for the ingestion of waterborne radionuclides by NTS workers and visitors, and it is sampled and evaluated frequently. The NTS drinking water system consists of nine wells that supply potable water to onsite distribution systems. The drinking water is pumped from the wells to the points of consumption. These supply wells are sampled on a monthly basis. All drinking water is sampled weekly at the end of distribution lines to provide a constant check on the end-use activity and to allow frequent comparisons to the radioactivity of the water in the supply wells. (See Section 5 for a discussion of point-of-use sampling).

Each monthly sample is analyzed by REECo for ^{3}H, gross beta, and gamma activity. An extra sample is taken each quarter and analyzed for ^{238}Pu, $^{239+240}Pu$, and gross alpha activity. (See Section 4, Table 4.1, for a complete summary of environmental sampling.) All environmental surveillance annual average results are presented in Section 5, including monitoring results from groundwater sampling conducted by REECo. A brief summary of the LTHMP results is provided in Section 9.2.1.

9.2.1 RADIOLOGICAL STATUS OF SAMPLED GROUNDWATER

In general, tritium is the only nuclear-test related radionuclide that appears in water from sampled wells at test sites. The on-NTS portion of the LTHMP that is operated by EMSL-LV includes two wells with decreasing concentrations of tritium and two wells with increasing concentrations as shown in Table 9.3 and Figures 9.3 and 9.4. Wells C and C-1 were used in hydrological transport studies many years ago, and the tritium added to the well as a tracer for the studies is decreasing. The source of the tritium in Test Well B is unknown but may be due to surface water infiltration or transport from a nearby test cavity. The tritium appearing with increasing concentration in Wells A and UE-15d is probably due to nuclear test cavities located near these wells.

The only offsite locations shown in Figure 9.2 from which water samples have contained measurable tritium concentrations are springs, surface waters, and shallow wells. The concentrations measured reflected normal environmental levels. The results from the LTHMP sampling for the NTS are shown in Tables 9.4 and 9.5.

The onsite water supply and potable water wells and springs that were sampled and analyzed by REECo in 1990 included the four wells listed in Table 9.3, although Well A was deleted from the network in 1989. The individual results of REECo sampling appear in Section 5.2.1.

The network average gross beta activity for NTS supply wells was 6.9×10^{-9} µCi/mL, which was 0.10 percent of the Derived Concentration Guide (DCG) for ^{40}K and 0.69 percent of the DCG for ^{90}Sr. In previous reports (Scoggins 1983 and Scoggins 1984) it was shown that the majority of gross beta activity was attributable to naturally occurring

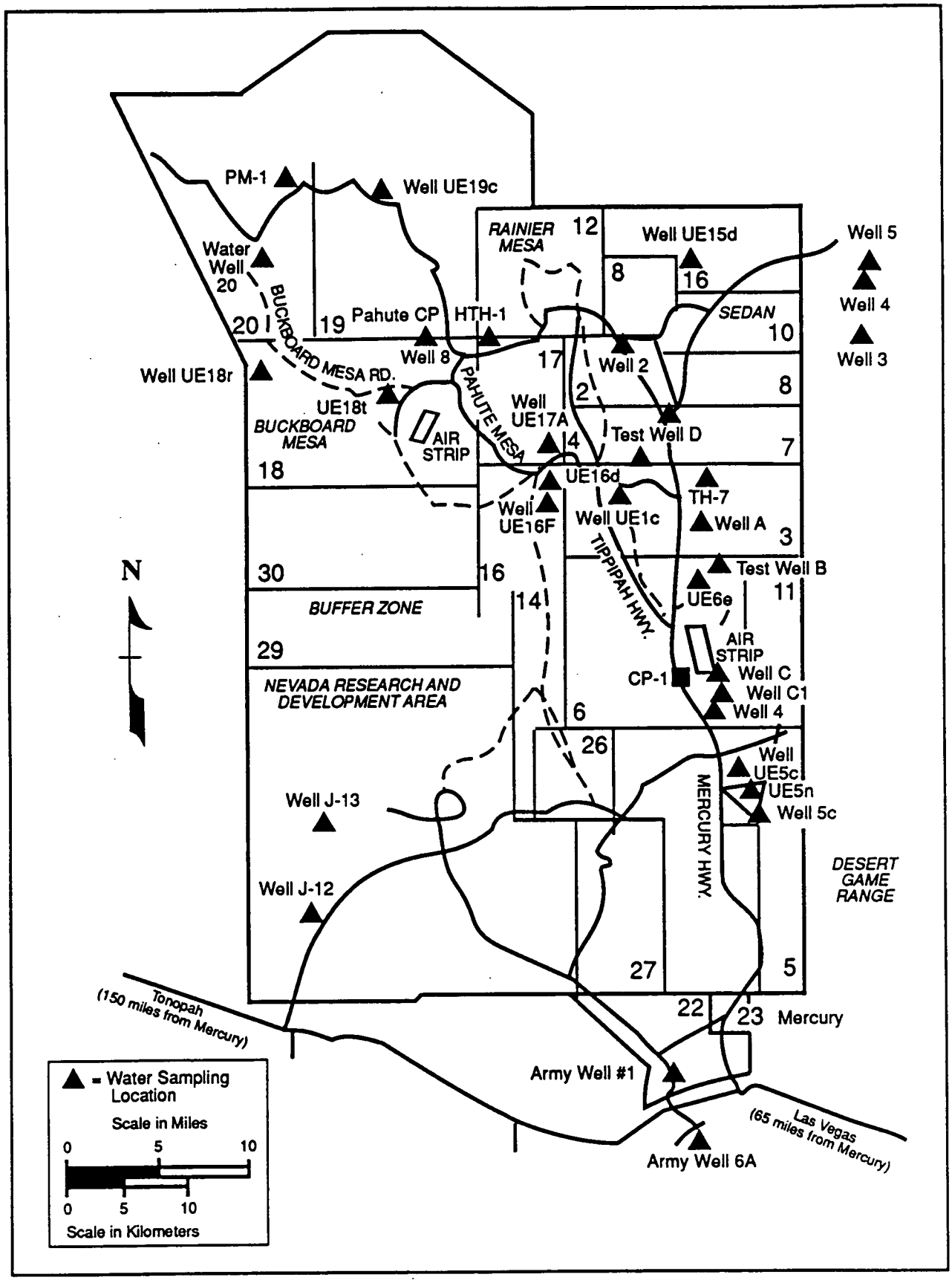


Figure 9.1 Wells On the NTS Included in the LTHMP

249

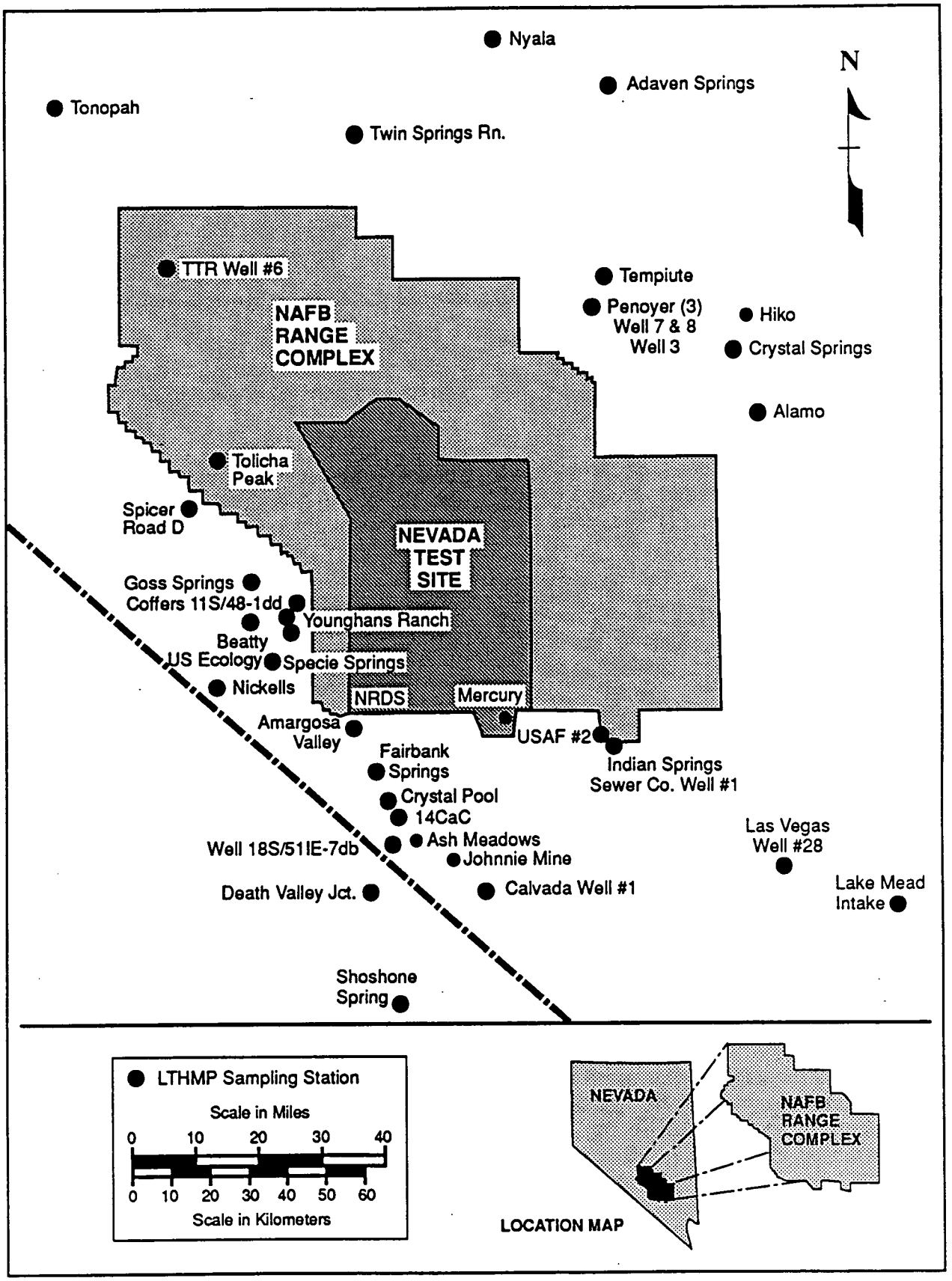


Figure 9.2 Wells Outside the NTS Included in the LTHMP

Table 9.3 Summary of Trends in Tritium in Sampled Groundwater

NTS Well	Tritium pCi/L Start	End	Trend	Remarks
Well C	150	32	Decreasing	Started in 1973
Test Well B	255	135	Decreasing	Started in 1972
Well UE15d	<8	80	Increasing	Started in 1973
Well A	<8	52	Increasing	Shut in 1989

^{40}K. The gross beta annual averages are shown at their respective supply well sampling locations in Section 5, Figure 5.12. The gross beta analysis is a sensitive method for noting trends of radioactivity in samples. The annual average values for NTS supply wells during the last several years are shown in Figure 9.5.

There were no supply well stations which displayed annual average concentrations different at the five percent significance level from the network annual average ^{3}H concentration of 1.1×10^{-7} µCi/mL. This annual average was 0.6 percent of the National Primary Drinking Water Regulation for ^{3}H.

The annual average network $^{239+240}Pu$ concentration of 2.3×10^{-13} µCi/mL was 0.001 percent of the DCG for this radionuclide. The annual average ^{238}Pu concentration of -2.9×10^{-12} µCi/mL was essentially zero. In accordance with the National Primary Drinking Water Regulation, gross alpha measurements were made on samples from the drinking water systems. The annual average gross alpha results from quarterly sampling conducted at each location indicated that samples taken from four potable water locations averaged over 5×10^{-9} µCi/mL (5 pCi/L), which is the screening level for ^{226}Ra analysis. Water from the wells supplying that water was collected and analyzed for ^{226}Ra. None of the ^{226}Ra results was above 3×10^{-9} µCi/mL; thus, onsite drinking water was in compliance with federal drinking water regulations.

The locations of all natural springs sampled are shown in Section 5, Figure 5.10, along with the annual average gross beta results. The annual average gross beta concentration for all samples collected from natural springs was 9.9×10^{-9} µCi/mL, which represents 0.14 percent of the ^{40}K DCG. None of the gross beta annual averages from natural springs were determined to be statistically different from the network average at the five percent significance level.

The network annual average ^{3}H from samples taken at the seven natural springs was 1.2×10^{-7} µCi/mL, which equaled 0.6 percent of the DCG for ^{3}H in drinking water. The sampling results from individual natural springs were not significantly different from the network average at the five percent significance level.

All of the results from which the above summaries were derived are shown in the appendices in Volume II, Appendix C, of this report, together with the statistical analyses of the data. Other agencies also monitored the groundwater at the NTS. The EPA/EMSL-LV collected samples as part of its LTHMP, and the state of Nevada Division of Environmental Protection also sampled various supply wells on the NTS. None of the sampling results have given an indication of movement of groundwater contaminants off the NTS.

5453

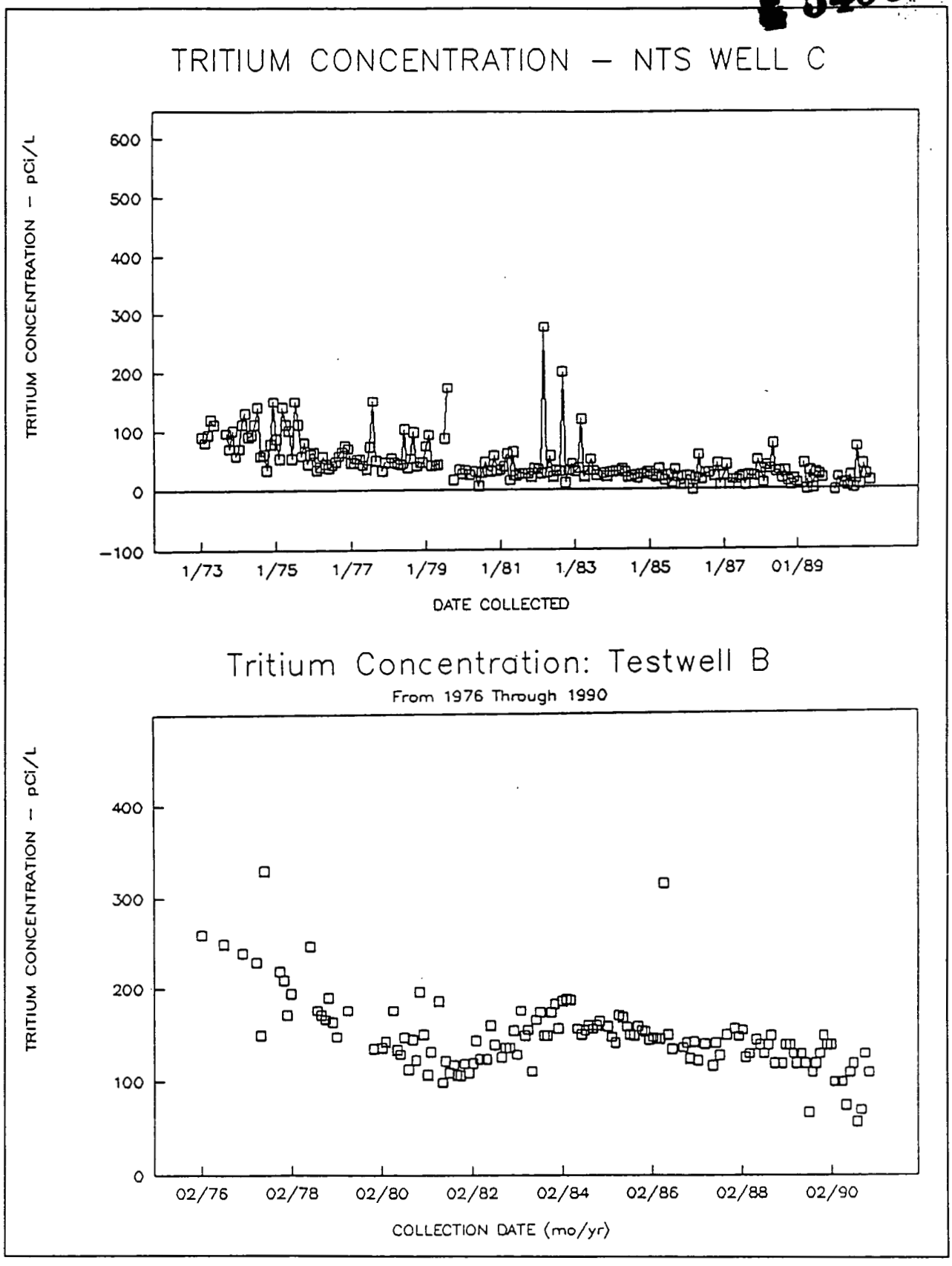


Figure 9.3 Wells with Decreasing Trends of Tritium Concentration in Groundwater

252

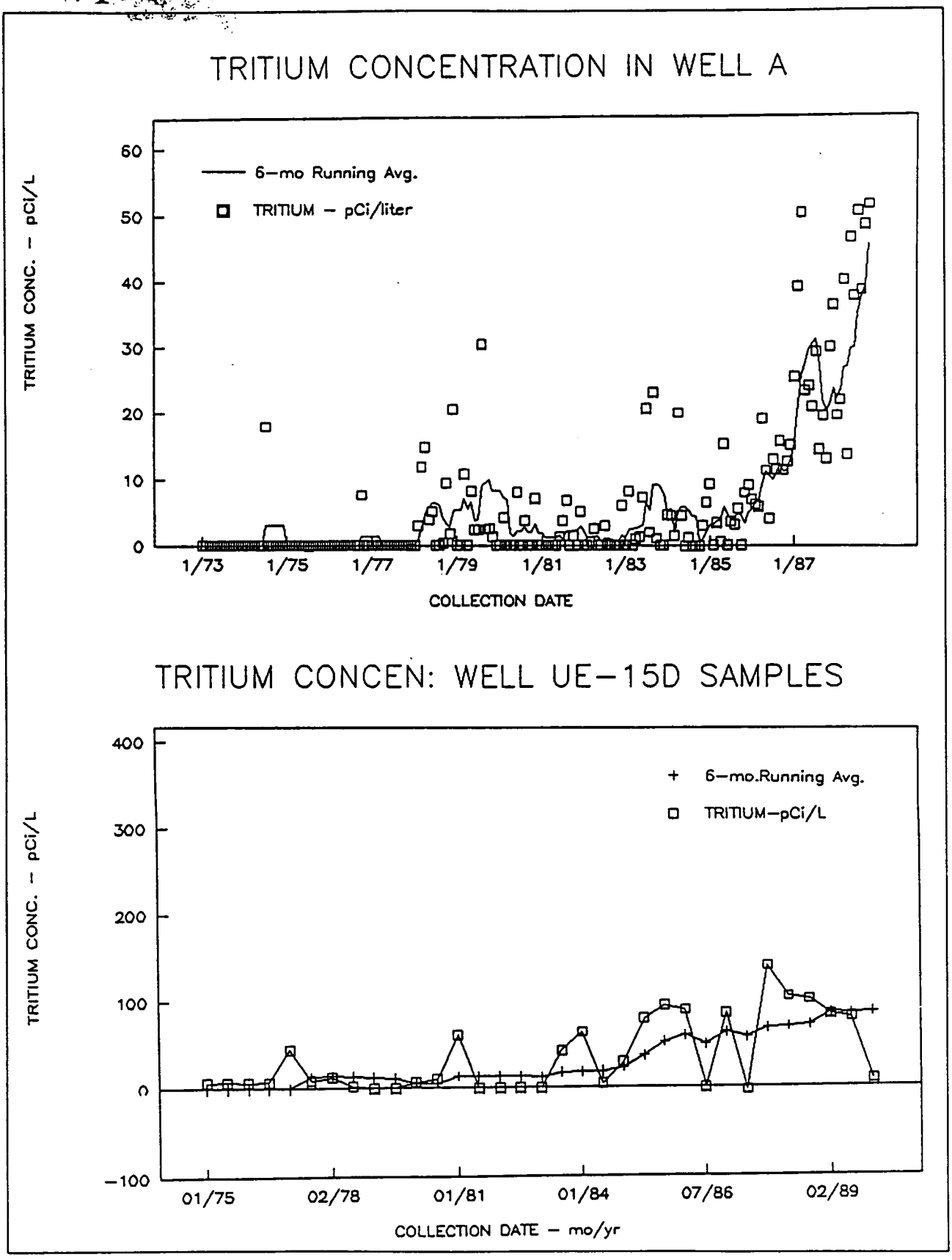


Figure 9.4 Wells with Increasing Trends of Tritium Concentration in Groundwater

Table 9.4 LTHMP Results for the NTS Semi-Annual Network - 1990

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
Shoshone, CA					
Shoshone Spring	01/02	1.1	±	3.2[a]	<0.01
	02/06	-2	±	3.6[a]	<0.01
	08/07	-67	±	140 [a]	-- [b]
Adaven, NV					
Adaven Spring	01/09	43	±	3.4	0.22
	07/02	-40	±	140 [a]	--
Alamo, NV					
Well 4, City	01/11	-2.3	±	3.2[a]	<0.01
	07/02	-110	±	140 [a]	--
Amargosa Valley, NV					
Mary Nickell's Well	02/08	1.4	±	3 [a]	<0.01
	08/07	-39	±	140 [a]	--
Community Center	05/10	-2	±	3	<0.01
Ash Meadows, NV					
Crystal Pool	05/09	-0.2	±	2.8[a]	<0.01
	11/21	320	±	140 [a]	--
Fairbanks Springs	05/09	-1.0	±	3.5[a]	<0.01
	11/21	170	±	140 [a]	--
Well 17S-50E-14CAC	12/12	-36	±	140 [a]	--
Well 18S-51E-7DB	05/09	4.9	±	2.8[a]	0.02
	11/21	320	±	140 [a]	--
Beatty, NV					
Low-Level Waste Site	06/14	1.0	±	3.7[a]	<0.01
	12/05	-260	±	140 [a]	--
Specie Springs	02/07	170	±	140 [a]	--
	07/10	20	±	2.9	0.10
Tolicha Peak	02/07	81	±	130 [a]	--
	08/01	0.1	±	3.8[a]	<0.01
Well 11S-48-1DD, Coffers	01/04	2.2	±	2.7[a]	0.01
	07/11	4.8	±	2 [a]	0.02
Well 12S-47E-7DBD, City	02/09	-58	±	130 [a]	--
	07/12	4.2	±	2.9[a]	0.02

(a) Concentration is less than the minimum detectable concentration (MDC).
(b) Indeterminate for conventional tritium analysis.

Table 9.4 (LTHMP Results for the NTS Semi-Annual Network - 1990, cont.)

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
Beatty, NV, cont.					
Road D, Spicers Well	02/08	210	±	140 [a]	--
	08/08	-0.9	±	3 [a]	<0.01
Younghans Ranch (House Well)	06/13	0.4	±	3.2[a]	<0.01
	12/05	-0.4	±	2.5[a]	<0.01
Boulder City, NV					
Lake Mead Intake	03/13	-150	±	130 [a]	--
	09/14	44	±	3.7	0.22
Clark Station, NV					
Well 6, Tonopah Test Range	02/07	-35	±	130 [a]	--
	08/09	-2	±	2.6[a]	<0.01
Hiko, NV					
Crystal Springs	01/11	-9	±	140 [a]	--
	07/02	49	±	140 [a]	0.24
Indian Springs, NV					
Trough Springs-Toiyabe	06/01	28	±	2.9	0.14
Well 1, Sewer Company	03/05	81	±	130 [a]	--
	05/01	36	±	140 [a]	--
	09/04	-1	±	3 [a]	<0.01
Well 2, U.S. Air Force	03/05	31	±	130 [a]	--
	05/01	260	±	140 [a]	--
	09/04	-2.2	±	2.4[a]	<0.01
Johnnie, NV					
Mine Well	01/02	50	±	140 [a]	--
	03/06	31	±	140 [a]	--
	07/17	0	±	2.2[a]	<0.01
	09/04	5.3	±	3.5[a]	0.03
Las Vegas, NV					
Well 28, Water District	03/14	96	±	140 [a]	--
	09/14	-2.1	±	4.4[a]	<0.01
Lathrop Wells, NV					
Well 15S-50E-18CDC, City	04/03	1.6	±	3.5[a]	<0.01

(a) Concentration is less than the MDC.
(b) Indeterminate for conventional tritium analysis.

Table 9.4 (LTHMP Results for the NTS Semi-Annual Network - 1990, cont.)

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
Nyala, NV					
Sharp's Ranch	02/06	69	±	130 [a]	--
	08/08	-2.3	±	4 [a]	<0.01
Oasis Valley, NV					
Goss Springs	02/08	-58	±	130 [a]	--
	08/14	-4.2	±	3 [a]	<0.01
Pahrump, NV					
Calvada Well	02/06	-1.2	±	2.8[a]	<0.01
	08/10	-120	±	140 [a]	--
	09/04	-130	±	140 [a]	--
Rachel, NV					
Wells 7 and 8, Penoyer	04/11	-74	±	130 [a]	--
	10/01	0.6	±	3.2[a]	<0.01
Well 13, Penoyer	04/11	180	±	130 [a]	--
	10/01	6.3	±	3.4[a]	0.03
Well, Penoyer Culinary	04/04	310	±	130 [a]	--
	10/01	-3.6	±	3.9[a]	<0.01
Tempiute, NV					
Union Carbide Well	02/07	-58	±	130 [a]	--
	08/08	-0.6	±	3.1[a]	<0.01
Tonopah, NV					
City Well	03/07	-19	±	130 [a]	--
	09/06	-2.6	±	2.8[a]	<0.01
Warm Springs, NV					
Twin Springs Ranch	09/05	-51	±	140 [a]	--
	04/03	100	±	130 [a]	--
	11/12	3.2	±	3 [a]	0.02
NTS, NV					
Well 6A Army	01/11	160	±	140 [a]	--
	07/19	3.3	±	3.5[a]	0.02
Well C-1	04/16	0.8	±	2.9[a]	<0.01
	11/20	-260	±	140 [a]	--

(a) Concentration is less than the MDC.
(b) Indeterminate for conventional tritium analysis.

256

Table 9.4 (LTHMP Results for the NTS Semi-Annual Network - 1990, cont.)

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
NTS, NV, cont.					
Well D Test	01/03	5.1	±	3.3[a]	0.03
	07/19	-9	±	140 [a]	--
Well HTH-1	06/07	39	±	3.6	0.19
Well UE1C	01/04	0.0	±	3.2[a]	<0.01
	07/19	-1.6	±	1.9[a]	<0.01
Well UE5C	03/05	4.4	±	3.2[a]	0.02
	09/10	-0.6	±	4.6[a]	<0.01
Well UE-5N	12/07	70	±	4.6	0.35[c]
Well UE6E	03/06	33	±	2.7	0.17
Well UE15D	04/16	8.4	±	2.5	0.04
	11/20	270	±	140 [a]	--
Well UE16D	05/15	-0.3	±	2.7[a]	<0.01
	11/19	0.0	±	140 [a]	--
Well UE-16F	05/14	9.2	±	3 [a]	0.05
	11/19	260	±	140 [a]	--
Well UE-17A	05/14	2.9	±	2.6[a]	0.01
	12/11	-140	±	140 [a]	--
Well UE18R	06/06	1.5	±	2 [a]	<0.01
	12/11	-140	±	140 [a]	--
Well UE-18T	06/06	210	±	3.5	1.05

(a) Concentration is less than the MDC.
(b) Indeterminate for conventional tritium analysis.
(c) Other sampling results showed 1.24 ± 0.08 x 10^{-9} µCi/mL for ^{234}U, 0.03 ± 0.02 x 10^{-9} µCi/mL for ^{235}U, and 0.62 ± 0.05 x 10^{-9} µCi/mL for ^{238}U.

9.2.2 NONRADIOLOGICAL MONITORING ON THE NTS

As there are no industrial production facilities on the NTS, there is no significant production of nonradiological air emissions or liquid discharges to the environment when compared to many other DOE nuclear facility operations. Sources of potential contaminants are limited to construction support and Site operation activities. These include motor pool facilities; large equipment and drilling rig maintenance areas; cleaning, warehousing and supply facilities; and general worker support facilities such as feeding, lodging, and administrative services in the Mercury Base Camp, Area 12 Base Camp, and to a lesser extent in Area 20 and the NTS Control Point complex in Area 6. The Liquified Gaseous Fuels Spill Test Facility in Area 5 is a source of potential release of nonradiological contaminants, but the releases have been limited to high vapor pressure chemicals with little probability of affecting groundwater. Consequently, nonradiological environmental monitoring at the NTS is limited to:

- Routine sampling of drinking water distribution systems for Safe Drinking

257

Table 9.5 LTHMP Tritium Results for the Monthly NTS Network - 1990

Sampling Location	Area	Number Samples	^3H Concentration x 10^{-9} µCi/mL[a] Maximum	Minimum	Average	Percentage of Concentration Guide
Well 1, Army	22	12	3.2	-4.5	-0.3	<0.01
Well 2	2	12	3.2	-4.9	-0.9	<0.01
Well 3	Groom	4	3.7	-2.3	2.0	<0.01[b]
Well 4	Groom	12	4.9	-4.0	0.7	<0.01
Well 4	6	11	8.6	-3.6	0.8	<0.01
Well 5	Groom	12	9.4	-1.6	2.6	0.01
Well 5C	5	12	4.5	-7.8	-0.5	<0.01
Well 8	18	12	7.8	-5.4	0.2	<0.01
Well U-20	20	12	5.2	-3.6	-0.2	<0.01
Test Well B	6	11	140	57	100	0.5
Well C	6	12	70	-2.2	19	0.10
Well J-12	25	12	2.0	-4.1	-0.8	<0.01
Well J-13	25	12	8.6	-4.9	-0.4	<0.01
Well UE-19c	19	12	3.8	-6.8	-0.5	<0.01

(a) The unit 10^{-9} µCi/mL is equal to pCi/L.
(b) Other sampling results showed 3.69 ± 0.18 x 10^{-9} µCi/mL for ^{234}U, 0.07 ± 0.02 x 10^{-9} µCi/mL for ^{235}U, and 1.56 ± 0.10 x 10^{-9} µCi/mL for ^{238}U.

Water Act and state of Nevada compliance (the data were summarized in Section 3 and individual sample results are shown in Section 7).

- Sampling of soil, water, sediment, waste oil, and other media for Resource Conservation and Recovery Act (RCRA) constituents.

None of the supply wells were analyzed for RCRA organic constituents (volatiles, semi-volatiles, pesticides) in 1990. Samples for these analyses were taken from 11 of the supply wells in 1988. Analysis by participating laboratory in the EPA Contract Laboratory Program indicated that three of the wells contained volatile organic compounds (VOCs). Well 8 had hexane in a detectable amount (there is no present standard for this organic). The other two wells contained VOCs in excess of the Nevada Secondary Drinking Water Standard. Benzene was found in one of the duplicate samples from Well 5C, and trichloroethylene and benzene were found in the sample from Well J-12. None of the 11 wells contained semi-volatiles, pesticides, or polychlorinated biphenyl (PCB) levels above the drinking water limits.

9.3 OFF-NTS LONG-TERM HYDROLOGICAL MONITORING PROGRAM

Nuclear explosives have been used at non-NTS locations for various purposes, i.e., Plowshare tests, Vela Uniform tests, and calibration tests for high-yield devices for which the NTS is not suitable. The locations of these sites and other data were summarized in Table 9.2.

At nearly all LTHMP locations, the standard operating procedure is to collect four samples from each source. Two samples are collected in 500-mL glass bottles to be

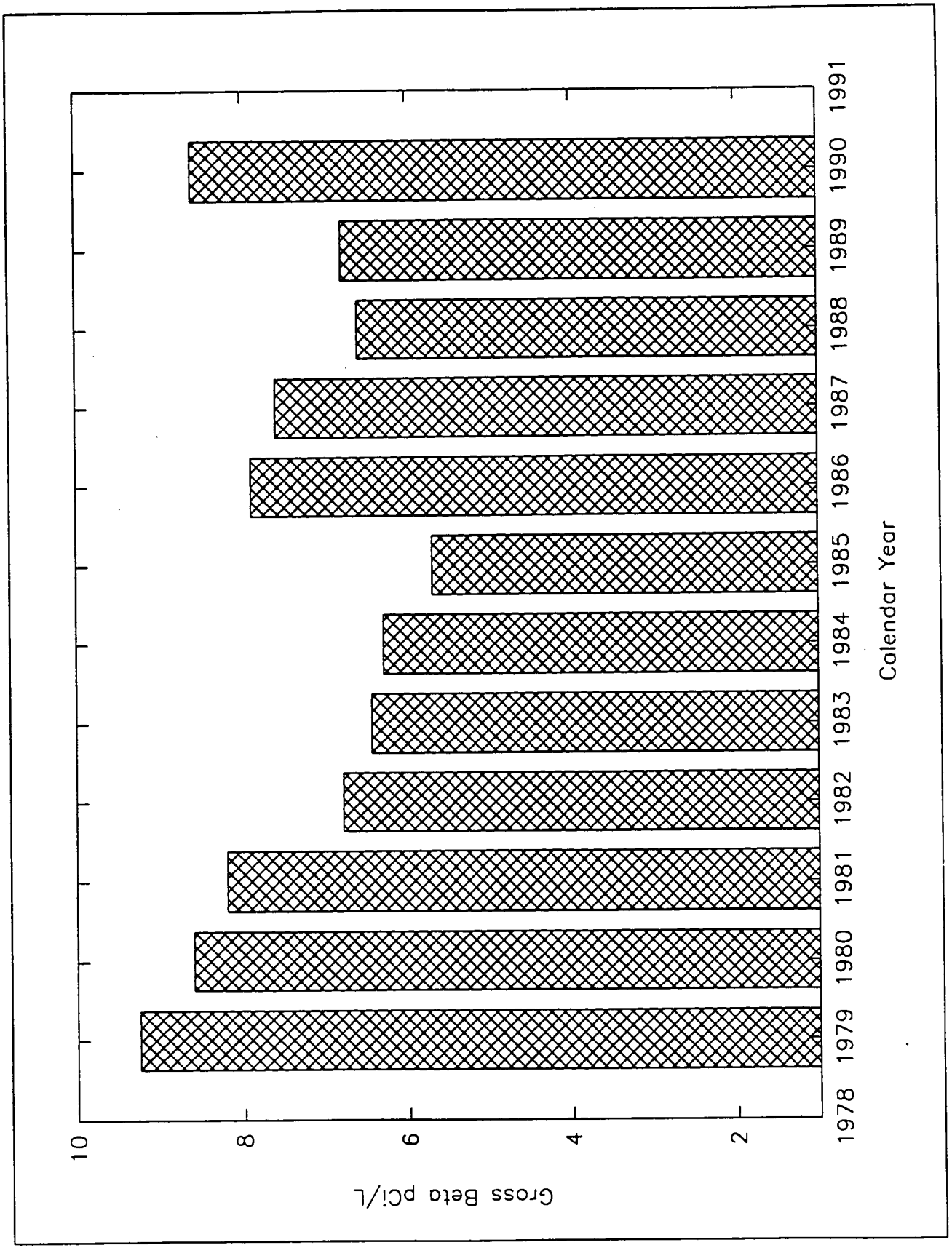


Figure 9.5 Annual Average Gross Beta in NTS Supply Well Water - 1979-1990

analyzed for tritium. The results from analysis of one of these samples are reported while the other sample serves as a backup in case of loss or, if the tritium is at a detectable concentration, as a duplicate sample. The remaining two samples are collected in 3.8-liter plastic containers (Cubitainers). One of these is analyzed by gamma spectrometry and the other is stored as a backup or for duplicate analysis. For wells with operating pumps, the samples are collected at the nearest convenient outlet. If the well has no pump, a truck-mounted sampling rig is used. With this rig it is possible to collect three-liter samples from wells as deep as 1800 meters. At a few locations, because of limited supply, only 500-mL samples for tritium analysis are collected. At the normal sample collection sites, the pH, conductivity, and water temperature are measured when the sample is collected. Also, the first time samples are collected from a well, $^{89,90}Sr$, ^{226}Ra, $^{238,239}Pu$, and uranium isotopes are determined by radiochemistry as time permits. All samples are collected annually at those LTHMP sites shown in Figures 9.6 to 9.13, and the concentrations of all detectable radionuclides are listed in Table 9.6. (Samples are collected biannually from the sites on Amchitka Island, Alaska; no samples were taken in 1990.)

Tritium has been detected in water samples from five of the off-NTS test sites (Dribble, GNOME, LONG SHOT, RIO BLANCO and RULISON), with some indication that tritium is increasing in a deep monitoring well at Project GASBUGGY. The levels in samples from RIO BLANCO and RULISON in Colorado are due solely to a high background. Tritium concentrations in samples from Project GNOME are in wells to which tritium had been added for hydrological studies or that intersected the device cavity. Tritium in water samples from Project Dribble is due to low-level waste spillage near the emplacement hole and has occurred only in non-potable water. Tritium in well and surface water samples from Project LONG SHOT probably originates in the device cavity and the pathway, perhaps, is through or around the emplacement shaft into shallow groundwater and surface water. All tritium concentrations are below the National Primary Drinking Water Regulations set forth in 40 CFR 141, except for the U.S. Geological Survey (USGS) wells at Project GNOME. These wells are locked and unavailable for public use. Summary data for the LTHMP samples that contain detectable tritium which could be ascribed to nuclear device tests are presented in Table 9.7.

Because of the variability noted in past years in samples obtained from the shallow monitoring wells at Project Dribble in Mississippi, a second sample is taken after pumping for awhile or after the hole has refilled with water. These second samples are frequently higher in ^{3}H concentration and may be representative of formation water. Also, residents near the Tatum Dome Test Site became concerned that radioactivity had escaped from the test cavity of Project Dribble events and was increasing their exposure to radiation. At the request of Senator Lott (Democrat, Mississippi) special sampling and analyses were conducted at this site in 1990. This is discussed in Section 9.3.3 below.

9.3.1 RESULTS

The locations at which water samples were found to contain man-made radioactivity are shown in Table 9.1 along with the analytical results. For tritium, only those samples having a concentration exceeding one percent of the National Primary Drinking Water Regulations i.e., greater than 2×10^{-7} µCi/L, are shown. Well DD-1 is linked to the GNOME cavity as is LRL-7, so the results of those samples are expected. The results for Wells USGS-4 and USGS-8 are also expected as radioactivity was added to those wells for hydrological testing. The tritium in samples from Project Dribble is a result of disposal of low-level contaminated debris and drilling fluids at the site.

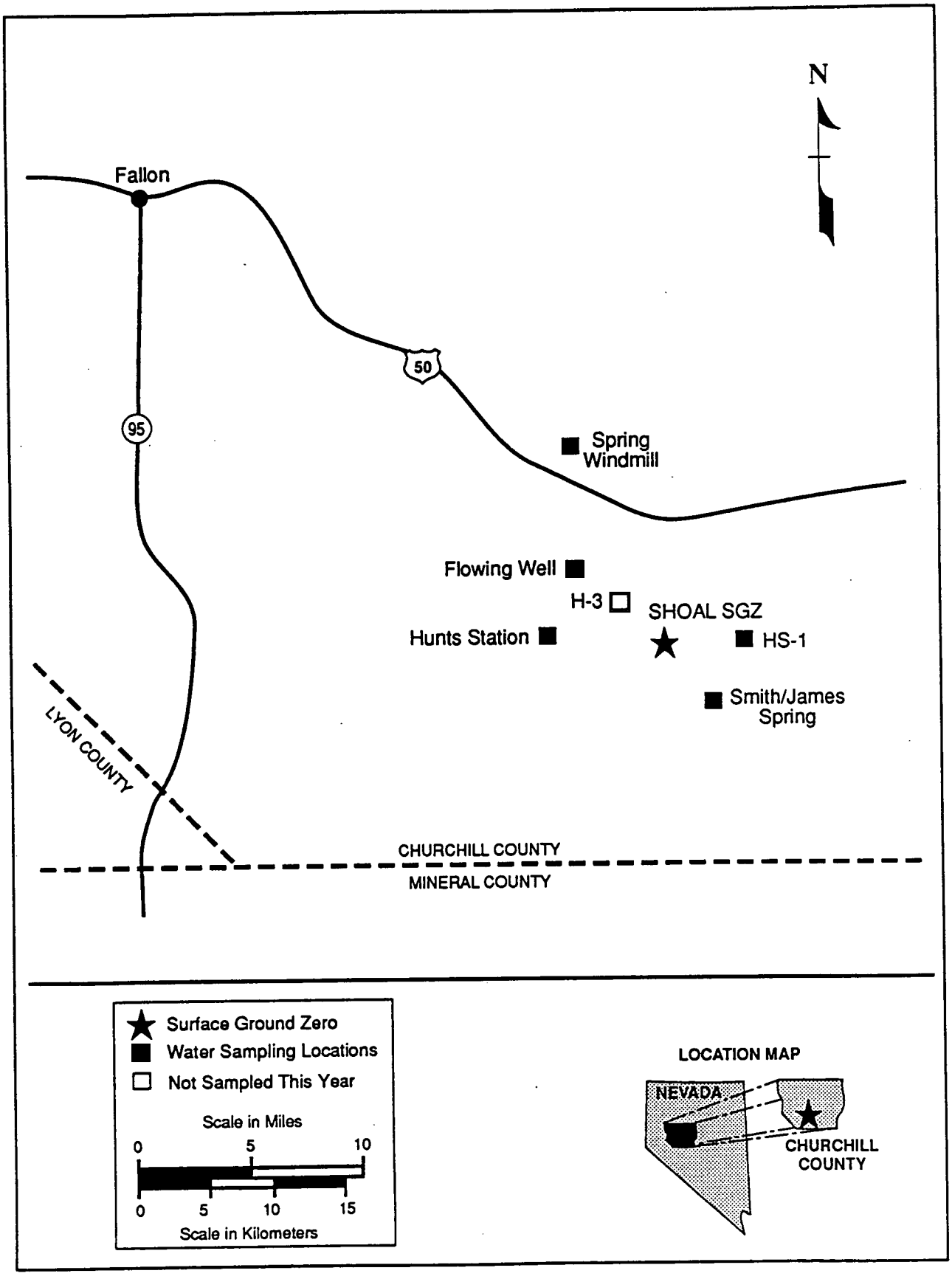


Figure 9.6 LTHMP Sampling Locations for Project SHOAL - 1990

261

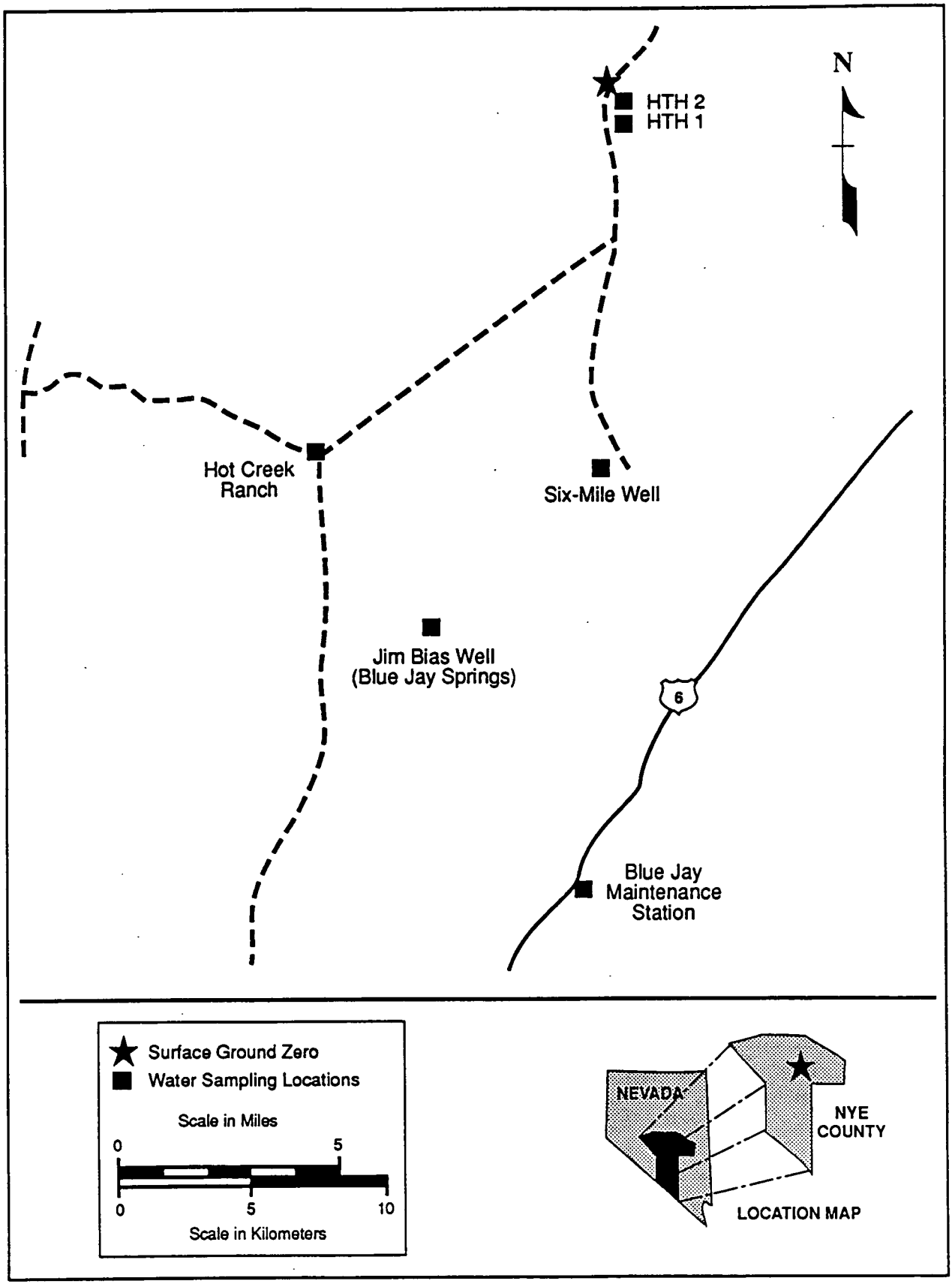


Figure 9.7 LTHMP Sampling Locations for Project FAULTLESS - 1990

262

5453

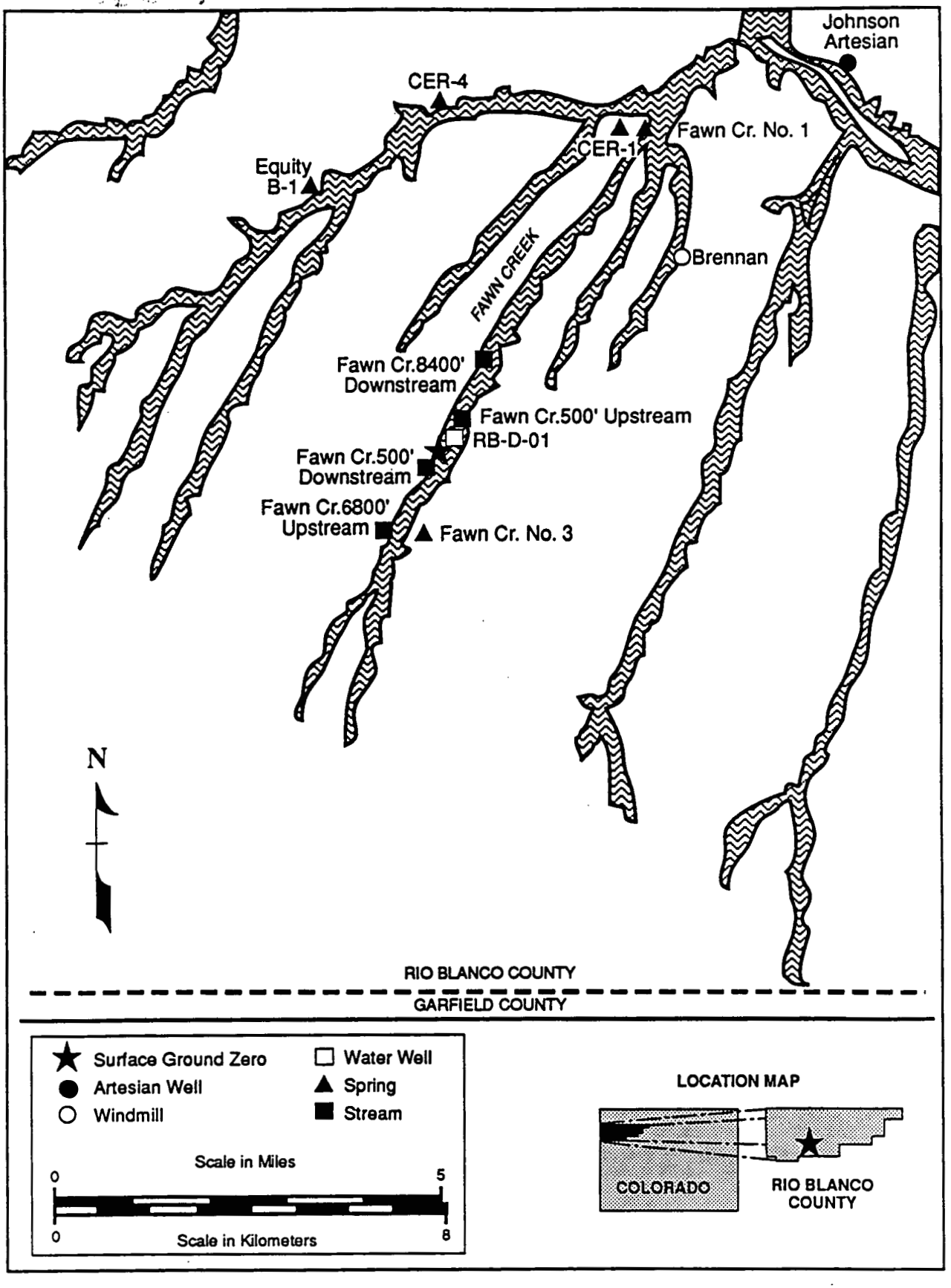


Figure 9.8 LTHMP Sampling Locations for Project RIO BLANCO - 1990

263

5453

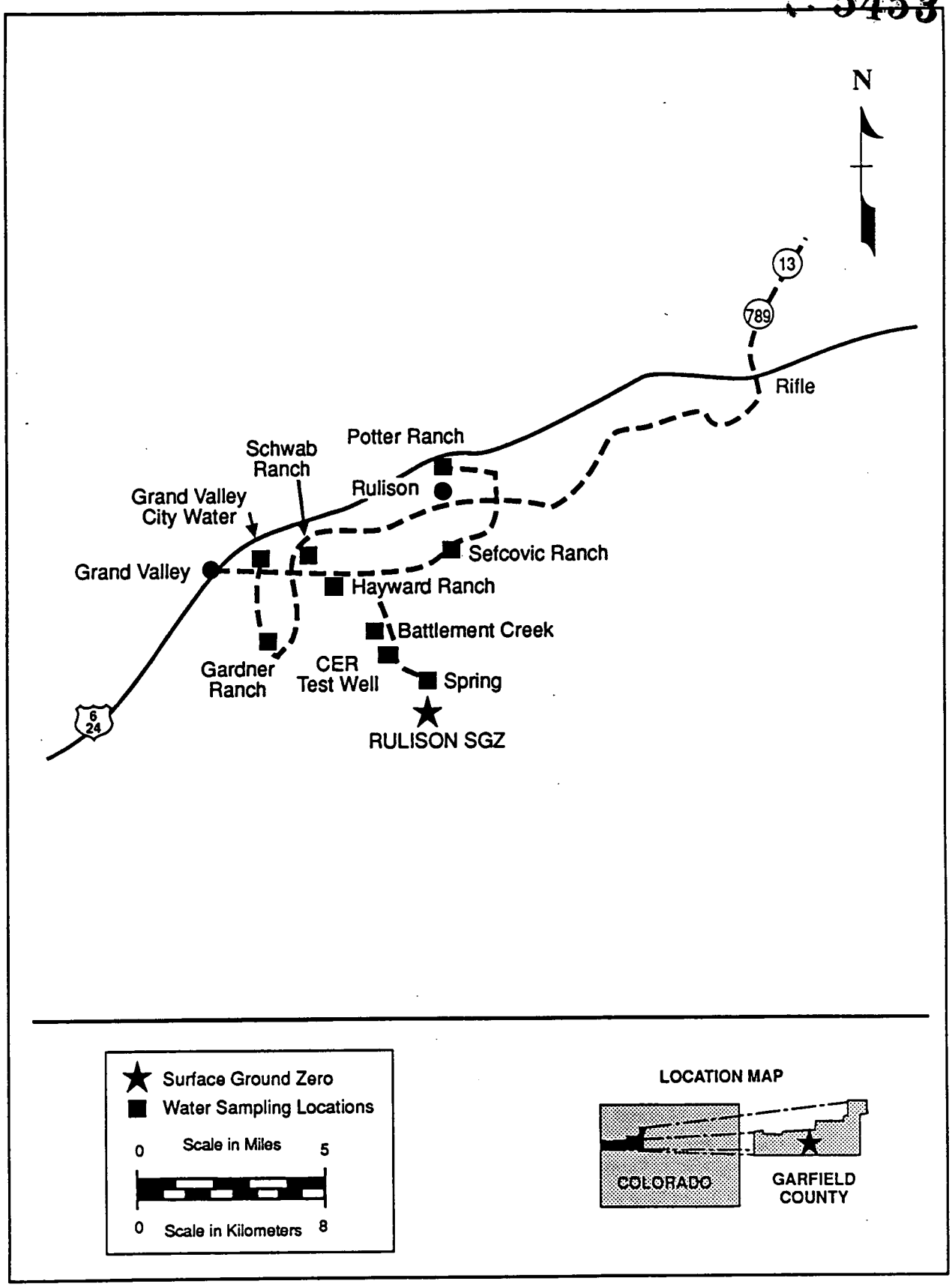


Figure 9.9 LTHMP Sampling Locations for Project RULISON - 1990

264

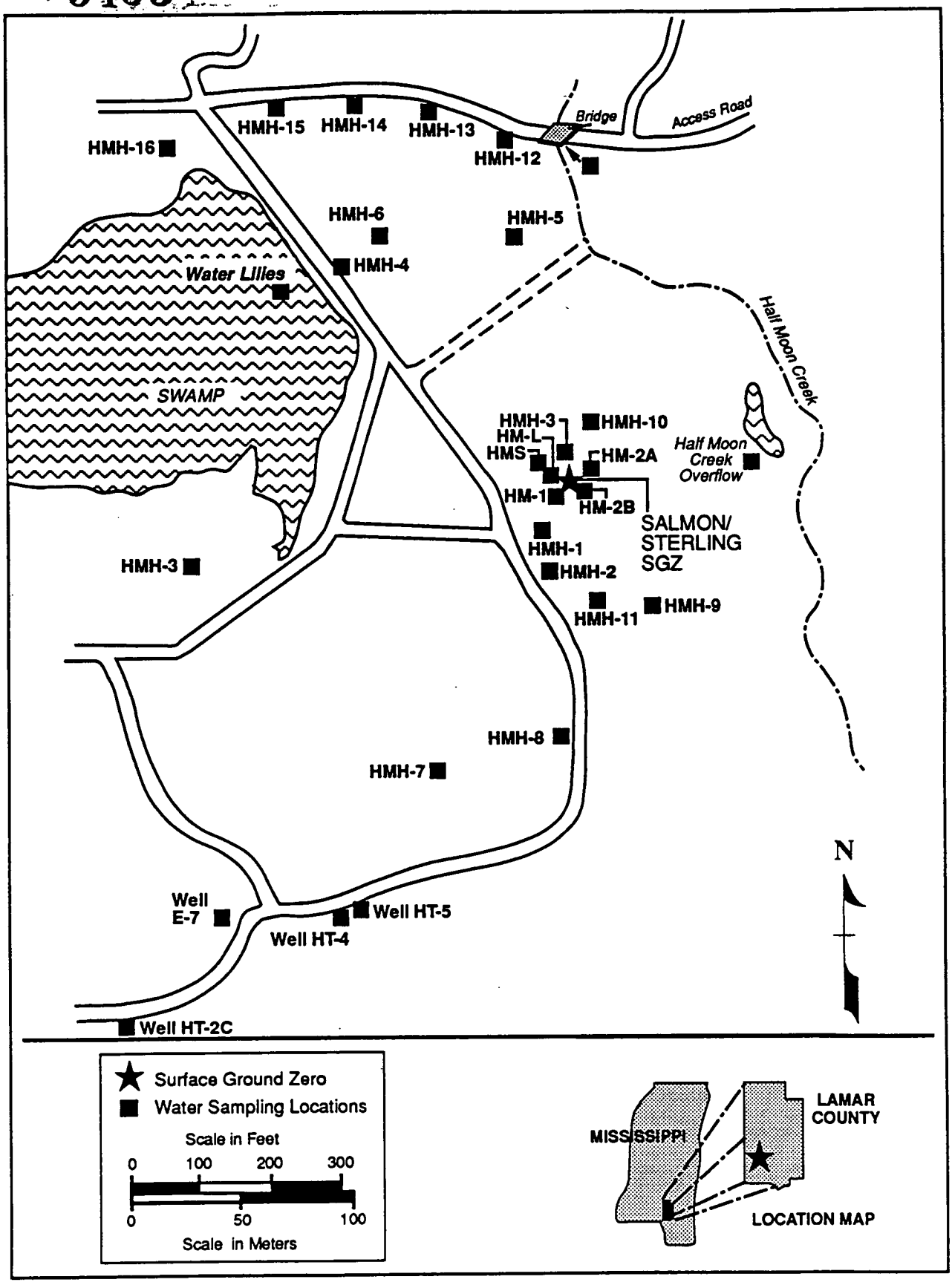


Figure 9.10 LTHMP Sampling Locations for Project Dribble, Near Ground Zero - 1990

5453

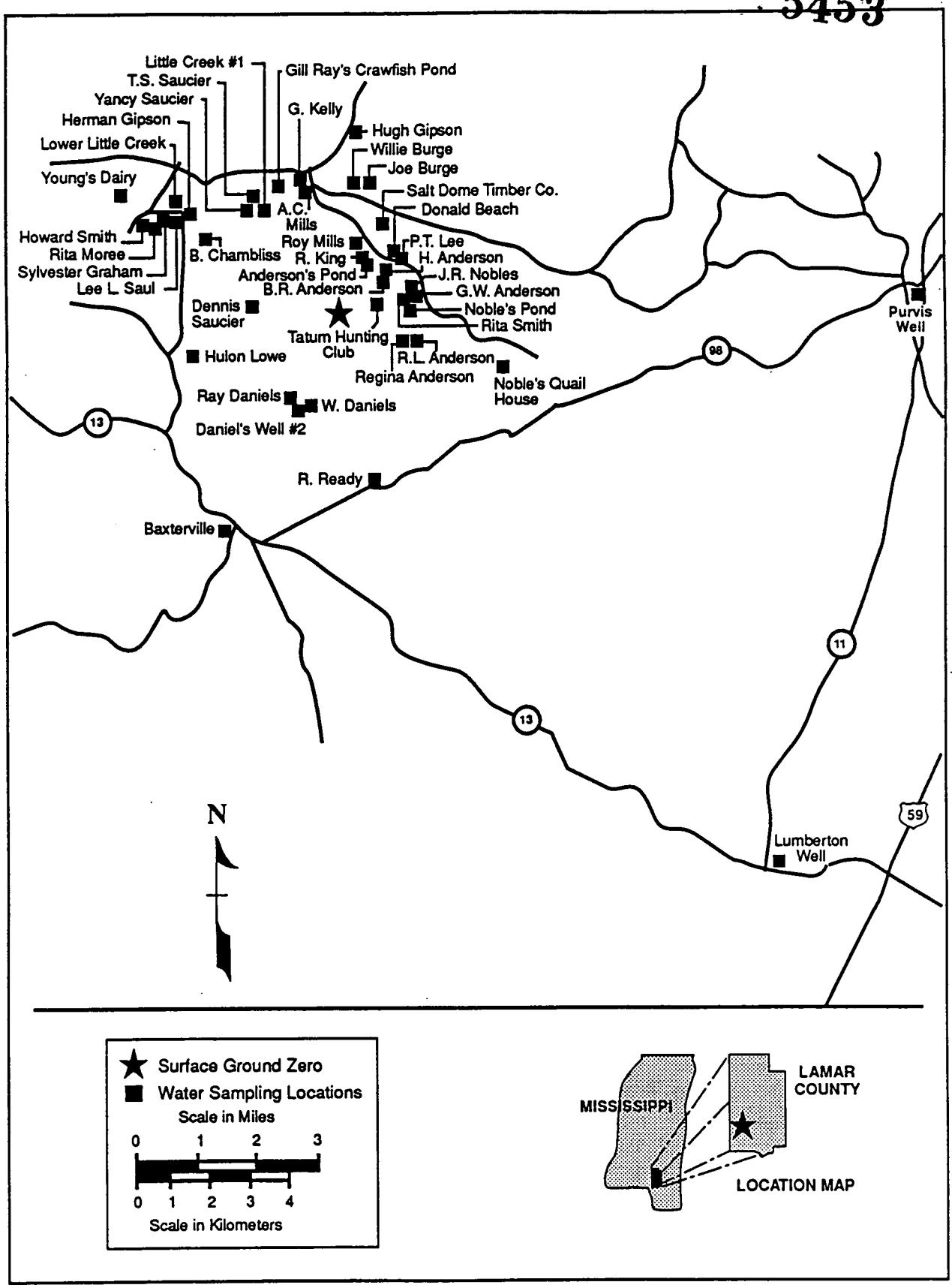


Figure 9.11 LTHMP Sampling Locations for Project Dribble, Towns and Residences - 1990

266

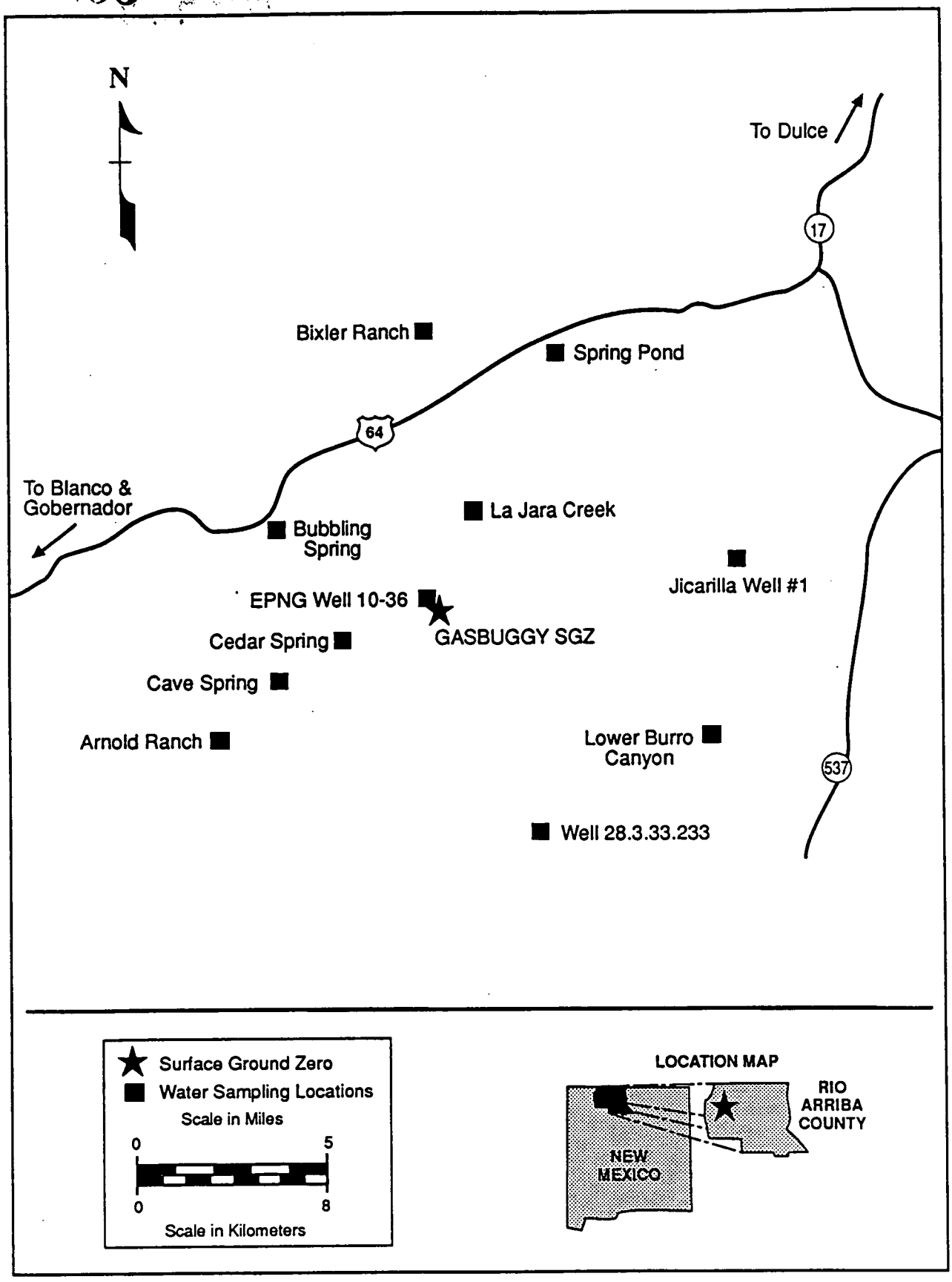


Figure 9.12 LTHMP Sampling Locations for Project GASBUGGY - 1990

267

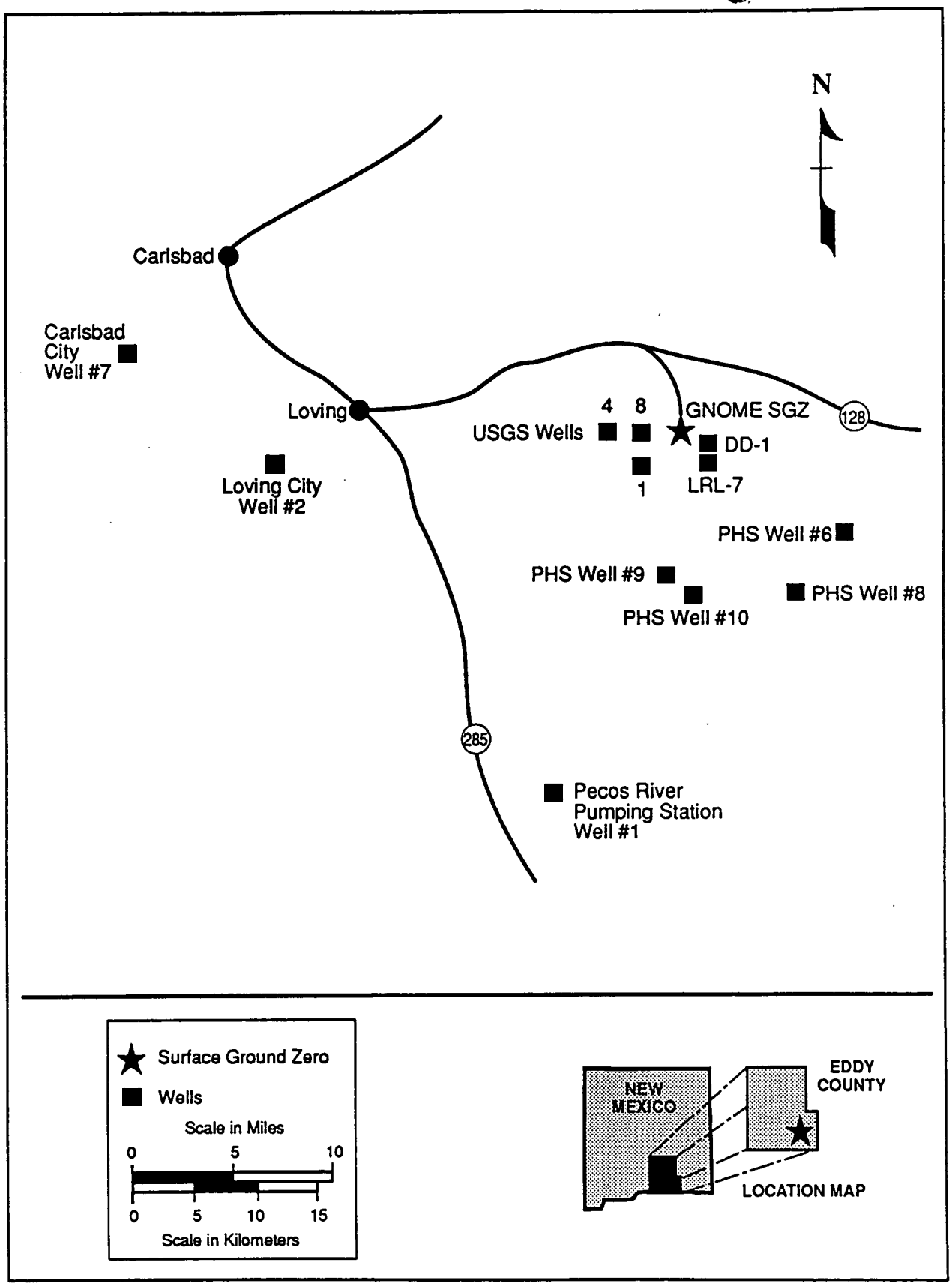


Figure 9.13 LTHMP Sampling Locations for Project GNOME - 1990

Table 9.6 LTHMP Non-NTS Locations Water Sample Results - 1990

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
		Project GNOME			
Carlsbad, NM					
Well 7, City	08/01	2.9	±	3.0[a]	0.01
Loving, NM					
Well 2, City	08/01	8.1	±	3.4[a]	0.04
Malaga, NM					
Well 1, Pecos Pumping Station	08/01	7	±	3.7[a]	0.03
Well LRL-7	08/02	14000	±	190	71 [b]
Well PHS 8	08/01	27	±	4.5	0.13
Well PHS 9	08/02	13	±	4.2[a]	0.07
Well PHS 10	08/03	4.6	±	4 [a]	0.02
Well USGS 1	08/01	-1.6	±	2.2[a]	<0.01
Well USGS 4	08/02	150000	±	490	760
Well USGS 8	08/02	120000	±	440	600 [c]
		Project Dribble			
Baxterville, MS					
Half Moon Creek	04/21	300	±	4.5	1.5
	04/23	19	±	3.4	0.09
Half Moon Creek Overflow	04/21	450	±	4.3	2.3
	04/23	390	±	5.1	2.0
Little Creek #1	04/20	7.1	±	3.7[a]	0.04
Lower Little Creek	04/18	14	±	3.3	0.07
Pond West of Ground Zero (GZ)	04/21	2.3	±	2.2[a]	0.01
	04/23	25	±	3.2	0.13
REECo Pit Drainage-A	04/23	21	±	3	0.10
REECo Pit Drainage-B	04/23	130	±	3.3	0.69
REECo Pit Drainage-C	04/23	150	±	4.7	0.79
Salt Dome Hunting Club	04/21	6.9	±	2.5[a]	0.03
Salt Dome Timber Co.	04/18	19	±	3.7	0.09
Anderson Pond	04/21	5.4	±	3 [a]	0.03
Anderson, Billy Ray	04/21	11	±	3.3	0.06
Anderson, Regina	04/20	7.9	±	3.6[a]	0.04
Anderson, Robert Harvey	04/21	17	±	2.9	0.08
Anderson, Robert Lowell	04/20	12	±	3.7	0.06
Burge, Joe	04/21	6.3	±	5.1[a]	0.03

(a) Result less than the minimum detectable for that sample.
(b) Other sampling results showed 180 ± 8 x 10^{-9} µCi/mL for ^{137}Cs.
(c) Other sampling results showed 64 ± 7 x 10^{-9} µCi/mL for ^{137}Cs

Table 9.6 (LTHMP Non-NTS Locations Water Sample Results - 1990, cont.)

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
Baxterville, MS, cont.					
Chambliss, B.	04/19	3.1	±	5.6[a]	0.02
Daniels, Ray	04/18	20	±	3.6	0.10 [b]
Daniels, Webster Jr.	04/18	31	±	2.8	0.15
Daniels - Well #2	04/18	25	±	2.9	0.13
Kelly, Gertrude	04/19	-1.4	±	3.8[a]	<0.01
King, Rhonda	04/21	13	±	2.2	0.07
Lee, P. T.	04/19	23	±	3.6	0.11
Mills, A. C.	04/19	0	±	4.5[a]	<0.01
Mills, Roy	04/19	29	±	5	0.1
Noble's Pond	04/19	21	±	3.1	0.10
Noble's Quail House	04/21	44	±	3.4	0.22
Noble, W. H., Jr.	04/19	30	±	2.6	0.15
Ready, R. C.	04/18	12	±	2.7	0.06
Saucier, Dennis	04/18	18	±	3.2	0.09
Saucier, Talmadge S.	04/20	10	±	3.5[a]	0.05
Saucier, Wilma and Yancy	04/20	20	±	2.8	0.10
Smith, Rita	04/19	-0.5	±	3.6[a]	<0.01
Well, City	04/17	13	±	3.4	0.06
Well E-7	04/21	7.4	±	2.7[a]	0.04
Well HM-1	04/21	0.1	±	3.5[a]	<0.01
	04/21	3.6	±	3.6[a]	0.02
	04/21	2	±	3.3[a]	0.01
	04/21	5.1	±	3.3[a]	0.03
Well HM-2A	04/21	6.5	±	3.4[a]	0.03
	04/21	0.3	±	2.6[a]	<0.01
Well HM-2B	04/21	6.7	±	3.6[a]	0.03
	04/21	0.5	±	3.4[a]	<0.01
Well HM-3	04/21	3.5	±	3.3[a]	0.02
	04/21	4.2	±	3 [a]	0.02
Well HM-L	04/21	910	±	150	4.6
	04/21	1300	±	150	6.5
	04/21	1000	±	140	5.4
	04/21	940	±	150	4.7
Well HM-L2	04/21	4.4	±	3.4[a]	0.02
	04/21	-7.9	±	3.6[a]	<0.01
Well HM-S	04/21	9300	±	180	46
	04/21	9500	±	180	48

(a) Result less than the minimum detectable for that sample.
(b) Other sampling results showed 0.08 ± 0.035 x 10^{-9} µCi/mL for ^{238}U.

Table 9.6 (LTHMP Non-NTS Locations Water Sample Results - 1990, cont.)

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
Baxterville, MS, cont.					
Well HMH-1	04/21	4000	±	160	20
Well HMH-2	04/21	8100	±	180	41
Well HMH-3	04/21	22	±	3	0.11
Well HMH-4	04/21	14	±	2.8	0.07
Well HMH-5	04/21	1800	±	150	9.0
Well HMH-6	04/21	110	±	3.3	0.55
Well HMH-8	04/21	25	±	3.2	0.13
Well HMH-9	04/21	92	±	3.1	0.46
Well HMH-10	04/21	19	±	3.4	0.09
Well HMH-11	04/21	36	±	3.6	0.18
Well HMH-12	04/21	8	±	2.9[a]	0.04 [b]
	04/19	1.4	±	4 [a]	<0.01
	04/21	4.3	±	4 [a]	0.02
Well HMH-13	04/21	51	±	3.2	0.25 [c]
	04/19	5.6	±	3.5[a]	0.03
	04/21	-0.85	±	3.1[a]	<0.01
Well HMH-14	04/21	18	±	3	0.09 [d]
	04/19	1.2	±	4.6[a]	<0.01
	04/21	10	±	3.9[a]	0.05
Well HMH-15	04/21	9.7	±	4.5[a]	0.05 [e]
	04/19	0	±	3.7[a]	<0.01
	04/21	2.3	±	3.7[a]	0.01
Well HMH-16	04/21	550	±	4.5	2.8 [f]
	04/19	970	±	140	4.8
	04/21	490	±	5.3	2.5
Well HT-2C	04/22	6.8	±	3 [a]	0.03
Well HT-4	04/22	0.67	±	3 [a]	<0.01
Well HT-5	04/22	0.17	±	3.1[a]	<0.01

(a) Result less than the minimum detectable for that sample.
(b) Other sampling results showed 0.27 ± 0.04 x 10^{-9} µCi/mL for ^{234}U and 0.26 ± 0.04 x 10^{-9} µCi/mL for ^{238}U.
(c) Other sampling results showed 0.27 ± 0.08 x 10^{-9} µCi/mL for ^{234}U and 0.17 ± 0.05 x 10^{-9} µCi/mL for ^{238}U.
(d) Other sampling results showed 4.45 ± 0.27 x 10^{-9} µCi/mL for ^{234}U and 4.26 ± 0.26 x 10^{-9} µCi/mL for ^{238}U.
(e) Other sampling results showed 0.10 ± 0.04 x 10^{-9} µCi/mL for ^{238}U.
(f) Other sampling results showed 0.11 ± 0.04 x 10^{-9} µCi/mL for ^{234}U and 0.10 ± 0.03 x 10^{-9} µCi/mL for ^{238}U.

271

Table 9.6 (LTHMP Non-NTS Locations Water Sample Results - 1990, cont.)

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
Columbia, MS					
Well 64B, City	04/17	12	±	3.4	0.06
Lumberton, MS					
Anderson, G. W.	04/20	27	±	3.6	0.13
Gil Ray's Crawfish Pond	04/23	13	±	3.2	0.07 [b]
Gipson, Herman	04/19	12	±	3.8	0.06
Graham, Sylvester	04/23	-1.3	±	3 [a]	<0.01
Moree, Rita - House Well	04/20	-4	±	3.2[a]	0.02 [c]
Beach, Donald	04/23	21	±	4.6	0.10
Saul, Lee L.	04/23	-1.4	±	3.1[a]	<0.01
Smith, Howard	04/20	-2.9	±	3.7[a]	<0.01
Well 2, City	04/17	3.4	±	1.7[a]	0.02
Purvis, MS					
City Supply	04/17	-0.78	±	3.5[a]	<0.01
	Project GASBUGGY				
Gobernador, NM					
Arnold Ranch	06/22	0	±	2.3[a]	<0.01
Bixler Ranch	06/22	10	±	2.7	0.05
Bubbling Springs	06/22	13	±	2.6	0.07
Cave Springs	06/21	53	±	2.7	0.26
Cedar Springs	06/21	23	±	2.7	0.11
La Jara Creek	06/21	2.4	±	2.2[a]	0.01
Lower Burro Canyon	06/24	63	±	3.2	0.32
Pond N Well 30.3.32.343	06/22	41	±	2.8	0.21
Well EPNG 10-36	06/24	230	±	4.5	1.16 [d]
Well Jicarilla 1	06/21	9	±	2.4	0.05
Well 28.3.33.233 (South)	06/24	59	±	3.5	0.29 [e]
	Project RULISON				
Grand Valley, CO					
Battlement Creek	06/19	22	±	2.2	0.11
City Springs	06/19	9.9	±	4.1[a]	0.05
Albert Gardner Ranch	06/19	87	±	5	0.44
Spring 300 yard north of GZ	06/19	18	±	2	0.09

(a) Result less than the minimum detectable for that sample.
(b) Other sampling results showed 0.13 ± 0.05 x 10^{-9} µCi/mL for ^{234}U and 0.10 ± 0.05 x 10^{-9} µCi/mL for ^{238}U.
(c) Other sampling results showed 0.031 ± 0.04 x 10^{-9} µCi/mL for ^{238}U.
(d) Other sampling results showed 13 ± 4 x 10^{-9} µCi/mL for ^{137}Cs.
(e) Other sampling results showed 4.65 ± 0.18 x 10^{-9} µCi/mL for ^{234}U, 0.08 ± 0.02 x 10^{-9} µCi/mL for ^{235}U and 1.87 ± 0.09 x 10^{-9} µCi/mL for ^{238}U.

Table 9.6 (LTHMP Non-NTS Locations Water Sample Results - 1990, cont.)

Sampling Location	Collection Date in 1990	Tritium (Concentration ± 1s) x 10^{-9} µCi/mL			Percent of Concentration Guide
Grand Valley, CO, cont.					
Well CER Test	06/19	41	±	2.2	0.21
Rulison, CO					
Lee Hayward Ranch	06/19	88	±	2.7	0.44
Potter Ranch	06/19	43	±	2.1	0.22
Robert Searcy Ranch (Schwab)	06/19	41	±	2.8	0.21
Felix Sefcovic Ranch	06/19	27	±	2.6	0.13
	Project RIO BLANCO				
Rio Blanco, CO					
Brennan Windmill	06/17	6.6	±	2.5[a]	0.03
CER No. 1 Black Sulphur	06/18	340	±	6	1.73
CER No. 4 Black Sulphur	06/18	56	±	4.8	0.28
Fawn Creek 3	06/17	22	±	2.5	0.11
	06/17	24	±	2.5	0.12
Fawn Creek, 500 ft. upstream	06/17	34	±	2.7	0.17
Fawn Creek, 500 ft. downstream	06/17	33	±	2.7	0.17
Fawn Creek, 6800 ft. upstream	06/17	31	±	2.5	0.15
Fawn Creek, 8400 ft. downstream	06/12	29	±	2.7	0.15
Well Johnson Artesian	06/17	0.99	±	2.7[a]	<0.01
Well RB-D-01	06/18	3.3	±	3.8[a]	0.02
Well RB-D-03	06/17	0.65	±	2.8[a]	<0.01
Well RB-S-03	06/18	4.1	±	4.3[a]	0.02
B-1 Equity Camp	06/18	71	±	5.5	0.36
	Project FAULTLESS				
Blue Jay, NV					
Hot Creek Ranch Spring	03/09	6.5	±	2.5[a]	0.03
Maintenance Station	03/09	-1.8	±	3.1[a]	<0.01
Well, Bias	03/09	-4.3	±	2.9[a]	<0.01
Well HTH-1	03/23	0.88	±	4.5[a]	<0.01
Well HTH-2	03/23	2.3	±	3 [a]	0.01
Well, Six Mile	03/09	1.2	±	3.8[a]	<0.01
	Project SHOAL				
Frenchman Station, NV					
Hunt's Station	02/26	-2.7	±	2.8[a]	<0.01
Smith/James Springs	02/26	70	±	3.7	0.35
Well, Flowing	02/26	-4.4	±	2.6[a]	<0.01
Well H-3	02/26	Not collected			
Well HS-1	02/26	-1.3	±	3.4[a]	<0.01

(a) Result less than the minimum detectable for that sample.

Table 9.7 Locations Having Device-Related Tritium in Groundwater[a]

Location/ Well	Tritium pCi/L Start	Tritium pCi/L Present	Trend	Remarks
Project Dribble				
Well HM-L	2600	1000	Decreasing	Started in 1980
Well HM-S	36×10^3	9300	Decreasing	Started in 1980
Project LONG SHOT				
Well EPA-1	1200	20	Decreasing	Started in 1977
Well GZ-1	5300	2300	Decreasing	Started in 1977
Well GZ-2	1800	130	Decreasing	Started in 1977
Well WL-2	730	49	Decreasing	Started in 1977
Project GASBUGGY				
Well EPNG 10-36	38	110	Increasing	Starting in 1974
Project GNOME				
Well PHS-6	450	51	Decreasing	Starting in 1972
Well USGS-4	13×10^5	19×10^4	Decreasing	Starting in 1972
Well USGS-8	15×10^5	13×10^4	Decreasing	Starting in 1972

(a) The National Primary Drinking Water Regulation is 2×10^4 pCi/L.

With all but a few exceptions, all the gamma spectra were negligible (there was no measurable peak in the 2000 channels of the gamma spectrometer), so only the tritium results are listed in the main portion of Table 9.6. Samples with detectable levels of other radionuclides are listed as footnotes.

9.3.2 DISCUSSION

The trends of results for some water samples are shown in Figures 9.14 and 9.15. The data for the HMH holes at Project Dribble are typical, showing a general downward trend with time. Other locations that follow this trend are wells HM-L and HM-S at the Dribble events site and Wells PHS-6, USGS-4, and USGS-8 at the GNOME event site. The graph in Figure 9.15 for Well EPNG 10-36 at the GASBUGGY event site indicates some sort of low-level pulse of tritium passing through the area.

Regardless of the finding of detectable amounts of radioactivity in some water samples, the exposure of the public to the radioactivity is negligible. The HMH holes at the Project Dribble site tap shallow, nonpotable water, and the HM-S and HM-L wells are locked. The wells at the GNOME site are locked and inaccessible to the general public, while the EPNG well at the GASBUGGY site is a monitoring well with no pump.

The results for the Mississippi residents' special request samples are shown in Section 9.3.3.

9.3.3 SPECIAL STUDY FOR THE LTHMP - TATUM DOME TEST SITE, MISSISSIPPI

This section summarizes the results of analyses of samples collected in April 1990

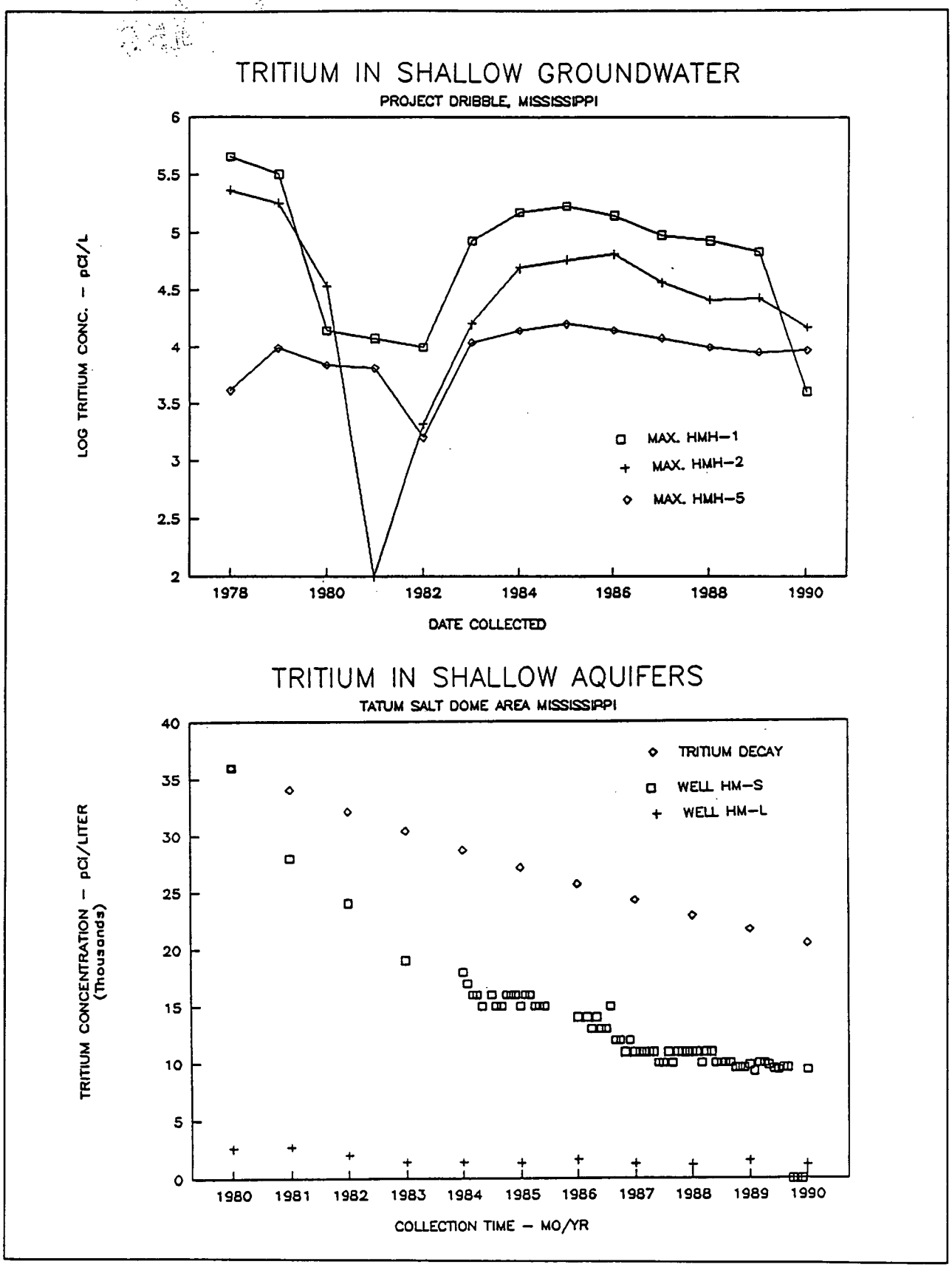


Figure 9.14 Tritium Trends in Groundwater - Tatum Salt Dome Area

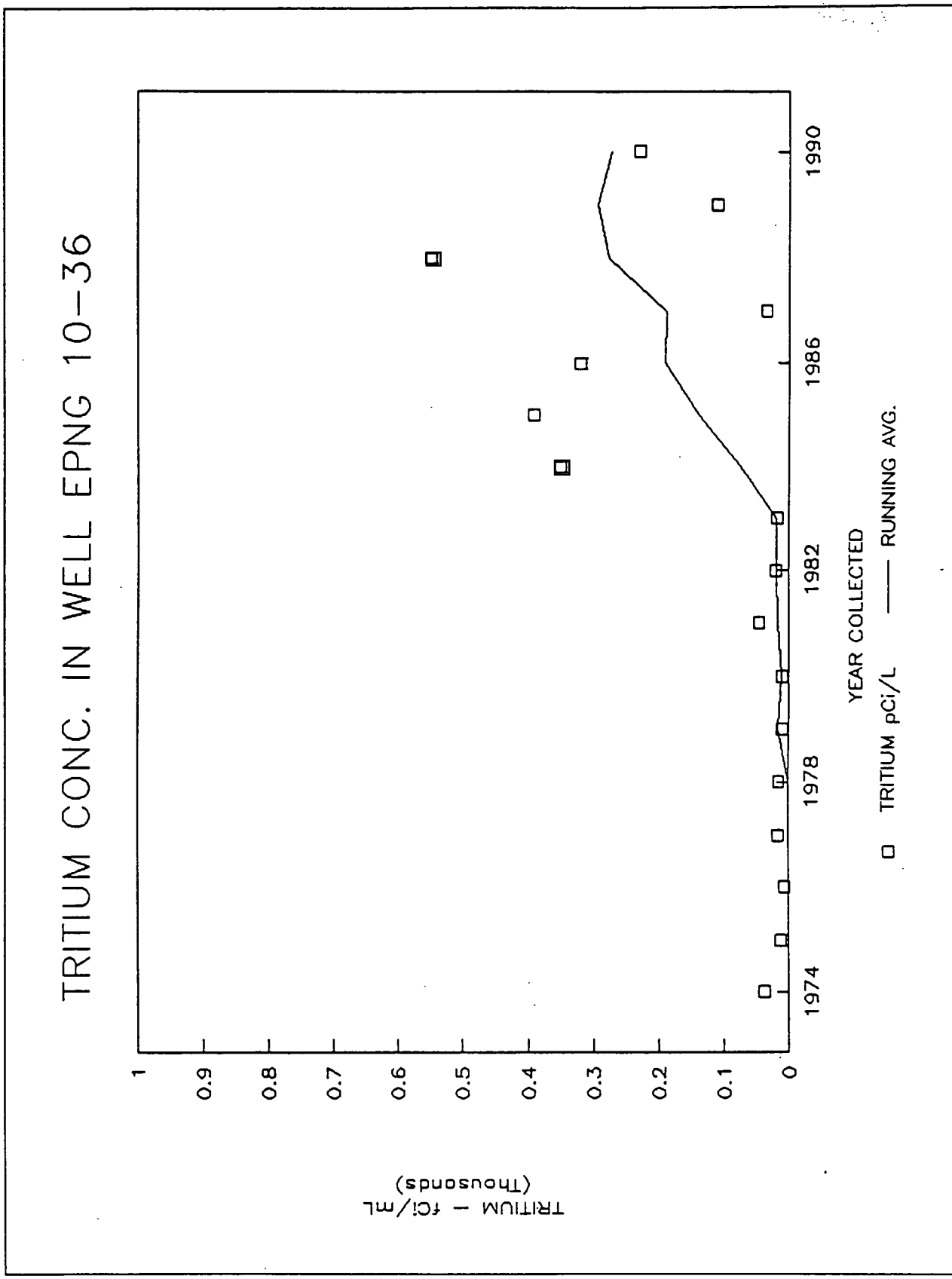


Figure 9.15 Tritium Trends in Groundwater - Project GASBUGGY

Table 9.8 Tatum Salt Dome Events Summary

Date of Test	Name of Test	Type	Yield (kilotons)
10/22/64	SALMON	Nuclear	5.3
12/03/66	STERLING	Nuclear	0.38
02/02/69	DIODE TUBE	Gas	0.32
04/19/70	HUMID WATER	Gas	0.32

on and around the Project Dribble testing area at the Tatum Dome Test Site in Lamar County, Mississippi.

9.3.3.1 HISTORY

Four explosive tests were conducted in the Tatum Salt Dome as shown in Table 9.8. These tests were conducted to study the decoupling principle; that is, to determine if it is possible to disguise an underground nuclear test, thus making it difficult to verify a nuclear test ban. To do this, the SALMON event of Project Dribble was used to create a large cavity in the salt dome and the other three tests were then conducted inside that cavity.

During and following each of the tests, the PHS (and later the EPA) closely monitored the area around the salt dome to detect any release of radioactivity caused by the tests. This monitoring included use of film badges on about 200 people near the site and at fixed locations around the site supplemented by gamma-rate recorders and hand-held survey meters in areas surrounding the site. Analyses of samples for radioactivity in air, milk, water, and vegetation samples before, during, and after each test were also performed. No radioactivity above worldwide fallout levels has ever been detected in the near offsite area by this comprehensive monitoring program.

After cleanup activities at the Tatum Dome Test Site in 1971 and 1972, the LTHMP was instituted. As previously mentioned, in this program all drinkable groundwaters, other groundwaters, many individual wells, some public water supplies, and some surface waters in the immediate area are sampled and the samples analyzed for ^{3}H and for any gamma-emitting radioactivity.

A special study was conducted in 1977 and 1978 because of irregularities in tritium results for samples collected in the Half Moon Creek Overflow Pond. Samples from 171 shallow holes drilled onsite indicated that a small area on the Tatum Dome Test Site had tritium concentrations due to disposal of drilling fluids and materials near the sampling area. This tritium is in surface water (6 to 10 feet below the surface) that is not drinkable. However, 11 of these shallow wells were added to the LTHMP to be sampled along with the existing water supply wells.

Tritium in the surficial aquifer and the lower aquifer groundwater supplies has always been less than the National Primary Drinking Water Regulation of 20,000 pCi/L and has been decreasing with time as shown in Figure 9.14. The tritium concentrations in the shallow surface water sources in the immediate vicinity of the emplacement well, although initially higher than the National Primary Drinking Water Regulation, have also been decreasing with time, also shown in Figure 9.14. Since the tritium concentration in these surface water samples varies dramatically with the amount of rainfall, the data plotted in Figure 9.14 are

the maximum concentrations measured in each year. All other groundwater sources have had background concentrations of tritium.

To analyze for tritium, two methods are used. The conventional method used for environmental samples such as milk, animal tissue, vegetation, urine, etc., has a MDC of about 400 pCi/L of water (about two percent of the National Primary Drinking Water Regulation). An enrichment method (MDC of about 10 pCi/L) is used for groundwater and monitoring wells to detect the appearance of tritium as early as possible.

9.3.3.2 1990 SAMPLING PROGRAM

Because local residents had expressed concern about possible health effects due to radioactivity from the Tatum Dome Test Site, additional water samples as well as additional types of samples were collected for analysis in 1990. These included:

- Control samples and urine samples from nearby residents.
- Vegetables from local gardens and on-Site vegetation.
- Soil samples from local gardens and from on-Site areas.
- Goat and cow milk samples.
- Off- and on-Site moisture in air and on-Site air particulate samples.
- On-Site deer, turkey, catfish, and turtle samples and control deer and fish samples.
- Additional residential wells and five new shallow monitoring wells.
- Water samples for analysis of 33 VOCs, 64 semi-volatile organic compounds, 28 pesticides and PCBs, and 24 metals and other inorganic chemicals.

9.3.3.3 1990 RESULTS

5453

All of the analyses have been completed and the results for each sample type are shown in Table 9.9 as a range of values, together with a comment or a comparison range of values.

9.3.3.4 SUMMARY

Analyses of samples collected on and near the Tatum Dome Test Site in Lamar County, Mississippi, by gamma spectroscopy and radiochemistry for nuclear test-related radioactivity indicated that only worldwide fallout levels of radioactivity are present in samples taken away from the immediate emplacement hole area of the Tatum Dome Test Site. The only contamination related to the tests conducted in the salt dome is tritium in shallow groundwater near that emplacement hole area that is due to disposal of drilling fluids and industrial operations during Site cleanup activities in 1971 and 1972. Even in nondrinkable water this tritium concentration is less than the EPA National Primary Drinking Water Regulation. Of the nine onsite and one offsite wells sampled and analyzed for 149 different organic and inorganic chemicals, only three onsite wells had measurable amounts and, for those regulated chemicals, the levels were less than the National Primary Drinking Water Regulation level. The six organic compounds detected are probably due to drilling and industrial operations conducted during the tests.

9.3.3.5 CONCLUSIONS

From all the analyses conducted over the past 18 years, there is no indication that radioactivity from the nuclear tests conducted in the Tatum Salt Dome is escaping from the test cavity.

The only radioactivity detected in samples collected offsite is due to worldwide fallout, and the levels are similar to those in other southeastern states.

Table 9.9 Results of Tatum Dome Test Site Monitoring - 1990

Sample Type and Isotope	Range (pCi/L)	Comparison or Comment
	Tritium Enrichment Method, MDC = 10 pCi/L	
Residential wells	<1 to 30	Normal background levels
Onsite wells	0.3 to 9500	Maximum = 48% of standard
City water wells	<1 to 13	Normal background levels
	Conventional Tritium Analysis, MDC = 400 pCi/L	
Milk near the Tatum Salt Dome	84 to 360	Normal background levels
Milk from dairies	110 to 300	Normal background levels
Animal samples	-120 to 290	Controls are -150 to 240
Catfish (Half Moon Creek)	-290 to 210	Controls are -44 to 58
Vegetables	-110 to 240	Normal background levels
Air samples	-100 to 340	Controls are 77 to 350
Resident urine samples	-400 to 200	Controls are -170 to 200
	Gamma Analysis (^{137}Cs was the only fission product detected)	
Catfish	0.026 to 0.096 pCi/gram	Normal background
Garden soil	0.07 to 0.33 pCi/gram	Controls are 0.33 to 0.54
Tatum Salt Dome soil	0.05 to 0.08 pCi/gram	Controls are 0.33 to 0.54
Meat samples	0.02 to 0.51 pCi/gram	Controls are 0.05 to 7.0
	^{90}Sr Analysis (MDC = 2 pCi/L or 0.2 pCi/gram)	
Goat milk	6.3 pCi/L	Nationwide levels
Cow milk	8.4 and 9.1 pCi/L	are 0 to 5.7[a]
Dairy milk	3.1 and 3.5 pCi/L	
Deer bone	8.7 pCi/gram	Controls are 0.4 to 14
	Nonradioactive Analyses (found in only three onsite wells)	
HM-L	1,2-dichloroethene at 3 parts per billion (ppb)	
	1-methylnaphthalene at 11 ppb	
	naphthalene at 3 ppb	
	benzene at 1 ppb (20 percent of the standard)	
HM-1	n-nitrosodiphenylamine at 6 ppb (standard is 7 ppb)	
HM-3	2-methylnaphthalene at 10 ppb	
	naphthalene at 4 ppb	
	benzene at 1 ppb (20 percent of the standard)	

(a) Dairy milk is a mixture of low and high levels, so it tends to be less than some individual cow milk samples.

5453

10.0 ONSITE RADIOLOGICAL QUALITY ASSURANCE

Yun Ko Lee

The radiological quality assurance (QA) program included conformance to accepted procedures. The external quality assurance intercomparison program for radiological data quality assurance consisted of participation in the DOE Quality Assessment Program (QAP) administered by the DOE Environmental Measurements Laboratory (EML); the Nuclear Radiation Assessment and Cross Check Program (NRACC) conducted by the EPA Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV); and the quality assessment program sponsored the International Reference Center for Radioactivity (IRCR) of the World Health Organization (WHO).

10.1 OVERVIEW OF THE ONSITE QUALITY ASSURANCE PROGRAM

The 1990 QA program for onsite radiological environmental monitoring covered airborne effluent, liquid effluents, air, particulates, surface water, groundwater, and thermoluminescent dosimeter (TLD) ambient gamma monitoring for radioactive materials. Radiological sample collection, radiochemical analyses, and radiological monitoring of NTS samples were performed by the onsite operations contractor (Reynolds Electrical & Engineering Co., Inc. [REECo]). The onsite contractor laboratory maintained both internal and external quality control (QC) programs to ensure that the data and analytical results collected were representative of the actual concentrations in the environment.

Large numbers of routinely scheduled environmental samples were collected at various locations on the NTS in support of the testing programs and the Radioactive Waste Management Project. Samples from all locations were collected using documented REECo Health Physics Department (HPD) standard operating procedures. Current data for each environmental medium were compared to both recent results and historical data for each location to ensure that any deviations from previous conditions were identified and promptly evaluated. Review of analytical results relative to the applicable DOE orders and standards was performed on a daily basis to ensure that potential problems were noted in a timely manner.

A QA/QC program for radiological monitoring was maintained to ensure that the monitoring data generated could be used to accurately evaluate the environmental impacts from NTS operations. The continuous QA program focused on the following practices:

- Personnel training and work assignment qualifications.
- Sample acquisition documentation.
- Sample chain-of-custody control.
- Procedural compliance.
- Yield determination of radiochemistry procedures.
- Analytical QA including blanks, spikes, and blind replicates being used as QC samples to verify the maintenance of procedural control.

280

- Routine source and background count checks for control of counting system performance.
- Use of standards traceable to the National Institute of Standards and Technology (NIST) and NIST reference materials for instrument calibration and QC samples.
- Calibration of sampling, analytical, and counting instruments.
- Preventive and corrective maintenance for all systems which were crucial to data quality.
- QC data and QC charts review to assure control of methods and processes.
- Review of analytical data before reporting.
- External audits and surveillances.
- Internal compliance surveillances.
- Actively participating in the interlaboratory QA programs conducted by the DOE, EPA, and WHO.

10.2 SAMPLE CONTROL

Environmental monitoring samples were collected throughout the NTS and analyzed according to documented HPD standard operating procedures. Each of the samples submitted for analysis was identified with a unique packet number and was accompanied with a Laboratory Service Request and Chain of Custody Form. Personnel receiving the sample examined it and verified the information furnished on the accompanying forms. The sample preparation technician readied the sample materials for analyses. All samples were logged in through the Laboratory Data Analysis System (LDAS) resident on the HPD Laboratory VAX computer. Samples requiring chemical processing were signed out by appropriate radiochemistry laboratory personnel. Samples ready to be counted were signed out by radioanalysis counting laboratory personnel. When analysis was completed, the sample was returned to the sample custodian. Completed samples were normally stored for at least two months before disposal. When any samples were transferred to another person, verification signatures were required by both the persons submitting and receiving the samples.

10.3 INSTRUMENT CONTROL

Sampling, measuring, and test equipment used in the performance of quantitative measurements for the purpose of data production were controlled and calibrated with specific calibration requirements and procedures. All calibration standards used for calibration purposes were traceable to NIST and had the similar matrix and the same or closest possible similar geometry and as the samples which were to be counted. In general, each radiological counting instrument was certified for each radionuclide measured. The efficiencies of counting instruments were established using standards prepared from NIST reference materials or certified reference materials traceable to the NIST. When a gamma spectrometer was certified, a plot of efficiency versus energy was prepared to identify errors in the calibration of individual radionuclides and to determine the efficiencies of radionuclides for which standards were not available.

Gamma spectrometers were set to count check sources of known activities on a daily basis. The peaks' centroid energies were compared against the expected energies. Daily performance tests were performed with a NIST-traceable multiradionuclide standard with known radioactivities. The activities of three isotopes (^{241}Am, ^{137}Cs, and ^{60}Co) were calculated using production-mode computer algorithms, then compared with previous values. Counter backgrounds were measured regularly. Counters were decontaminated if background measurement showed evidence of above-background

radiation levels. Instrument performance check activities and pertinent data were recorded in the individual instrument logbooks. Control charts were prepared for all gamma spectrometers.

Radioactive check sources of known activities were used for instrument performance tests of alpha spectrometers. The sample holders and the circular disks in which these are imbedded were cleaned at least once a week and prior to performing the instrument performance tests. The peak channel (the full width at half maximum) and the count rate for each peak were recorded in the individual instrument logbook and were compared with both previous values and established acceptance criteria. Weekly background checks were performed and documented.

Proportional counters were set to count background and check sources of known activities on a daily basis. Data were recorded in the individual instrument logbooks for comparison to previously acquired values, and control charts were prepared for instrument performance monitoring. Sample holders of the counters were thoroughly cleaned on a regular basis.

Liquid scintillation counters were set to count background and standards of known activity along with each batch of ten or less samples analyzed. Data were recorded in the instrument logbooks. The instruments were under service and maintenance contracts with each instrument's manufacturer for calibration and maintenance.

For all counting instruments, performance test data were accumulated and presented to the laboratory radioanalysis supervisor to be permanently filed. If data obtained from background and/or source checks were considered outside the instrument control limits or showed any inconsistencies, the cause of the problem was investigated and corrective actions initiated. If the problem was found to be originated by the counting instrument, the instrument was removed from service. Any nonconforming instrument was repaired and recertified before it was allowed back in service. Performance histories of the counting instruments were maintained in instrument logbooks.

10.4 RADIOANALYSIS CONTROL

Personnel handling sample collection, preparation, and analysis were trained, qualified, and certified for their work assignments by their supervisors. Standard analytical methods used in radiochemistry analyses were derived from procedures published by the Environmental Measurements Laboratory, U.S. Department of Energy, New York, New York, for analyses of radionuclides. Drinking water samples were analyzed using procedures derived from those of EPA. In some of the radiochemistry procedures, NIST-traceable standards were used, whenever feasible, as tracers to determine the chemical yield of the procedure. The yield was compared to previously determined acceptable control limits to provide an immediate evaluation of the process. Spiked samples were prepared from NIST-traceable materials for various analyses. Whenever it was feasible, blanks, spikes, and replicates were submitted as QC samples to be analyzed along with every lot of field samples so that accuracy and precision of the analysis could be determined. The ratio of the number of QC samples to that of field samples analyzed varied depending on the types of analysis. Specific QC procedures and requirements were established and documented for each analysis. The laboratory QC program mandated that at least ten percent of the samples in each sample lot analyzed should be QC samples. However, in real practice, the number of QC samples analyzed was usually greater than the ten percent minimum.

10.5 DATA CONTROL

An internal QA/QC program was implemented to control and document the

accuracy and precision of data generated. Sample and counting data were entered (or acquired) and stored on an appropriate data base of the laboratory LDAS computer. Counting data were processed, and results were generated. Pertinent information on the samples and their analyses were recorded. Analytical results were reported with the uncertainty limits and a minimum detection limit. Radionuclide concentrations were reported as calculated even when they were less than the error limits or were negative. Analytical results were subjected to screening and peer review for correctness and accuracy. Analytical results were reviewed by the laboratory radioanalysis supervisor before being distributed and/or reported. Results of QC samples were promptly checked against the corresponding known values and examined with standard statistical methods. Control charts were plotted with 2 standard deviation (s) warning limits and 3s control limits. If any result was found to be outside the control limits, the QC check sample was recounted. If the QC sample still exceeded the limit, the root cause of the problem was investigated and corrected, and the entire sample lot was reanalyzed.

Corrective actions included, but were not limited to; interview with the analysts; performing data evaluation software verification and validation; recalibration of instruments; replacement of equipment; recollection and/or reanalysis of samples; retraining of personnel in correct implementation of sample collection, preparation, and analysis; reassignment of personnel to improve the overlap between the operator skills and method requirements; and revision of procedures.

Results were transferred to the REECo ShareBase 8000 Computer System as part of the historical data base and held for archives. Safeguards over the computer facility were provided as outlined in DOE Orders 1360.2 and 1330.1(c) to assure quality through the protection of results, equipment, and software.

10.6 EXTERNAL QUALITY ASSURANCE ASSESSMENT PROGRAMS

In addition to implementing the internal QA/QC program, the radioanalytical laboratory continued to participate in interlaboratory comparison and quality assessment programs in 1990.

One of these programs was the QAP conducted by the DOE/EML. The second program was the NRACC conducted by the EMSL-LV. Under both programs, a variety of standardized samples were sent to the participating laboratories at intervals throughout the year. Such standard samples consisted of various environmental media (e.g., water, air filters, soil, milk, foodstuffs, vegetation, and tissue ash) containing one or more radionuclides in known amounts. After the samples were analyzed by the laboratories, the results were forwarded to the program sponsor for comparison with the known values and with the results from other participating laboratories. Both the DOE/EML and EPA/EMSL-LV have established criteria for evaluating the accuracy and precision of results (Jarvis and Siu 1981, Sanderson and Scarpitta 1990, and Sanderson and Scarpitta 1991). These programs served as a regular means of evaluating the performance of the radioanalytical laboratories and provided indications where corrective actions were needed. During 1990 the laboratory also participated in the quality assessment program sponsored by the IRCR/WHO. Analytical results were sent to IRCR/WHO, but no information feedback was received from IRCR/WHO in 1990 for evaluation. Summaries of the 1990 results of the interlaboratory comparison and quality assessment programs conducted by the EPA/EMSL-LV and DOE/EML are provided in Tables 10.1 and 10.2. The 20 percent indicator shown in these tables serves as a convenient measure of overall relative performance of the participating laboratories and should not be used as a sole

5453

determinant for accuracy. As illustrated in Tables 10.1 and 10.2, REECo results were generally within the control limits determined by the program sponsors. Causes or results outside the control limits were investigated, and corrective actions were taken to alleviate the problems and to prevent reoccurrence.

10.7 COMPLIANCE AUDITS AND SURVEILLANCE

The REECo onsite laboratory was periodically audited for compliance by various divisions and branches of the DOE/NV and REECo Quality System Division. During 1990 the HPD Laboratory Operations Section also conducted internal surveillances on the radiochemistry, radioanalysis, and environmental surveillance functions of the laboratory for QA practices. Recommendations and corrective actions from the audit and surveillance reports were implemented or are in the process of being implemented.

10.8 RECENT DEVELOPMENTS IN THE QA/QC PROGRAM

QA activities continue to be influenced by programmatic changes. As required by DOE Orders 5400.1 and 5400.6 and the DOE/NV Environmental Protection Implementation Plan, specific QA program requirements are addressed and implemented by the analytical functions of the onsite laboratory. The REECo HPD Quality Procedure was approved and adapted in July 1990 to define and outline policies in implementing quality assurance requirements, including those from ANSI/ASME NQA-1 and EPA QAMS-005-80. A laboratory quality assurance strategy was developed and issued in September 1990 to describe the measures taken by the onsite laboratory to meet the quality requirements.

The onsite laboratory participated in the EPA/EMSL-LV Water Supply Laboratory Certification Program for mixed alpha, beta, and gamma analysis.

Table 10.1 Results of EPA/EMSL-LV Nuclear Radiation Assessment and Cross Checks - 1990

Analysis/ Date	Water Samples, pCi/L REECo[a]	EPA/EMSL-LV[b]	Control Limits[c]	Ratio of REECo/ EMSL-LV
Gross Alpha				
01/26/90	14.0 ± 0.0	12.0 ± 5.0	3.3 - 20.7	1.17
04/17/90	71.3 ± 5.1	90.0 ± 23.0	50.1 - 129.9	0.79
05/11/90	No Data[d]	22.0 ± 6.0	11.6 - 32.4	--
09/21/90	No Data[d]	10.0 ± 5.0	1.3 - 18.7	--
10/30/90	59.7 ± 5.0	62.0 ± 16.0	34.2 - 89.8	0.96
Gross Beta				
01/26/90	12.7 ± 0.6	12.0 ± 5.0	3.3 - 20.7	1.06
04/17/90	42.3 ± 1.2[e]	52.0 ± 5.0	43.3 - 60.7	0.81
05/11/90	No Data[d]	15.0 ± 5.0	6.3 - 23.7	--
09/21/90	No Data[d]	10.0 ± 5.0	1.3 - 18.7	--
10/30/90	40.3 ± 2.1[e]	53.0 ± 5.0	44.3 - 61.7	0.76

(a) Average value [± 1 standard deviation(s)] reported by REECo.
(b) The known value (± 1s) reported by EPA/EMSL-LV.
(c) The control limits determined by EPA/EMSL-LV.
(d) No data provided.
(e) The value is outside the control limits determined by EPA/EMSL-LV.

Table 10.1 (Results of EPA/EMSL Nuclear Radiation Assessment and Cross Checks - 1990, cont.)

Analysis/ Date	Water Samples, pCi/L *(cont.)* REECo[a]	EPA/EMSL[b]	Control Limits[c]	Ratio of REECo/ EMSL
^{3}H				
02/23/90	4810 ± 142	4976 ± 498	4113 - 5839	0.97
06/22/90	3057 ± 110	2933 ± 358	2519 - 3347	1.04
10/19/90	6066 ± 768	7203 ± 720	5954 - 8452	0.84
^{60}Co				
02/09/90	20.0 ± 1.0	15.0 ± 5.0	6.30 - 23.7	1.33
06/08/90	27.7 ± 0.6	24.0 ± 5.0	15.3 - 32.7	1.15
10/05/90	24.3 ± 1.15	20.0 ± 5.0	11.3 - 28.7	1.22
^{65}Zn				
02/09/90	154 ± 5	139 ± 14	115 - 163	1.11
06/08/90	166 ± 3	148 ± 15	122 - 174	1.12
10/05/90	127 ± 5	115 ± 12	94.2 - 136	1.10
^{89}Sr				
01/12/90	1.0 ± 3.0	25.0 ± 5.0	16.3 - 33.7	0.84
04/17/90	7.67 ± 0.58	10.0 ± 5.0	1.3 - 18.7	0.77
05/04/90	No Data[d]	7.0 ± 5.0	0.0 - 15.7	--
09/14/90	7.00 ± 2.65	10.0 ± 5.0	1.30 - 18.7	0.70
10/30/90	18.0 ± 4.9	20.0 ± 5.0	11.3 - 28.7	0.90
^{90}Sr				
01/12/90	18.7 ± 1.2	20.0 ± 1.5	17.4 - 22.6	0.94
04/17/90	8.33 ± 0.58	10.0 ± 1.5	7.4 - 12.6	0.83
05/04/90	No Data[d]	7.0 ± 5.0	0.0 - 15.7	--
09/14/90	9.00 ± 1.00	9.00 ± 5.0	0.30 - 17.7	1.00
10/30/90	13.7 ± 1.2	15.0 ± 5.0	6.3 - 23.7	0.91
^{106}Ru				
02/09/90	167 ± 29 [e]	139 ± 14	115 - 163	1.20
06/08/90	219 ± 9	210 ± 21	174 - 246	1.04
10/05/90	169 ± 16	151 ± 15	125 - 177	1.12
^{133}Ba				
02/09/90	70.0 ± 1.0	74.0 ± 7.0	61.9 - 86.1	0.95
06/08/90	95.0 ± 6.9	99.0 ± 10.0	81.7 - 116.3	0.96
10/05/90	104 ± 2	110 ± 11	90.9 - 129	0.95
^{134}Cs				
02/09/90	18.0 ± 2.0	18.0 ± 5.0	9.3 - 26.7	1.00
04/17/90	14.0 ± 1.0	15.0 ± 5.0	6.3 - 23.7	0.93
06/08/90	24.7 ± 1.5	24.0 ± 5.0	15.3 - 32.7	1.03
10/05/90	15.7 ± 0.6	12.0 ± 5.0	3.3 - 20.7	1.31
10/30/90	8.3 ± 1.2	7.0 ± 5.0	0.0 - 15.7	1.19

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1s) reported by EPA/EMSL-LV.
(c) The control limits determined by EPA/EMSL-LV.
(d) No data provided.
(e) The value is outside the control limits determined by EPA/EMSL-LV.

285

Table 10.1 (Results of EPA/EMSL Nuclear Radiation Assessment and Cross Checks - 1990, cont.)

Analysis/ Date	Water Samples, pCi/L *(cont.)* REECo[a]	EPA/EMSL[b]	Control Limits[c]	Ratio of REECo/ EMSL
^{137}Cs				
02/09/90	20.7 ± 1.5	18.0 ± 5.0	9.3 - 26.7	1.15
04/17/90	16.7 ± 0.6	15.0 ± 5.0	6.3 - 23.7	1.11
06/08/90	29.3 ± 1.5	25.0 ± 5.0	16.3 - 33.7	1.17
10/05/90	16.7 ± 4.7	12.0 ± 5.0	3.3 - 20.7	1.39
10/30/90	6.7 ± 0.6	5.0 ± 5.0	0.0 - 13.7	1.34
^{226}Ra				
03/09/90	4.8 ± 0.4	4.9 ± 0.7	3.7 - 6.1	0.98
04/17/90	4.1 ± 0.5	5.0 ± 0.8	3.6 - 6.4	0.82
07/13/90	12.0 ± 1.2	12.1 ± 1.8	9.0 - 15.2	0.99
10/30/90	13.1 ± 1.6	13.6 ± 2.0	10.1 - 17.1	0.96
11/09/90	8.1 ± 0.6	7.4 ± 1.1	5.5 - 9.3	1.09
^{228}Ra				
03/09/90	5.77 ± 0.25[d]	12.7 ± 1.9	9.4 - 16.0	0.45
04/17/90	8.23 ± 1.76	10.2 ± 1.5	7.6 - 12.8	0.81
07/13/90	9.23 ± 0.40[d]	5.1 ± 1.3	2.8 - 7.4	1.81
10/30/90	5.0 ± 1.0	5.0 ± 1.3	2.7 - 7.3	1.00
11/09/90	13.8 ± 2.6[d]	7.7 ± 1.9	4.4 - 11.0	1.79
^{239}Pu				
01/19/90	5.43 ± 0.25	5.6 ± 0.6	4.6 - 6.6	0.97
08/24/90	8.53 ± 0.32	9.1 ± 0.9	7.5 - 10.7	0.94
^{Nat}U				
03/16/90	3.67 ± 0.58	4.0 ± 6.0	0.0 - 14.4	0.92
04/17/90	21.3 ± 4.0	20.0 ± 6.0	9.6 - 30.4	1.07
07/20/90	19.3 ± 2.0	20.8 ± 3.0	15.6 - 26.0	0.93
10/30/90	9.6 ± 1.3	10.2 ± 3.0	5.0 - 15.4	0.94
11/16/90	28.8 ± 0.6[d]	35.5 ± 3.6	29.3 - 41.7	0.81
	Air Filters, pCi/Filter			
Gross Alpha				
03/30/90	5.7 ± 0.6	5.0 ± 5.0	0.0 - 13.7	1.14
08/31/90	12.0 ± 2.7	10.0 ± 5.0	1.3 - 18.7	1.20
Gross Beta				
03/30/90	3.0 ± 0.0[d]	31.0 ± 5.0	22.3 - 39.7	0.10
08/31/90	60.3 ± 2.5	62.0 ± 5.0	53.3 - 70.7	0.97
^{90}Sr				
03/30/90	8.7 ± 0.6	10.0 ± 1.5	7.4 - 12.6	0.87
08/31/90	19.3 ± 1.2	20.0 ± 5.0	11.3 - 28.7	0.97
^{137}Cs				
03/30/90	15.0 ± 1.0	10.0 ± 5.0	1.3 - 18.7	1.50
08/31/90	29.0 ± 3.5[d]	20.0 ± 5.0	11.3 - 28.7	1.45

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1s) reported by EPA/EMSL-LV.
(c) The control limits determined by EPA/EMSL-LV.
(d) The value is outside the control limits determined by EPA/EMSL-LV.

Table 10.2 Results of the DOE/EML Quality Assessment Program - 1990

Analysis/ Date	Air Filters, pCi/Filter REECo[a]		DOE/EML[b]		Mean[c]	Ratio of REECo/ EML
^{7}Be						
03/90	59.8	± 6%	51.4	± 7%	49.2	1.16
^{54}Mn						
03/90	12.4	± 5%	9.60	± 4%	9.66	1.29
09/90	64.0	± 4%	33.3	± 2%	34.3	1.92
^{57}Co						
03/90	7.75	± 5%	6.50	± 6%	6.33	1.19
09/90	21.0	± 5%	11.4	± 2%	12.2	1.84
^{60}Co						
03/90	11.1	± 5%	9.40	± 6%	8.81	1.11
09/90	41.0	± 6%	25.4	± 1%	23.2	1.61
^{90}Sr						
03/90	0.220	± 0%	0.240	±16%	0.255	0.92
09/90	0.109	± 8%	0.093	± 6%	0.114	1.17
^{134}Cs						
03/90	18.3	± 5%	18.2	± 8%	16.2	1.01
09/90	27.0	± 6%	16.3	± 2%	16.4	1.66
^{137}Cs						
03/90	25.7	± 4%	20.4	± 3%	19.9	1.26
09/90	29.0	± 7%	15.7	± 2%	15.7	1.85
^{144}Ce						
03/90	42.8	± 5%	31.2	± 4%	30.4	1.37
09/90	60.7	± 7%	16.5	± 3%	16.03.68	
^{239}Pu						
03/90	0.0369	± 9%	0.0390	±12%	0.0386	0.95
09/90	0.0500	± 7%	0.0510	± 7%	0.0466	0.98
^{241}Am						
03/90	0.0503	± 6%	0.0540	±11%	0.0502	0.93
09/90	0.0360	± 9%	0.0360	± 5%	0.0426	1.00
^{Nat}U						
03/90	0.0342	± 1%	0.0510	± 4%	0.0523	0.67
09/90	0.0270	± 9%	0.0250	± 3%	0.0328	1.08
^{40}K						
03/90	540	± 7%	608	± 0%	605	0.89
09/90	411	± 9%	513	± 5%	512	0.80

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1 standard error of the mean [sem]) reported by DOE/EML.
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value.

Table 10.2 (Results of the DOE/EML Quality Assessment Program - 1990, cont.)

Analysis/ Date	Soil Samples, Bq/kg REECo[a]		DOE/EML[b]		Mean[c]	Ratio of REECo/ EML
^{90}Sr						
03/90	599	± 1%	665	± 2%	665	0.90
^{137}Cs						
03/90	15400	± 4%	17500	± 1%	18800	0.88
09/90	172	± 6%	196	± 7%	209	0.88
^{239}Pu						
03/90	256	± 8%	212	± 4%	190	1.21
09/90	2.47	± 7%	1.15	± 6%	1.25	2.15
^{241}Am						
03/90	102	± 5%	106	± 9%	106	0.96
09/90	0.918	±20%	0.738	±16%	0.874	1.24
^{Nat}U						
09/90	21.9	±10%	55.6	± 3%	55.0	0.39
	Vegetation Samples, Bq/kg					
^{40}K						
03/90	271	± 8%	323	± 7%	325	0.84
09/90	884	± 7%	1030	± 6%	1020	0.86
^{90}Sr						
03/90	67.7	± 2%	70.2	± 3%	73.4	0.96
09/90	675	± 4%	889	± 6%	942	0.76
^{137}Cs						
03/90	26.8	± 7%	28.5	± 4%	32.5	0.94
09/90	16.0	±13%	18.2	± 6%	19.1	0.88
^{239}Pu						
03/90	0.410	±13%	0.333	± 4%	0.426	1.23
09/90	0.148	±12%	0.0959	± 2%	0.107	1.54
^{241}Am						
03/90	0.300	±16%	0.307	± 4%	0.334	0.98
^{Nat}U						
03/90	0.468	±34%	1.06	± 4%	1.50	0.44

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1 sem) reported by DOE/EML.
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value.

Table 10.2 (Results of the DOE/EML Quality Assessment Program - 1990, cont.)

Analysis/ Date	Water Samples, Bq/kg REECo[a]		DOE/EML[b]		Mean	Ratio of REECo/ EML
^{3}H						
03/90	1850	± 1%	1960	± 2%	1920	0.94
09/90	4330	± 1%	3900	± 9%	4110	1.11
^{54}Mn						
03/90	108	± 6%	103	± 4%	103	1.05
09/90	318	± 5%	301	± 1%	305	1.06
^{57}Co						
03/90	197	± 5%	198	± 5%	195	0.99
09/90	1470	± 4%	1300	± 2%	1410	1.13
^{60}Co						
03/90	190	± 5%	206	± 4%	185	0.90
09/90	511	± 5%	491	± 3%	509	1.04
^{90}Sr						
03/90	86.6	± 1%	111	± 4%	103	0.78
09/90	8.73	± 5%	9.93	± 4%	10.9	0.88
^{134}Cs						
03/90	414	± 4%	462	± 5%	431	0.90
09/90	386	± 5%	355	± 4%	379	1.09
^{137}Cs						
03/90	200	± 5%	198	± 5%	194	1.01
09/90	433	± 5%	390	± 3%	417	1.11
^{144}Ce						
03/90	588	± 5%	403	± 4%	462	1.46
09/90	725	± 7%	923	± 2%	918	0.79
^{239}Pu						
03/90	1.02	± 13%	1.04	± 9%	1.23	0.98
09/90	0.888	± 6%	1.09	± 1%	0.907	0.81
^{241}Am						
03/90	0.784	± 6%	0.860	± 9%	0.836	0.91
09/90	0.432	± 6%	0.567	± 6%	0.536	0.76
^{Nat}U						
03/90	1.90	± 9%	2.00	± 3%	1.75	0.95
09/90	0.510	± 10%	0.480	± 3%	0.524	1.06

(a) Average value (± 1s) reported by REECo.
(b) The known value (± 1 sem) reported by DOE/EML.
(c) The mean value was computed from all reported results, which are in the range of 0.5 to 2.0 times of the DOE/EML known value.

11.0 ONSITE NONRADIOLOGICAL QUALITY ASSURANCE

5453

Kevin R. Krenzien

The nonradiological program included sample acceptance and control criteria, quality control (QC) procedures, and interlaboratory comparisons through participation in the National Institute of Occupational Safety and Health (NIOSH) Proficiency Analytical Testing (PAT) Program, the American Industrial Hygiene Association (AIHA) Asbestos Analysts Registry (AAR) Program, the AIHA Bulk Asbestos Analysis Program, National Voluntary Laboratory Accreditation Program (NVLAP) Bulk Asbestos Fiber Analysis Program, and the College of American Pathologists (CAP) Analysis of Lead in Blood Program. Proficiency testing through participation in the EPA Contract Laboratory Program (CLP) was continued.

11.1 OVERVIEW OF THE ONSITE NONRADIOLOGICAL QUALITY ASSURANCE PROGRAM

Onsite nonradiological samples were analyzed by Reynolds Electrical & Engineering Co., Inc. (REECo), and four commercial laboratories during 1990. Most of the environmental samples for organic analyses were sent to CLP laboratories, which were Datachem Laboratories in Salt Lake City or Sierra Technical Services in Las Vegas. Samples containing high levels of radioactive components, as determined by the REECo radiochemistry laboratory, were sent to IT Corporation, Oak Ridge, Tennessee, for environmental analyses. Nonradiological samples included industrial hygiene air monitoring samples, asbestos monitoring program samples, environmental water and soil samples, and PCB samples.

The quality of the analytical data and results produced was assured with a program which included calibration of all instrumentation, use of standard analytical procedures, the inclusion and analysis of QC samples, and continuation of personnel training to maintain qualified staff. Prior to release, all analytical results were reviewed and compared to accepted QC data.

The onsite industrial hygiene laboratory continued to participate in a number of external quality assurance programs and maintained all external agency accreditations while progressing to achieve EPA CLP equivalency.

The QA program included:

- Specific sample acceptance criteria and maintenance of sample custody.
- Calibration of all analytical instrumentation.
- A program of preventative and periodic maintenance for all systems which were crucial to data quality.
- Use of National Institute of Standards and Technology (NIST) or EPA-traceable standards and reference materials.
- Spikes, blanks, and blind replicates as a measure of QA samples.
- Review of QC charts to assure control of methods and processes.

- Review of analytical data before final results were released.

The onsite laboratory participated in QA programs operated by the AIHA, NIST, NIOSH, and EPA.

11.2 SAMPLE ACCEPTANCE AND CONTROL

Samples submitted to the onsite industrial hygiene laboratory included a Chain of Custody Form and an appropriate Sample Data Sheet before they were accepted by the sample custodian. The sample custodian also checked the sample to ensure proper collection procedures were used, samples were transported correctly (i.e., organic samples were refrigerated), and sample holding times were not exceeded. If the samples met the laboratory sample acceptance criteria, they were logged into the Sample and Analysis Management System (SAM). The samples were then stored in a locked, walk-in cooler until a chemist was prepared to analyze the samples. If a sample was not destroyed during analysis, it was returned to the walk-in cooler for storage and future disposal. All sample transactions continued to be documented using the field-generated Chain of Custody Form.

11.3 QUALITY CONTROL

A program of daily, weekly, and monthly preventative maintenance was followed. This program included monitoring of laboratory water quality, monitoring of refrigerator temperatures, and verifying the accuracy of analytical balances. The preventative maintenance program also included periodic service by manufacturer service engineers. A maintenance logbook and a separate sample run logbook were maintained for each analytical instrument.

Analytical instrumentation was calibrated before the analysis of a sample batch. A multi-standard calibration curve had to exhibit a correlation coefficient of 0.995 or greater before the analytical data could be reported.

Check samples were run periodically throughout a sample batch. These analyses insured that the instrument calibration remained valid during the batch analysis.

Trip, field, holding, and method blanks were analyzed to insure that cross-contamination did not affect the final analytical result.

Spikes to measure analytical recovery were analyzed at a rate of 1 in 10. The spike results were plotted on QC charts and had to fall within three standard deviations of a population mean before sample results were verified. If the spike results did not meet this criteria, the cause was determined and the sample batch was reanalyzed if the holding time was valid.

Sample replicates were prepared and analyzed at a rate of 1 in 10. The relative percent difference (RPD) was calculated for the replicate samples and plotted on QC charts. The RPD had to be within three standard deviations of the population before the sample results were approved. The sample batch was reanalyzed if this criterion was not met. Before being released, all sample data and results underwent three levels of review: (1) peers reviewed the sample data for errors involving standard preparation and calculations, (2) the quality coordinator reviewed the data and results to assure that all QC criteria had been met, and (3) laboratory supervisor reviewed the data and results before certifying and transmitting the final results.

11.3.1 INTERLABORATORY COMPARISON PROGRAMS

External QA/QC program included participation in the NIOSH PAT program, AIHA AAR program, AIHA Bulk Asbestos Analysis Program, NIST NVLAP Bulk Asbestos Fiber Analysis Program, and CAP

Analysis of Lead in Blood Program. Participation in the EPA CLP quarterly proficiency testing program was continued.

All of these programs required participating laboratories to analyze proficiency samples at various intervals throughout the year.

The standard sample matrices (air monitoring filters, bulk asbestos samples, blood samples, soil, and water) were prepared by external reference agencies and contained one or more analytes in concentrations which were unknown to the participating laboratories. After the results were analyzed, they were forwarded to the sponsoring agency for comparison to the reference value and the results of other participating laboratories. These programs served to identify analytical problems requiring corrective action.

Tables 11.1, 11.2, and 11.3 are summaries of interlaboratory comparison results during 1990. Performance limits for these interlaboratory comparisons are set at plus or minus three normalized standard deviations for the participating laboratories. As asbestos results are qualitative and based on identification, no results are given for either the AIHA or NVLAP bulk asbestos programs. However, the industrial hygiene laboratory continued to maintain its accreditation in both of these programs. The results were generally within performance limits required by the sponsoring agencies. Causes for results which were not within acceptable performance limits were investigated, and corrective actions were taken to prevent reoccurrence. Corrective actions taken included developing a flame test to differentiate chrysotile asbestos from pulped polyethylene, moving silica analysis preparation area to avoid contamination, purchasing a new atomic absorption spectrophotometer to increase reliability of inorganic results, and developing improved procedures for desorbing solvents from charcoal tubes.

Table 11.1 NIOSH PAT Program Interlaboratory Comparison - 1990

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
Pb (in mg)				
02/21/90	0.0460	0.0443	1.04	0.0386-0.0501
	0.0587	0.0591	0.99	0.0519-0.0665
	0.0164[c]	0.0201	0.82	0.0169-0.0233
	0.0319	0.0328	0.97	0.0293-0.0364
05/23/90	0.0262	0.0241	1.09	0.0206-0.0276
	0.0453	0.0419	1.08	0.0370-0.0469
	0.0612	0.0575	1.06	0.0508-0.0642
	0.0389	0.0361	1.08	0.0319-0.0403
08/23/90	0.0627	0.0642	0.98	0.0543-0.0741
	0.0281	0.0268	1.05	0.0227-0.0310
	0.0854	0.0843	1.01	0.0731-0.0995
	0.0498	0.0483	1.03	0.0414-0.0552

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) REECo reported result was outside program performance limits.

Table 11.1 (NIOSH PAT Program Interlaboratory Comparison - 1990, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
(Pb, cont.)				
11/20/90	0.0720	0.0717	1.00	0.0639-0.0795
	0.0270	0.0265	1.02	0.0225-0.0304
	0.0395	0.0392	1.01	0.0339-0.0445
	0.0588	0.0598	0.98	0.0519-0.0676
Cd (in mg)				
02/21/90	0.0089	0.0089	0.92	0.0078-0.0100
	0.0113	0.0118	0.96	0.0106-0.0132
	0.0151	0.0157	0.96	0.0142-0.0174
	0.0093	0.0099	0.94	0.0091-0.0109
05/23/90	0.0155	0.0150	1.03	0.0135-0.0165
	0.0087	0.0080	1.09	0.0073-0.0089
	0.0128	0.0119	1.08	0.0107-0.0133
	0.0106	0.0100	1.06	0.0089-0.0113
08/23/90	0.0088	0.0090	0.98	0.0079-0.0101
	0.0116	0.0117	0.99	0.0102-0.0133
	0.0186	0.0192	0.97	0.0166-0.0217
	0.0118	0.0119	0.99	0.0104-0.0134
11/20/90	0.0064	0.0072	0.89	0.0062-0.0082
	0.0095	0.0107	0.89	0.0090-0.0123
	0.0098	0.0111	0.88	0.0094-0.0126
	0.0163	0.0185	0.88	0.0157-0.0213
Cr (in mg)				
11/20/90	0.0790	0.0894	0.88	0.0743-0.1046
	0.0475	0.0428	0.90	0.0437-0.0618
	0.0935	0.1015	0.92	0.0828-0.1200
	0.1715	0.1947	0.88	0.1578-0.2315
Zn (in mg)				
02/21/90	0.1344	0.1457	0.92	0.1230-0.1685
	0.0944	0.1043	0.91	0.0897-0.1190
	0.0758	0.0847	0.89	0.0733-0.0962
	0.1607	0.1704	0.94	0.1478-0.1932
05/23/90	0.2128	0.2153	0.99	0.1917-0.2390
	0.1821	0.1842	0.99	0.1637-0.2049
	0.1314	0.1275	1.03	0.1119-0.1432
	0.1034	0.1009	1.02	0.0840-0.1179
08/23/90	0.1105	0.1071	1.03	0.0922-0.1220
	0.1230	0.1297	0.95	0.1134-0.1459
	0.2033	0.2185	0.93	0.1880-0.2491
	0.1698	0.1751	0.97	0.1512-0.1990

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) REECo reported result was outside program performance limits.

Table 11.1 (NIOSH PAT Program Interlaboratory Comparison - 1990, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
Silica (in mg)				
02/21/90	0.0291[c]	0.0738	0.39	0.0448-0.1218
	0.0488[c]	0.0881	0.55	0.0550-0.1414
	0.0707	0.1102	0.64	0.0675-0.1800
	0.0285[c]	0.0986	0.29	0.0465-0.2096
05/23/90	0.0474	0.0910	0.52	0.0416-0.1993
	0.0859	0.0735	1.17	0.0285-0.1405
	0.0753	0.0707	1.07	0.0348-0.1443
	0.0537	0.0391	1.37	0.0147-0.1045
08/23/90	0.0692	0.0702	0.99	0.0337-0.1464
	0.0680	0.0778	0.87	0.0458-0.1321
	0.2500[c]	0.0534	4.68	0.0224-0.1276
	0.0523	0.0842	0.62	0.0460-0.1542
11/20/90	0.0932	0.0978	0.95	0.0556-0.1720
	0.0424	0.0381	1.11	0.0149-0.0976
	0.0832	0.0937	0.89	0.0517-0.1699
	0.1080	0.1206	0.90	0.0695-0.2094
Asbestos (in fibers/mm^2)				
02/21/90	828.0	763.4	1.08	426.0-1198.5
	506.0	503.5	1.00	255.7- 834.6
	152.0	158.5	0.96	73.5- 275.8
	415.0	383.3	1.08	193.5- 637.5
05/23/90	77.7	217.8	0.36	37.1- 548.9
	48.4	147.1	0.33	15.6- 412.9
	179.6	246.8	0.73	42.3- 621.0
	518.0	459.6	1.13	169.3- 892.2
08/23/90	549.4	369.3	1.49	194.7- 599.5
	866.2	573.2	1.51	201.4-1135.2
	1022.0	783.1	1.31	435.7-1231.5
	386.0	224.8	1.72	104.8- 390.1
11/20/90	158.0	173.3	0.91	55.9- 355.4
	334.0	361.6	0.92	111.9- 753.8
	600.0	521.3	1.15	221.3- 948.0
	510.0	554.4	0.92	253.9- 970.8

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) REECo reported result was outside program performance limits.

Table 11.1 (NIOSH PAT Program Interlaboratory Comparison - 1990, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
		Solvents[c]		
BNZ (in mg)				
08/23/90	0.1690	0.1909	0.89	0.1628-0.2189
	0.2230	0.2445	0.91	0.2165-0.2726
	0.2820	0.2894	0.97	0.2546-0.3242
	0.1335	0.1477	0.90	0.1257-0.1696
CTC (in mg)				
02/21/90	0.5760	0.5744	1.00	0.4856-0.6632
	0.7882	0.8073	0.98	0.6943-0.9204
	0.9470	1.0167	0.93	0.8710-1.1624
	0.4476	0.4581	0.98	0.3926-0.5326
11/20/90	1.2205	1.2119	1.01	1.0775-1.3462
	0.3980	0.4495	0.89	0.3899-0.5090
	0.9370	0.9283	1.01	0.8026-1.0540
	0.6385	0.6597	0.97	0.5731-0.7461
DCE (in mg)				
02/21/90	0.8603	0.8692	0.99	0.7273-1.0111
	0.6529	0.6752	0.97	0.5721-0.7784
	0.4232	0.4394	0.96	0.3721-0.5068
	1.0224	1.0773	0.95	0.9256-1.2290
11/20/90	0.6925	0.6528	1.06	0.5748-0.7308
	0.9990	0.9434	1.06	0.8229-1.0639
	1.2110	1.1060	1.09	0.9805-1.2315
	0.8425	0.7943	1.06	0.6935-0.8950
MCM (in mg)				
05/23/90	0.7055	0.7153	0.99	0.6037-0.8270
	0.7610	0.8474	0.90	0.7412-0.9537
	0.4490	0.4361	1.03	0.3684-0.5039
	1.1340	1.0451	1.09	0.9039-1.1864
OXY (in mg)				
08/23/90	1.0600	1.0888	0.9	0.9120-1.2657
	0.8170	0.8029	1.02	0.6725-0.9333
	1.2985	1.2496	1.04	1.0490-1.4501
	1.6060	1.5362	1.05	1.2765-1.7959
PCE (in mg)				
05/23/90	0.4540	0.4979	0.91	0.4209-0.5750
	0.6400[d]	0.7694	0.83	0.6495-0.8894
	1.0925	1.0992	0.99	0.9228-1.2757
	0.3495	0.3605	0.97	0.2962-0.4249

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) Solvent abbreviations: BNZ=Benzene, CTC=Carbon Tetrachloride, DCE=1,2 Dichloroethane, MCM=1,1,1-Trichloroethane, OXY=o-Xylene, PCE=Tetrachloroethylene.
(d) REECo reported result was outside program performance limits.

Table 11.1 (NIOSH PAT Program Interlaboratory Comparison - 1990, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
		Solvents[c] *(cont.)*		
TCE (in mg)				
02/21/90	0.8312	0.8394	0.99	0.7156-0.9632
	0.9330	0.9611	0.97	0.8290-1.0932
	0.6502	0.6908	0.94	0.6026-0.7791
	0.7452	0.7723	0.96	0.6743-0.8703
05/23/90	0.7870	0.8619	0.91	0.6996-1.0244
	0.3300[d]	0.4305	0.77	0.3706-0.4904
	0.5700	0.6061	0.94	0.5040-0.7083
	0.6690	0.6869	0.97	0.5736-0.8004
11/20/90	0.9190	0.8790	1.05	0.7757-0.9821
	0.5925	0.5839	1.01	0.5086-0.6592
	1.0015	0.9533	1.05	0.8522-1.0544
	1.2045	1.1533	1.04	1.0130-1.2934
TOL (in mg)				
08/23/90	1.5385	1.5987	0.96	1.3999-1.7975
	0.8930	0.9020	0.99	0.7683-1.0357
	1.1920	1.1526	1.03	1.0167-1.2884
	1.4100	1.3808	1.02	1.2171-1.5446

(a) Value provided by the NIOSH PAT Program.
(b) Ratio = REECo Result/Reference value.
(c) Solvent abbreviations: TCE=Trichloroethylene and TOL=Toluene.
(d) REECo reported result was outside program performance limits.

Table 11.2 CAP Program Interlaboratory Comparison - 1990

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
Blood Pb (in µg/dL)				
03/12/90	11.5	13.34	0.86	4.0-21.0
	38.0	37.58	1.01	30.7-46.0
	17.3	16.50	1.05	9.5-23.0
06/11/90	13.0	16.01	0.81	7.0-24.0
	15.0	15.59	0.96	8.0-23.5
	17.0	22.56	0.75	13.1-31.0

(a) Value provided by the CAP Blood Lead Survey Program.
(b) Ratio = REECo Result/Reference value.

Table 11.2 (CAP Program Interlaboratory Comparison - 1990, cont.)

Analysis and Date	REECo Result	Reference Value[a]	Ratio[b]	Performance Limits[a]
Blood Pb, (cont.)				
09/10/90	14.6	14.41	1.01	5.0-22.0
	17.2	13.61	1.26	7.0-20.0
	14.4	10.34	1.39	5.0-16.0
12/14/90	13.3	13.47	0.98	7.0-21.0
	19.8	23.57	0.84	16.0-31.0
	39.5	48.82	0.81	37.0-06.4

(a) Value provided by the CAP Blood Lead Survey Program.
(b) Ratio = REECo Result/Reference value.

Table 11.3 AAR Program Interlaboratory Comparison - 1990

Analysis and Date	REECo Result[a]	Reference Value[b]	Ratio[c]	Performance Limits[b]
Quantitative Asbestos (in f/mm^2)				
03/22/90	177	301	0.59	151 - 602
	264	301	0.88	151 - 602
	202	301	0.67	151 - 602
	136[d]	301	0.45	151 - 602
	230	393	0.59	196 - 785
	244	393	0.62	196 - 785
	276	393	0.70	196 - 785
	245	393	0.62	196 - 785
	453	488	0.93	244 - 975
	500	488	1.02	244 - 975
	444	488	0.91	244 - 975
	423	488	0.87	244 - 975
	560	793	0.71	397 -1587
	866	793	1.09	397 -1587
	552	793	0.70	397 -1587
	685	793	0.86	397 -1587

(a) Individual analyst results reported by REECo.
(b) Value(s) provided by AAR.
(c) Ratio = REECo Result/Reference Value.
(d) REECo reported result was outside program performance limits.

Table 11.3 (AAR Program Interlaboratory Comparison - 1990, cont.)

Analysis and Date	REECo Result[a]	Reference Value[c]	Ratio[b]	Performance Limits[c]
Quantitative Asbestos (cont.)				
06/04/90	210	307	0.68	153 - 614
	236	307	0.77	153 - 614
	185	307	0.60	153 - 614
	351	307	1.14	153 - 614
	111	207	0.54	103 - 414
	92[d]	207	0.44	103 - 414
	110	207	0.53	103 - 414
	165	207	0.80	103 - 414
	335	356	0.94	178 - 711
	264	356	0.74	178 - 711
	264	356	0.74	178 - 711
	322	356	0.90	178 - 711
	453	434	1.04	217 - 869
	298	434	0.69	217 - 869
	292	434	0.67	217 - 869
	408	434	0.94	217 - 869
10/12/90	120	128	0.94	64 - 255
	132	128	1.03	64 - 255
	260[d]	128	2.03	64 - 255
	147	128	1.15	64 - 255
	328	301	1.09	151 - 603
	342	301	1.14	151 - 603
	339	301	1.13	151 - 603
	327	301	1.09	151 - 603
	501	451	1.11	225 - 902
	446	451	0.99	225 - 902
	459	451	1.02	225 - 902
	582	451	1.29	225 - 902
	132	216	0.61	108 - 431
	212	216	0.98	108 - 431
12/05/90	95[d]	216	0.44	108 - 421
	579	537	1.08	268 -1074
	726	537	1.35	268 -1074
	675	537	1.26	268 -1074
	656	537	1.22	268 -1074
	382	480	0.80	240 - 960

(a) Individual analyst results reported by REECo.
(b) Value(s) provided by AAR.
(c) Ratio = REECo Result/Reference Value.
(d) REECo reported result was outside program performance limits.

Table 11.3 (AAR Program Interlaboratory Comparison - 1990, cont.)

Analysis and Date	REECo Result[a]	Reference Value[c]	Ratio[b]	Performance Limits[c]
Quantitative Asbestos (cont.)				
(12/05/90, cont.)	452	480	0.94	240 - 960
	417	480	0.87	240 - 960
	455	480	0.95	240 - 960
	209	295	0.71	147 - 590
	210	295	0.71	147 - 590
	228	295	0.77	147 - 590
	246	295	0.83	147 - 590
	493	403	1.22	201 - 805
	381	403	0.95	201 - 805
	398	403	0.99	201 - 805
	425	403	1.05	201 - 805

(a) Individual analyst results reported by REECo.
(b) Value(s) provided by AAR.
(c) Ratio = REECo Result/Reference Value.

12.0 OFFSITE RADIOLOGICAL QUALITY ASSURANCE

David G. Easterly

The quality assurance program conducted by the Nuclear Radiation Assessment Division (NRD) of the Environmental Monitoring Systems Laboratory, Las Vegas (EMSL-LV), includes standard operating procedures, data quality objectives, data validation, quality control, health physics oversight, and efforts to determine the precision and accuracy of analysis. Duplicate samples were analyzed for the Air Sampling Network (ASN), Noble Gas and Tritium Sampling Network (NGTSN), Dosimetry Network, Milk Sampling Network (MSN), and Long-Term Hydrological Monitoring Program (LTHMP), and the data were used to estimate precision of analysis. The coefficient of variation of replicate samples for these networks varied from a median value of 0.5 percent for the MSN to 17 percent for the LTHMP. The EPA/DOE Environmental Monitoring Laboratory (EML) ratios from the DOE program for 1990 varied from 0.79 to 1.32, indicating good correlation between the two laboratories. The results of participation in the EPA Quality Assurance (QA) Intercomparison Study Program indicated that the analytical procedures were in control.

12.1 POLICY

One of the major goals of the EPA has been to ensure that all EPA decisions that are dependent on environmental data are supported by data of known quality. The policy, initiated by the EPA Administrator in 1979, required participation in a centrally managed QA program by all EPA laboratories and by those monitoring and measurement efforts supported or mandated through contracts, regulations, or other formalized agreements. Further, EPA policy required participation in a QA program by all organizational units involved in environmental data collection. EMSL-LV's QA policies and requirements are summarized in Report EPA/600/X-87/241, Quality Assurance Program Plan (EPA 1987), and were fully adhered to by the EPA NRD in 1990.

12.2 STANDARD OPERATING PROCEDURES

Elements of the QA program include local standard operating procedures (SOPs) which define methods of sample collection, handling, sample control, analysis, data validation, trending, and reporting. These SOPs support the goal of the QA program in maintaining the quality of results within established limits of acceptance and with the primary purpose of assessing the effects of human exposures to radiological hazards in the environment.

The SOPs describe the extent of quality control practices conducted within the radioanalytical laboratory. They describe what activities are to be performed and include complete instructions for preparation and use of control charts, use of spiked samples for accuracy and precision determinations, and other activities used for controlling the quality of data. The SOPs applied to all analytical and data-producing activities of the NRD.

12.3 DATA QUALITY OBJECTIVES

The EPA requires all projects involving environmentally related measurements to

develop data quality objectives (DQOs). DQOs must clearly define the level of uncertainty that a decision maker is willing to accept in results derived from environmental data. DQOs contain quantitative statements relating to the decision to be made, how environmental measurements will be used, time and resource constraints on data collection, descriptions of the data or measurements to be made, specifications of which portions of the physical systems from which samples will be collected, and the calculations that will be performed on the data in order to arrive at a result. The offsite monitoring program has always been operated with DQOs specified, but they were imbedded in various documents prepared by the EMSL-LV and Atomic Energy Commission/DOE. In 1987 formal DQOs were developed for the EMSL-LV and are currently available as a single document. The DQOs for NRD surveillance activities are as follows:

- Measurements of the volume of air, water, and milk samples must be accurate within 10 percent.
- The results of gamma spectrometric analyses must be accurate with no more than a five percent risk of either a false positive or a false negative report.
- Radiochemical analyses must have an uncertainty no greater than 25 percent for results near the minimum detectable concentration (MDC) and no greater than 10 percent for results that are 10 times the MDC.
- The calculation of effective dose equivalents based on all environmental measurements must have an uncertainty no greater than 50 percent for annual exposures at or less than 1 mrem per year and no greater than 10 percent for 5 mrem per year or more.

12.3.1 DECISION TO BE MADE

In connection with nuclear weapons tests at the NTS, there were two questions to be answered, namely; (1) Were radiation exposures of the offsite public from routine operations at the NTS within the radiation exposure standards set by the International Commission on Radiation Protection (ICRP) and adopted by national authorities, and (2) Do radiation exposures of the offsite public from accidental releases of radioactivity from the NTS exceed the Protective Action Guides published by the Food and Drug Administration or the maximum exposure level recommended by the ICRP? The standards addressed by these decisions are shown in Table 12.1.

There are several reference levels specified by DOE Order 5400.6 to be observed. These are:

- All pathways that lead to the following exposures shall be routinely monitored:
  - 1 mrem annual effective dose equivalent to any offsite individual,
  - 100 person-rem annual collective effective dose equivalent per million individuals within 80 kilometers of the site center, or
  - 5 mrem annual whole-body dose equivalent or 15 mrem to the skin of offsite individuals.
- Any exposure to an offsite person of 25 mrem effective dose equivalent in any year shall be reported to DOE Headquarters.
- Unplanned releases of radioactivity shall be monitored and quantified.

All measurements shall be based on statistically significant differences between the point of measurement and the background in the area or suitable control data.

12.3.2 WHY ENVIRONMENTAL DATA WERE NEEDED AND HOW THEY WERE USED

Environmental data were needed so that the pathways for human exposure to radioactivity

Table 12.1 Standards Used to Evaluate Compliance with ICRP and National Authorities

Source	Recipient	Annual Effective Dose Equivalent mrem	mSv
For routine operations, including controlled releases (tunnel purgings and drill-backs):			
All	Offsite person	100	1
Air pathway	Offsite person	10	0.1
Drinking water	Offsite person	4	0.04
For accidental releases of radioactivity:			
All	Offsite person	500	5 [(a)]

(a) Permissible for a few years if the lifetime average does not exceed 100 mrem/y.

could be assessed for possible contribution to total exposure. The pathways to be assessed included inhalation, ingestion, and direct radiation, so air, water, milk, meat, and vegetables as well as external exposures due to penetrating radiation needed to be measured.

These measurements, together with appropriate models and correction factors, could be summed to give an effective dose equivalent for an individual or a critical population. The effective dose equivalent could then be compared with the criteria stated above to estimate the degree of compliance with those criteria.

12.3.3 TIME AND RESOURCES REQUIRED

The resources used in collecting the pertinent environmental data have been negotiated annually. Any restraints were adjusted by decreasing the frequency of sample collection and/or analyses where long-term trends have shown this procedure to be feasible.

12.3.4 DESCRIPTION OF DATA COLLECTED

The data collected were the average annual exposures contributed by each pathway to an individual. For the inhalation pathway, air samples were collected in such a manner that the average annual concentration of radioactive particulates, reactive gases, and tritium could be calculated.

For the ingestion pathway, the concentrations of radionuclides in water, milk, meat, and vegetables need to be measured. The radioisotopes of concern included those of hydrogen, strontium, cesium, and iodine. The capability to detect other radionuclides was also available.

For external exposure measurement of penetrating radiation exposure of individuals and locations which were above natural background had to be made. Whole-body and skin exposure could also have resulted from atmospheric concentrations of radioactive noble gases, so the average annual concentrations of those species needed to be measured.

12.3.5 DOMAIN OF THE DECISION

The environmental data on which a decision regarding compliance had to be made was collected in the area from the boundary of the Nellis Air Force Base Range Complex out to 300 kilometers from that boundary, although the Nuclear Regulatory Commission required only the inclusion of all population centers within 80 kilometers of the NTS center. As a policy, where public concern has been evident, suitable environmental monitoring has been extended as far as is feasible given the equipment and manpower available.

12.3.6 CALCULATIONS TO BE PERFORMED ON THE DATA

For air, water, milk, and food samples, the lower limit of detection (LLD) was calculated from the formula:

$$MDC = 4.65 \cdot K \cdot s_b$$

where K is the proportionality constant relating detector response to the activity concentration in the sample, s_b is the standard deviation of background counts for the instrument and a blank sample, and 4.65 is the factor used when both Type I and Type II errors (alpha and beta) are set at five percent. The MDC for a sample is $3.29 \cdot K \cdot s$, where s is the standard deviation of the sample counts.

For reporting purposes, the actual result obtained was used in the calculation of concentration averages, even if that result was less than the MDC, so that exposure values over time or space could be estimated.

The external exposure data as measured by thermoluminescent dosimeters (TLDs) were compared with environmental background data for each area. The background data were the average and standard deviation obtained for the previous four quarters at a given location. For personnel exposures, the data from the personnel TLDs were compared with the area background also. To determine any net exposure, the data from both the area and the personnel TLDs were compared with the background data using the Student's t test to detect the difference, if any existed.

In the case of atmospheric emissions from the NTS as reported by the DOE, a Gaussian plume dispersion model and the EPA AIRDOSE/RADRISK code were used to calculate exposure to offsite individuals. Effective dose equivalents from inhalation and ingestion of radionuclides were calculated using the methods in ICRP Report 26, with the dose conversion factors given in ICRP Report 30.

12.4 DATA VALIDATION

An essential element of QA is the validation of data. Four categories of data validation methods were employed by the NRD. These include data from procedures that (1) were applied routinely to ensure adherence to acceptable analytical methods, (2) ensure completeness of data was attained, (3) were used to test the internal comparability within a given data set, and (4) were used to compare data sets with historical data and other data sets.

Completeness was the amount of data successfully collected with respect to that amount intended in the design, and comparability refers to the degree of similarity of data from different sources included in a single data set. All data were reviewed by supervisory personnel to ensure that sufficient data have been collected and that the conclusions were based upon valid data.

Completeness is an important part of quality, since missing data could reduce the precision of estimates, introduce bias, and thus lower the level of confidence in the conclusions.

Box-and-whisker plots are used to graphically summarize the main features of a distribution of data values and are used to validate data for all networks. Within a data set, these plots allow the detection of outliers and asymmetric behavior (i.e., they show little or no correspondence of form on the opposite side of a boundary). The box-and-whisker plot allows for closer examination of the data to determine the reason for unusual or out-of-range data. A complete set of box-and-whisker plots for each network appears in the EPA annual report (EPA 1991).

12.5 QUALITY CONTROL

The quality control (QC) portion of the NRD QA program consists of the routine use of methods and procedures designed to achieve and maintain the specified level of quality for the given measurement system. Accuracy of analysis was achieved through the regular determination of bias and precision of the results.

Bias is defined as the difference between the data set mean value (or sample average for statistical purposes) and the true or reference value (EPA 1980). The NRD Laboratory participates in EPA, EML, and World Health Organization (WHO) Laboratory intercomparison cross-check studies. The results of the EPA intercomparison study are discussed later in this section. Blank samples and samples "spiked" with known quantities of radionuclides were also routinely analyzed. Internal "blind spiked" samples (that is, samples spiked with a known quantity of radionuclides but without this information being revealed to the analyzing chemist) were also entered into the normal chain of analysis.

Precision is the degree of mutual agreement among individual measurements made under prescribed conditions (EPA 1980). Approximately five percent of all samples were collected and analyzed in duplicate and the results used for calculating precision.

In addition, instruments were calibrated with standards directly or indirectly traceable to National Institute for Standards and Technology (NIST) or NIST-approved, EPA-generated sources. Performance checks were routinely accomplished, control charts of background and check source data were maintained, and preventive maintenance on equipment was scheduled and performed, generally with manufacturer's maintenance contracts.

12.5.1 MILK SURVEILLANCE NETWORK

Samples were collected from established locations using documented SOPs. Milk samples were delivered to sample control by field monitoring personnel or by U.S. Mail. Samples were accompanied by a sampling report, sample collection tag, and chain-of-custody form.

Upon receipt, milk samples were assigned a unique identification number, the information from the sampling report was keyed into the computer system, and a header sheet was generated. For gamma analysis, 3.5 kilogram samples were weighed into labelled Marinelli beakers. Sample size was verified by a balance which was calibrated using NIST-certified weights. An accuracy of within five percent of the known value met the DQOs.

Gamma spectrometers were efficiency calibrated using NIST-mixed radionuclide sources prepared with the same geometry and matrix as the milk samples.

Analysis was performed with vendor-supplied software to calculate and store an efficiency-versus-energy curve. A daily performance check was completed and control charts prepared using software designed for QA. Analysis of results was accomplished using vendor-supplied software. Results were reviewed by a gamma spectroscopist, and the data were entered onto the computer system. Ten percent of the samples were

reanalyzed as duplicates (replicates). Eight percent of the samples were blanks, three percent were spiked, and one percent were used as a blind. The blind and matrix spectroscopy control limits were 20 percent.

Aliquots for radiochemical analysis of the radiostrontiums also were subjected to sample control procedures as outlined above. Spiked samples were prepared from NIST-traceable materials. Three percent of the samples were blanks, duplicates, or spikes, respectively, while one percent were blanks. Samples were analyzed within three months of collection. Results were accurate within 20 percent. Balances were calibrated annually by the vendor, and the gas flow counter was calibrated annually using NIST-traceable standards. Control charts for the check standard and background were maintained.

If any samples remained after analysis, they were returned to sample control according to chain-of-custody procedures and were stored in a cooler for six months.

12.5.2 BIOASSAY

Bioassay of urine samples for tritium followed sample control procedures similar to that for milk. A minimum of 10 percent of samples were for quality control.

Three percent of samples were blanks, duplicates, and spikes, respectively, and one percent were blinds. The procedure was accurate within ten percent as measured with NIST-traceable spiked samples. The liquid scintillation counter was calibrated annually with NIST-traceable standards as part of the maintenance contract. Check standards and background counts were used for performance checks, and control charts were maintained.

All data were entered onto the computer data base and reviewed for transcription errors and anomalous results. Occasionally, data entered into the permanent data base needed to be corrected to preserve the integrity of the data base and document data changes. In this case a data correction form was prepared and approved by two persons before being submitted to the data base operator.

12.5.3 INTERNAL DOSIMETRY

The whole-body detector was efficiency calibrated annually using a BOMAB phantom containing a NIST-traceable mixed radionuclide source. The lung counter was also calibrated annually with a male realistic lung phantom. A separate set of efficiency calibration data was kept for each combination of sample shape/organ geometry.

All efficiency curves were generated by the vendor whole-body and lung counting software. Daily performance and background routines were completed, and QA software was used to monitor the systems by performing out-of-range tests for predetermined parameters. Results were plotted and reports generated daily and monthly. All data were stored in the computer. Determination of precision was limited by the sample (i.e., human being). Replicate counting of the standard phantom provided a measure of consistency. Replicate counts of blind intercalibration phantoms and of people counted previously in other facilities provided additional measurements of precision and accuracy. Verification and validation were completed before results were entered onto a data base. Calculation of internal dose was accomplished utilizing software based on ICRP-30 methodology. Dose calculation was verified using ICRP and National Council on Radiation Protection and Measurement (NCRP) guidelines. Preventive maintenance and repair of analytical equipment was done by the vendor service representative. Data are retained permanently, and subject confidentiality and data security are maintained through well-established procedures. DOE and EPA QA training was

participated in by whole-body counting personnel.

12.5.4 PRESSURIZED ION CHAMBER NETWORK

External ambient gamma exposure rate measurements made by the pressurized ion chambers (PICs) were validated by calibrating them annually. Weekly checks were made using radioactive sources of a fixed activity. Data and calibration checks were evaluated to detect trends or anomalies. Validated data are summarized and stored in a database.

12.5.5 DOSIMETRY NETWORK

The TLD program for monitoring of exposures to individuals has been fully accredited by the DOE's Laboratory Accreditation Program (DOELAP). Environmental monitoring with TLDs was conducted in accordance with the recommendations of ANSI Standard N545-1975 and U.S. Nuclear Regulatory Commission Regulatory Guide 4.13.

Each field-deployed TLD was processed together with transit and unirradiated background controls and with irradiated reference correction factor (RCF) TLDs. A ^{137}Cs source having a calibrated output traceable to NIST was used. All exposures were verified by simultaneous exposure to a precision ionization chamber having a NIST-traceable calibration. Performance and calibration of the TLD readers were verified by a series of daily QA/QC checks as well as semi-annual system calibration. System calibration verified that the readers were linear in response over the range of 2 to 10,000 mR. Blind performance testing conducted as part of the DOELAP process verified system linearity for X rays, gamma photons, and mixtures.

12.6 HEALTH PHYSICS OVERSIGHT

All analytical results received a final review by the health physics staff of the NRD Dose Assessment Branch for completeness and comparability. Trends of increasing or decreasing amounts of radionuclides in the environment were identified, and potential risks to humans and the environment were determined based on the data.

12.7 PRECISION OF ANALYSIS

The duplicate sampling program was initiated for the purpose of routinely assessing the errors due to sampling, analysis, and counting of samples obtained from the surveillance networks operated by the EMSL-LV. This program consists of analyzing duplicate or replicate samples from the ASN, NGTSN, MSN, LTHMP, and Dosimetry Network. As the radioactivity concentration in samples collected from the LTHMP and the MSN have usually been below detection levels, most duplicate samples for these networks were prepared from spiked solutions. The noble gas samples were generally split to yield two samples for analysis, and duplicate samples were collected in the ASN. Since two TLD cards consisting of three TLD phosphors each were used at each station of the Dosimetry Network, no additional samples were necessary.

At least 30 duplicate samples from each network were normally collected and analyzed over the reporting period. Table 12.2 summarizes the sampling information for each surveillance network. For expressing the precision of measurement in common units, the coefficient of variation ($s/\bar{x}$) was calculated for each sample type. These are displayed in Table 12.3 for those analyses for which there were adequate data (Nelson 1975).

To estimate the precision of counting, approximately ten percent of all samples were counted twice. The results of the first analysis were unknown to the analyst performing the duplicate count. Since all such replicate counting showed results within

the counting error, the precision data in Table 12.3 represent errors in sampling and analysis.

12.8 ACCURACY OF ANALYSIS

Data from the analysis of intercomparison samples were statistically analyzed and compared to known values and values obtained from other participating laboratories. A summary of the statistical analysis is given in Table 12.4, which compares the mean of three replicate analyses with the known value. The normalized deviation is a measure of the accuracy of the analysis when compared to the known concentration. The determination of this parameter was explained in detail in the reference (Jarvis and Siu 1981). If the value of this parameter (in multiples of standard normal deviate) lay between control limits of ±3, the precision or accuracy of the analysis was within normal statistical variation. However, if the parameters exceeded these limits, one suspected that there was some other than normal statistical variation that contributed to the difference between the measured values and the known value. Only two results were outside the control limits as shown in Table 12.4.

The analytical methods were further checked by NRD Laboratory participation in the semiannual DOE Quality Assurance Program conducted by the DOE Environmental Measurements Laboratory, New York, New York. The results from these tests are shown in Table 12.5, and indicated that the NRD Laboratory's results were of acceptable quality.

To measure the performance of the contractor laboratory that analyzed the animal tissues, a known amount of activity was added to several sets of bone as samples. The reported activity was compared to the known amount in the bone ash as shown in Table 12.6, together with the calculated bias and precision. The average bias for $^{239+240}Pu$ was -14 percent,

Table 12.2 Offsite Surveillance QA Samples and Analyses for Duplicate Sampling Program - 1990

Surveillance Network	Number of Sampling Locations	Samples Collected	Sets of Duplicate Samples Collected	Number Per Set	Sample Analysis
ASN	110	2,020	118	2	Gross beta, gamma spectrometry, $^{238,239+240}Pu$
NGTSN	19	837 (^{85}Kr)	-	2	^{85}Kr
		837 (^{133}Xe)	-	2	^{133}Xe
		1,003 (HTO)	4	2	HTO
Dosimetry	133	610	610	6	Effective dose from gamma
MSN	132	403	100	2	^{40}K, $^{89,90}Sr$, ^{3}H
LTHMP	265	1,089	379	2	^{3}H

Table 12.3 Offsite Surveillance QA Sampling and Analytical Precision - 1990

Surveillance Network	Analysis	Sets of Replicate Samples Evaluated	Coefficient of Variation (Percentage)
ASN	Gross Beta	276	9
NGTSN	^{85}Kr	46	8
Dosimetry	TLD	663	22.7[a]
MSN	^{90}Sr	15	1.3
	^{3}H	44	0.5
LTHMP	^{3}H	44	4.1
	^{3}H+ (enriched tritium)	23	17

(a) The too-high error in the program has not yet been found.

and the average bias for ^{90}Sr was -44 percent. The average precision for two sets of liver samples was 7.2 percent for ^{90}Sr. For plutonium, the precision was 29 percent for one pair and 200 percent for the other. The average precision for three sets of liver samples was 66 percent. The percent bias for the spiked samples was determined by subtracting 100 from the average percent of activity recovered. Precision was determined by calculating the coefficient of variation for each pair of values and then averaging.

12.9 LABORATORY QUALITY CONTROL

This section describes the extent of quality control practices conducted within the radioanalytical laboratory. SOPs described what activities were to be performed and included complete instructions for preparations and use of control charts, use of spiked samples for accuracy and precision determinations, and other activities used for controlling the quality of data.

The analytical quality control program is described below to demonstrate that the EMSL-LV Laboratory operated within prescribed requirements for accuracy and precision. These data were used in the preparation of control charts for each type of analysis and appropriately evaluated. The quality control samples were analyzed within the normal sample stream. The intralaboratory quality control samples are summarized in Table 12.5.

A minimum of 10 percent of the work load consisted of QC samples. All of the various QC types were used where possible, but this was not practical for all analyses. Blind samples helped provide independent verification of laboratory operation.

When applicable, method blanks for each analytical procedure were prepared. The

Table 12.4 EPA QA Intercomparison Results - 1990

Analysis	Month	Concentration x 10^{-9} µCi/mL[a] Known Value	Grand Average	Laboratory Average	Normalized Deviation from Known Concentration
Water Studies					
Alpha	January	12.0	11.5	8.3	1.3
	April	90.0	81.2	N/D	N/A
	May	22.0	17.0	N/D	N/A
	September	10.0	10.0	N/D	N/A
	October	62.0	60.6	N/D	N/A
Beta	January	12.0	12.9	13.3	0.5
	April	52.0	49.1	N/D	N/A
	May	15.9	16.2	N/D	N/A
	September	10.0	10.9	N/D	N/A
	October	53.0	50.8	N/D	N/D
^{3}H	February	4976.0	4915.6	5531.0	1.9
	June	2933.0	2066.8	3230.0	1.4
	October	7203.0	7125.1	7281.3	0.2
^{60}Co	February	15.0	15.3	15.3	0.1
	June	24.0	25.1	25.7	0.6
	October	20.0	20.5	20.0	0.0
^{65}Zn	February	139.0	138.9	136.3	0.3
	June	148.0	149.2	157.3	1.1
	October	115.0	116.2	112.3	0.4
^{89}Sr	January	25.0	25.3	22.3	0.9
	April	10.0	9.6	10.7	0.2
	May	7.0	7.6	7.3	0.1
	September	10.0	9.9	8.3	0.6
	October	20.0	18.8	17.3	0.9
	January	20.0	19.2	17.0	3.5[b]
	April	10.0	9.5	8.0	2.3
	May	7.0	7.0	6.3	0.2
	September	9.0	9.3	9.3	0.1

(a) Multiply by 3.7 x 10^{7} to obtain Bq/L.
(b) Analytical results are outside of control limits.

Table 12.4 (EPA QA Intercomparison Results - 1990, cont.)

Analysis	Month	Concentration x 10^{-9} µCi/mL[a] Known Value	Grand Average	Laboratory Average	Normalized Deviation from Known Concentration
Water Studies (cont.)					
(^{90}Sr, cont.)	October	15.0	14.4	12.3	0.9
^{106}Ru	February	139.0	133.6	128.3	1.3
	June	210.0	201.0	193.0	1.4
	October	151.0	140.4	131.3	2.3
^{131}I	August	39.0	40.3	44.3	1.5
^{133}Ba	February	74.0	72.5	76.7	0.7
	June	99.0	96.3	100.0	0.2
	October	110.0	107.7	105.7	0.7
^{134}Cs	February	18.0	17.0	17.0	0.3
	April	15.0	14.4	13.0	0.7
	June	24.0	23.3	22.3	0.6
	October	12.0	11.9	10.7	0.5
	October	7.0	7.5	7.0	0.0
^{137}Cs	February	18.0	18.8	19.0	0.3
	April	15.0	15.8	15.0	0.0
	June	25.0	26.2	26.0	0.3
	October	12.0	13.1	12.0	0.0
	October	5.0	5.9	5.0	0.0
^{226}Ra	March	4.9	5.2	5.7	2.0
	April	5.0	5.0	N/D	N/A
	July	12.1	11.4	N/D	N/A
	October	13.6	12.7	N/D	N/A
	November	7.4	7.1	N/D	N/A
^{228}Ra	March	12.7	12.2	14.7	1.9
	April	10.2	10.4	N/D	N/A
	July	5.1	5.5	N/D	N/A
	October	5.0	5.4	N/D	N/A
	November	7.7	8.1	N/D	N/A

(a) Multiply by 3.7 x 10^7 to obtain Bq/L.
(b) Analytical results are outside of control limits.

Table 12.4 (EPA QA Intercomparison Results - 1990, cont.)

Analysis	Month	Concentration x 10^{-9} µCi/mL[a] Known Value	Grand Average	Laboratory Average	Normalized Deviation from Known Concentration
Water Studies (cont.)					
^{Nat}U	March	4.0	4.2	4.0	0.0
	April	20.0	19.2	20.0	0.0
	July	20.8	19.2	20.9	0.1
	October	10.2	10.1	10.3	0.1
	November	35.5	34.3	33.5	1.0
$^{239+240}Pu$	January	5.6	5.2	4.8	2.4
	August	9.1	8.3	8.9	0.4
Milk Studies					
^{89}Sr	April	23.0	23.1	18.7	1.5
	September	16.0	13.5	12.7	1.2
^{90}Sr	April	23.0	22.3	19.7	1.2
	September	20.0	17.6	18.0	0.7
^{131}I	April	99.0	98.0	98.0	0.2
	September	58.0	58.9	63.3	1.5
^{137}Cs	April	24.0	24.7	25.3	0.5
	September	20.0	21.5	20.3	0.1
Air Filter Studies (pCi/filter)					
Alpha	March	5.0	6.3	6.0	0.3
	August	10.0	12.2	14.0	1.4
Beta	March	31.0	32.2	36.7	2.0
	August	62.0	64.7	80.3	6.4[b]
^{90}Sr	March	10.0	9.7	11.0	1.2
	August	20.0	19.4	18.7	0.5
^{137}Cs	March	10.0	11.6	10.7	0.2
	August	20.0	22.7	22.3	0.8

N/D = Analytical results were not received.
N/A = Not applicable.
(a) Multiply by 3.7 x 10^7 to obtain Bq/L.
(b) Analytical results are outside of control limits.

Table 12.5 QA Results from DOE Program - 1990

Analysis	EPA EMSL-LV Results	EML Results	Ratio EPA/EML
Air			
^{54}Mn	41.9	33.3	1.26
^{57}Co	15.1	11.4	1.32
^{60}Co	28.1	25.4	1.11
^{90}Sr	0.100	0.093	1.08
^{134}Cs	20.7	16.3	1.27
^{137}Cs	19.6	15.7	1.25
^{144}Ce	20.9	16.5	1.27
$^{239+240}Pu$	0.0467	0.0510	0.92
Water			
^{3}H	4430	3900	1.14
^{54}Mn	302	30	1.00
^{57}Co	1350	1300	1.04
^{60}Co	503	491	1.02
^{90}Sr	9.0	9.93	0.91
^{134}Cs	372	355	1.05
^{137}Cs	403	390	1.03
^{144}Ce	908	923	0.98
$^{239+240}Pu$	0.857	1.09	0.79
Total Uranium	0.527	0.480	1.10

blank was carried throughout the entire procedure. The final analyte was prepared exactly the same as the rest of the actual samples and counted accordingly. The NRA Quality Control Program gave special emphasis to blank control whenever blank correction was significant.

Duplicate and blind samples were prepared on a schedule, entered into the sample stream, and analyzed in the exact manner as the regular samples for that particular type of analysis. Blind sample data were evaluated on the basis of the percentage recovery and accuracy.

Matrix spikes were entered into the sample stream and analyzed in the exact manner as the regular samples for that particular type of analysis. Matrix spike sample data were evaluated on the basis of the percentage of recovery.

Control charts provided a graphical means to demonstrate statistical control, monitor a measurement process, diagnose measurement problems, document measurement uncertainty, identify and diagnose instrumental problems, and generally aid in methodology development.

Background control charts were used for controlling the system background of counting instrumentation and determining possible contamination and/or trends. Technicians were responsible for counting a standard check source on a daily basis or before each use. These check sources were counted for a predetermined length of time. The technician recorded this value in a controlled notebook especially designated for this purpose, and the value was plotted on a control chart established for a specific system. Normalized deviation values falling

Table 12.6 QA Results for the Bioenvironmental Program - 1990

Sample ID and Shipment Number (Bone Ash)	Nuclide	Activity Added pCi/g Bone Ash	Activity Reported pCi/g Bone Ash
	Spiked Samples		
Ash-1	$^{239+240}Pu$	0.34	Lost
82	^{90}Sr	2.19	0.9 ± 0.004
Ash-2	$^{239+240}Pu$	0.37	Lost
82	^{90}Sr	2.4	1.6 ± 0.07
Ash-3	$^{239+240}Pu$	0	Lost
82	^{90}Sr	0	0.23 ± 0.003
Ash-4	$^{239+240}Pu$	0	Lost
82	^{90}Sr	0	0.2 ± 0.002
Ash-1	$^{239+240}Pu$	0.35	0.23 ± 0.06
84	^{90}Sr	0	Lost
Ash-2	$^{239+240}Pu$	0	0.0002 ± 0.0015
84	^{90}Sr	1.5	Lost
Ash-3	$^{239+240}Pu$	0	0.002 ± 0.003
84	^{90}Sr	0	Lost
Ash-1	$^{239+240}Pu$	0	Lost
86	^{90}Sr	1.65	1.6 ± 0.06
Ash-2	$^{239+240}Pu$	0	Lost
86	^{90}Sr	2.05	Lost
Ash-3	$^{239+240}Pu$	0.448	0.47 ± 0.08
86	^{90}Sr	0	Lost
Ash-4	$^{239+240}Pu$	0.468	Lost
86	^{90}Sr	0	Lost
Ash-5	$^{239+240}Pu$	0	Lost
86	^{90}Sr	0	Lost

Table 12.6 (Bioenvironmental Program QA, cont.)

Sample ID and Shipment Number	Nuclide	Activity Added pCi/g Bone Ash	Activity Reported pCi/g Bone Ash
	Duplicate Samples		
Bone Cow #2 84	$^{239+240}Pu$	0	$(8 \pm 10) \times 10^{-4}$
	^{90}Sr	0	1.09 ± 0.06
Dup-Bone Cow #2 84	$^{239+240}Pu$	0	$(6 \pm 10) \times 10^{-4}$
	^{90}Sr	0	1.19 ± 0.02
Liver-Cow #2 84	$^{239+240}Pu$	0	$(8.8 \pm 4.6) \times 10^{-3}$
Dup Liver-Cow #2 84	$^{239+240}Pu$	0	$(2.5 \pm 0.5) \times 10^{-2}$
Bone-Cow #5 86	$^{239+240}Pu$	0	$(-3 \pm 7) \times 10^{-4}$
	^{90}Sr	0	0.74 ± 0.45
Dup Bone-Cow #5 86	$^{239+240}Pu$	0	$(1.2 \pm 1.4) \times 10^{-3}$
	^{90}Sr	0	0.70 ± 0.44
Liver-Cow #5 86	$^{239+240}Pu$	0	$(28 \pm 6) \times 10^{-3}$
Dup Liver Cow #5 86	$^{239+240}Pu$	0	$(22 \pm 5) \times 10^{-3}$
Liver - Cow #6 86	$^{239+240}Pu$	0	$(1.9 \pm 2.8) \times 10^{-3}$
Dup Liver-Cow #6 86	$^{239+240}Pu$	0	$(4.3 \pm 2.3) \times 10^{-3}$

outside the upper and lower control limits (± 3s) indicated "outlier" data values. The NRD used 2s and 3s values for corrective action purposes. Indicators for an "out-of-control" situation included:

- One point outside of the 3s limit.
- Two successive points outside of the 2s limit.
- Any consistent trend.

When an out-of-control situation arose, the check source was recounted a minimum of five times to see whether there was a

3/4

problem or the outlier was due to randomness (rare events).

Quality Assurance review was performed on all QC samples using the following method:

- The sample paperwork was reviewed.
- All information was cross-checked for correctness and completeness of data.
- The QC result was evaluated according to the control limits given in the applicable procedure.
- If a QC result was outside of the acceptable limits, the problem was investigated and the impact on other analytical results was determined. Processing of samples was stopped if necessary to resolve the problem.
- If QC results were acceptable, the supervisor signed and dated the listing.

REFERENCES

Anspaugh, L. R., S. C. Black, C. F. Costa, D. R. Elle, E. H. Essington, R. O. Gilbert, D. A. Gonzalez, R. B. Hunter, R. D. McArthur, P. A. Medica, T. P. O'Farrell, S. E. Patton, E. M. Romney, J. H. Shinn, and C. B. Thompson, 1990, "Radiation-Related Monitoring and Environmental Research at the Nevada Test Site," Environmental Monitoring, Restoration, and Assessment: What Have We Learned?, R. Gray ed., Twenty-Eighth Hanford Symposium on Health and the Environment, Pacific Northwest Laboratory, Richland, Washington.

Beck, H. L., 1972, Environmental Radiation Fields, Health and Safety Laboratory, U.S. Atomic Energy Commission, New York, New York.

Blankennagel, R. K. and J. E. Weir, 1973, "Geohydrology of the Eastern part of Pahute Mesa, Nevada Test Site, Nye County, Nevada," U.S. Geological Survey Professional Paper 712-B.

Committee on the Biological Effects of Ionizing Radiations (BEIR), 1980, The Effects on Populations of Exposure to Low Levels of Ionizing Radiation: 1980, available from National Academy Press, 2101 Constitution Ave, N.W., Washington, D.C. 20418.

Engineering-Science, 1990, "Project Report of Air Quality Study at the Nevada Test Site, Mercury, Nevada," PE192.05, November 1990.

Freund, J. E., 1962, Mathematical Statistics, Prentice Hall, Englewood, New Jersey, pp. 189-235.

Gilbert, R. O., D. W. Engel, and L. R. Anspaugh, 1989, "Transfer of Aged $^{239+240}$Pu, ^{238}Pu, ^{241}Am, and ^{137}Cs to Cattle Grazing a Contaminated Arid Environment," The Science of the Total Environment, 85:53-62.

Gonzalez, D. A., 1988, Onsite Environmental Report for the Nevada Test Site, (January 1987 through December 1987), Nevada Operations Office Report DOE/NV/10327-39.

Jarvis, A. N., and L. Siu, 1981, Environmental Radioactivity Laboratory Intercomparison Studies Program - FY 1981-82, EPA-600/4-81-004, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, Nevada.

Kercher, J. R., and L. R. Anspaugh, 1989, "Analysis of the Nevada-Applied-Ecology-Group Model of Transuranic Radionuclide Transport and Dose," Journal of Environmental Radioactivity (in press), UCRL-91781, Rev. 2, Preprint.

McArthur, R. D., 1990, Radionuclides in Surface Soil at the Nevada Test Site, draft report DOE/NV/10845-02, Water Resources Center, Desert Research Institute, University of Nevada, Las Vegas, Nevada.

National Council on Radiation Protection and Measurement (NCRP), 1989, "Screening Techniques for Determining Compliance with Environmental Standards: Releases of Radionuclides to the Atmosphere," NCRP Commentary No. 3.

Nelson, L. S. J., 1975, Qual. Tech. 7 (1), January.

References cont.

Norman, F. V. C., 1969, "Archaeological Investigations at the U.S. Atomic Energy Commission's Nevada Test Site and Nuclear Rocket Development Station," Los Alamos Scientific Laboratory Report, LA-4125.

O'Farrell, T. P., and L. A. Emery, 1976, Ecology of the Nevada Test Site: A Narrative Summary and Annotated Bibliography, Desert Research Institute, U.S. Department of Energy, NVO-167.

Russell, C. E., 1990, "Assessment of the Nevada Test Site Monitoring Well System," Water Resources Center, Desert Research Institute, University of Nevada, Las Vegas, Nevada.

Sanderson, C. G., and S. C. Scarpitta, 1990, Environmental Measurements Laboratory, Semi-Annual Department of Energy Quality Assessment Program Report, Report #EML-530, U.S. Department of Energy, New York, New York.

Sanderson, C. G., and S. C. Scarpitta, 1991, Environmental Measurements Laboratory, Semi-Annual Department of Energy Quality Assessment Program Report, Report #EML-535, U.S. Department of Energy, New York, New York.

Schulz, R. K., E. M. Romney, E. W. Kendall, R. B. Hunter, L. M. Fujii, and P. D. Greger, 1990, Tritium Migration Studies at the Nevada Test Site, Nevada Operations Office Draft Report DOE/NV-345.

Scoggins, W. A., 1983, Environmental Surveillance Report for the Nevada Test Site, January 1982 through December 1982, DOE/NVO-410-76, Reynolds Electrical & Engineering Co., Inc., Las Vegas, Nevada.

Scoggins, W. A., 1984, Environmental Surveillance Report for the Nevada Test Site, January 1983 through December 1983, DOE/NVO-10327-4, Reynolds Electrical & Engineering Co., Inc., Las Vegas, Nevada.

Seber, G. A. F., 1982, The Estimation of Animal Abundance and Related Parameters, Second Edition, Macmillan, New York.

Shinn, J. H., D. N. Homan, and C. B. Hoffmann, 1986, A Summary of Plutonium Aerosol Studies: Resuspension at the Nevada Test Site, UCRL-90746, Lawrence Livermore National Laboratory, Livermore, California, Preprint.

Shinn, J. H., E. H. Essington, F. L. Miller, T. P. O'Farrell, J. A. Orcutt, E. M. Romney, J. W. Shugart, and E. R. Sorom, 1989, "Results of a Cleanup and Treatment Test at the Nevada Test Site: Evaluation of Vacuum Removal of Pu-Contaminated Soil," Health Physics 57:771-779.

Snedecor, G. W., and W. G. Cochran, 1967, Statistical Methods, The Iowa State University Press, Ames, Iowa, 6th Ed. 1967, pp. 39-47.

Thordarson, W., 1965, "Perched Ground Water in Zeolitized Bedded Tuff, Rainier Mesa and Vicinity, Nevada Test Site," U.S. Geological Survey Open-File Report TEI-862.

U.S. Department of Commerce (DOC), 1990, Population Count Pursuant to Public Law 94-171, Bureau of Census.

U.S. Department of Energy (DOE), 1991, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance, DOE/EH-0173T.

U.S. Department of Energy (DOE), 1990, Nevada Test Site Annual Site Environmental Report - 1989, DOE/NV10630-11, Nevada Operations Office, Las Vegas, Nevada.

U.S. Department of Energy (DOE), 1988, "Unclassified Computer Security Program," DOE Order 1360.2A.

U.S. Department of Energy (DOE), 1990, "Occurrence Reporting and Processing of Operations Information," DOE Order 5000.3A.

U.S. Department of Energy (DOE), 1990, "General Environmental Protection Program," DOE Order 5400.1.

U.S. Department of Energy (DOE), 1990, "Radiation Protection of the Public and the Environment," DOE Order 5400.5.

U.S. Department of Energy (DOE), 1990, "Environmental Protection, Safety, and Health Protection Program for DOE Operations," DOE Order 5480.1B.

U.S. Department of Energy (DOE), 1990, "Radiation Protection for Occupational Workers," DOE Order 5480.11.

U.S. Department of Energy (DOE), 1990, "Environmental Protection, Safety, and Health Protection Information Reporting Requirements," DOE Order 5484.1.

U.S. Department of Energy (DOE), 1988, "Radioactive Waste Management," DOE Order 5820.2A.

U.S. Energy Research and Development Administration (ERDA), 1977, Final Environmental Impact Statement, Nye County, Nevada, Nevada Operations Office, Las Vegas, Report ERDA-1551, available from the U.S. Department of Commerce, NTIS, Springfield, VA 22161.

U.S. Environmental Protection Agency (EPA), 1980, Upgrading Environmental Radiation Data, Health Physics Society Committee Report HPSR-1, EPA 520/1-80-012, U.S. Environmental Protection Agency, Washington, D.C.

U.S. Environmental Protection Agency (EPA), 1987, Quality Assurance Program Plan, EPA/600/X-87/241, EMSL-LV, P.O. Box 93478, Las Vegas, Nevada 89193-3478.

U.S. Environmental Protection Agency (EPA), 1991, Offsite Environmental Monitoring Report, Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1990, DRAFT.

5453

References cont.

Winograd, I. J., and W. Thordarson, 1975, Hydrogeologic and Hydrochemical Framework, South-Central Great Basin, Nevada-California, with Special Reference to the Nevada Test Site, U.S. Geological Survey Professional Paper 712-c, U.S. Government Printing Office, Washington, D.C., 1975.

319