SAIC-87/8000
DOE/NV-10576-6

SAIC-87/8000
DOE/NV-10576-6

U.S. DEPARTMENT OF ENERGY
OCRWM
OGR

Nevada
Nuclear Waste
Storage Investigations Project

RADIOLOGICAL MONITORING PLAN FOR THE NNWSI PROJECT

VOLUME I

NNWSI/88-14

UNCONTROLLED

MARCH 1988

Nevada Operations Office

UNITED STATES DEPARTMENT OF ENERGY

9007120239 PART 1

Rev. 0

RADIOLOGICAL MONITORING PLAN
FOR THE NNWSI PROJECT

UNCONTROLLED

This document was prepared by:

S. W. Woolfolk and J. K. Prince of the T&MSS Contractor (SAIC) to the DOE NNWSI Project with support from:

C. Costa	U.S. EPA/NRAD
J. Pagliaro	U.S. EPA/NRAD
S. Black	U.S. EPA/NRAD
C. Liu	U.S. EPA/NRAD
D. Thome´	U.S. EPA/NRAD
N. Sunderland	U.S. EPA/NRAD
L. Smith	U.S. EPA/NRAD
F. Grossman	U.S. EPA/NRAD
A. Jarvis	U.S. EPA/NRAD
E. Collins	EG&G/EM
C. Wills	EG&G/EM
T. O'Farrell	EG&G/EM
G. Daer	SAIC/T&MSS
A. Colarusso	SAIC/T&MSS
R. Bellanger	SAIC/Campus Point
L. Fairobent	SAIC/McLean
and technical editing by	
C. Weiss	SAIC/T&MSS

as part of DOE Contract Number DE-AC08-87NV10576.

Approved by:

William V. Macnott — March 31, 1988
Technical and Management Support Services Contractor Project Manager — Date

Charles F. Costa — March 31, 1988
Nuclear Radiation Assessment Division, U.S. EPA/LV Director — Date

Peter K. Fitzsimmons — 4/18/88
Health Physics and Environmental Division, U.S. DOE/NV Manager — Date

5/25/88
Waste Management Project Office, U.S. DOE/NV Project Manager — Date

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF TABLES

LIST OF TABLES (continued)

EXECUTIVE SUMMARY

The Radiological Monitoring Plan (RMP) provides a detailed description of the radiological monitoring activities to be performed during site characterization of the Yucca Mountain site in southern Nevada. Radiological monitoring activities for all Nevada Nuclear Waste Storage Investigations (NNWSI) Project phases through site closure will be detailed in subsequent revisions of the document (six revisions are currently planned).

The RMP is the controlling document for the implementation of the Technical and Management Support Services (T&MSS) Contractor's radiological monitoring activities in support of the NNWSI Project. The document replaces the Preliminary Site Characterization Radiological Monitoring Plan (PSCRMP), which addressed a few aspects of those radiological monitoring activities requiring early implementation. The RMP describes the collection of required radiological data identified in the Radiological Compliance Guide (RCG), Site Characterization Plan (SCP), (DOE, 1986b), Environmental Program Plan (EPP), and other Project documents. Procedures are issued as part of a controlled procedure manual, which is maintained in an updated, audited form by each user. The RMP complies with the requirements of the Waste Management Project Office (WMPO) Quality Assurance Program Plan (QAPP) and supporting documents, including NNWSI Project and T&MSS administrative procedures.

THE RADIOLOGICAL MONITORING PROGRAM

The RMP (Rev. 0) represents a blueprint for the radiological monitoring program during the site characterization phase. The proposed monitoring program (as detailed in Section 4 of the RMP) will collect environmental radiological information to establish existing radiological conditions and satisfy eight basic objectives:

Characterization of the worksite environment. This element will involve determining the existing radioactivity concentrations in the background environment at the site and the potential radon emission from the site. These activities are underway as described in the PSCRMP.

Characterization of the radiological impact of Nevada Test Site (NTS) activities on the repository site. This element will involve determination of ambient airborne radionuclide concentrations in the Yucca Mountain area, evaluation of radioactivity concentrations in the groundwater, performance of soil and driftwall sampling in surface and underground work areas, biota sampling, and surface and sedimentation analyses of the Fortymile Canyon/Wash ephemeral stream.

Facility design and preparation of the Safety Analysis Report. This element will require ambient radiation data, radon exposure data, and soil and driftwall sampling data. Results from evaluation of these data will be used in the design of the facility's ventilation system, airborne radioactivity monitoring systems, and safety analysis activities.

Monitoring of site characterization impacts. This element will include soil sampling, water sampling, and radon monitoring.

Verification of the feasibility of monitoring the environment for appropriate radionuclides. This element will involve quantification of existing conditions at the site using various environmental samples and an indicator species. An indicator species is an animal which can be used to indicate the presence or absence of unsuspected sources of radioactivity (release pathways).

Planning of facility decontamination and decommissioning. This element will involve soil, biota, and water sampling. Archiving of these samples in the Sample Management Facility will be required.

Verification of compliance with DOE Orders and NTS requirements during site characterization. The program will monitor water samples for tritium. Soil columns will not be used to remove radioactive material from liquids. Groundwater characteristics will be verified as safe before release of any such water to the surface-water system.

Preparation of the Environmental Impact Statement (EIS). Specific data and collection activities for the EIS will be identified during the EIS scoping process. Data collected for site characterization activities will also be used to supplement the data collected specifically for the EIS radiological baseline.

The radiological monitoring program will evaluate various wa's in which an individual can be exposed to radioactivity (exposure pathways to man): direct exposure to radiation, inhalation of resuspended (or airborne) radioactive particulates, worker and equipment contamination, and indirect pathways (such as ingestion of contaminated foodstuffs or fauna). The program will gather environmental radiological data to satisfy these evaluation needs as well as many others. Approximately six years are needed to establish an environmental data base (barring unplanned releases at the NTS). Characterization of the radon baseline requires much less time: two years of data collection are desirable, but only one year of data may be collected because of Project schedule constraints.

The radiological monitoring program's sampling activities are directed toward monitoring release pathways and the exposure pathways to man in two areas: a circular area measuring 168-kilometers across and centered on Yucca Mountain (the program sampling area), and the City of Las Vegas. This arrangement meets all regulations and requirements for model pathways. There are five basic types of sampling described in the RMP: airborne monitoring, water sampling, soil and drift surface sampling, biota sampling, and ambient radiation monitoring.

Airborne monitoring. Airborne monitoring is the foundation of the radiological monitoring program activities and involves the monitoring of radioactive particulates, radioiodine, tritium, and inert gases. These four categories account for most of the radioactive materials released from any site. C-14 (CO_2) will also be monitored. Air sampling will be conducted to evaluate potential doses to offsite inhabitants from inhaled radionuclides, direct radiation, or ingestion of contaminants. Both far-field (beyond a

15-kilometer radius of the site) and near-field (within a 15-kilometer radius of the site) air samplers will be used. Radon/radon daughter product sampling activities will be restricted to the near-field area. Only seven new far-field stations are being added to the current NTS network; data from existing U.S. Environmental Protection Agency (EPA) stations will be used, and NNWSI Project stations will be installed at some existing Reynolds Electrical and Engineering Co. (REECo) air sampler locations. Data from the REECo air monitoring program will also be available.

Particulate sample analyses will be performed by the EPA Nuclear Radiation Assessment Division (NRAD) Laboratory. For tritium and inert-gas (non-radon) sampling, equipment both currently in use and being evaluated by the NRAD will be used by the radiological monitoring program. The tritium and inert-gas samples will also be analyzed by the NRAD Laboratory. Radon monitoring will involve the used of time-integrating samplers supplemented by continuous radon monitors. The radon monitoring network is intended to establish a baseline and measure the future changes in the radon levels near the exploratory shaft. Underground air in the main drifts and near the working face will be sampled for radon and its daughter products. The monitoring of CO_2 will be based on the C-14 content in flora.

Water sampling. In general, the principal exposure pathways from waterborne radionuclides to individuals are ingestion of drinking water and consumption of aquatic species or irrigated crops. Potential water pathways at Yucca Mountain include ephemeral streams, catch basins, groundwater, airborne deposition to the Amargosa River or streams, and reservoirs or ponds supplied from groundwater sources.

Surface-water samples will be collected routinely at a representative unaffected control location to provide background data for comparison with data from affected locations. Ephemeral stream samples will be collected at four stations located in Fortymile Wash just east of Yucca Mountain. Water sampling will rely to a large extent on existing EPA water samplers and locations. A representative sampling of water from catch basins within the near-field will be made, and sediment samples will be taken at all surface-water and ephemeral stream locations.

Grab samples of drinking water will be collected from nearby communities. Lake Mead water will be included in this activity and is currently being sampled by the NRAD. EPA water sampling data available for several sampling locations will be also be used.

Monitoring of groundwater will be conducted near the proposed repository facility and in areas downgradient from other facilities or activities. To facilitate the assessment of potential sources of radionuclides, at least two wells will be selected for evaluation. Where available, existing NNWSI Project and NTS wells and planned NNWSI Project wells will be used. Water samples will be obtained (if possible) from U.S. Geological Survey (USGS) or other test wells in the near-field area as they become available. Most of the near-field samples will be archived.

Surface-water samples will be taken from beneath the water surface to avoid floating debris, while ephemeral streams will be sampled by installing a large-volume passive container in the stream bed. Sediment samples from surface-water sampling locations will be usually be collected using hand-held equipment or a core sampler.

Water typically will be sampled annually. Sediment samples also will be taken annually, following the first significant waterflow in the spring. Ephemeral stream sampling will be conducted each time a significant waterflow occurs in the stream being evaluated.

Soil and drift surface sampling. Soil sampling will be used to assess deposition of radionuclides from site activities, evaluate the long-term accumulation trends of radionuclides, and estimate environmental radionuclide inventories. Soil samples will be collected at air sampling locations, and a set of representative samples will be taken throughout the indicator species sampling area. The latter will allow characterization of the conditions to which the indicator species is exposed. Representative soil samples will be taken from all environmental sampling locations and areas where major activities are planned. These samples will be archived for possible use in future evaluations or activities. An annual sampling frequency is planned to assess long-term trends.

Driftwall samples are directed towards characterizing natural radon emissions. During underground mining and operation, driftwall sampling will be used to characterize the uranium and thorium sources which produce the radon/radon daughter products emanating from the mine.

Biota sampling. Biota sampling involves sampling of milk, crops, game, and animal produce from livestock. These samples provide the most direct means for assessing the radiation dose to man from ingestion of contaminants (the food pathways to man). Many details of the biota sampling activities cannot be presented until a detailed survey is conducted of the agricultural and cultural activities within the program sampling area. This information will be collected over the next two years. For now, the biota samples collected in the program will include the indicator species and items representing both direct and indirect pathways to man.

Direct pathways to man are represented by food items. Sampling may include milk, crops intended for human consumption, beef, poultry, and eggs. Milk sampling of all dairy cattle herds in the sampling area is already performed by the NRAD for the NTS. Data from the NRAD program should be sufficient for the radiological monitoring program. To monitor iodine-129, cattle thyroids will be collected each fall when grazing activities end. Crop samples will include those produced for human consumption as well as for livestock feed. Meat, poultry, and egg samples may be obtained from commercial producers and local family farms. Domestic animal produce will be sampled annually at the time of the slaughter or harvest. Poultry and eggs may be sampled quarterly. Field surveys of game bird species will be conducted quarterly.

Indirect pathways to man include cattle and deer forage. Native cattle forage samples will be taken from eight locations established on lands where cattle are grazed within the program sampling area. Three forage species will be chosen for monitoring. Three samples from each species will be collected at each location. A total of 72 samples will be collected over a two-year period. Cattle forage sampling will not be initiated before 1989.

The food habits of mule deer will be studied by analyzing scat samples collected from Yucca Mountain. Results will determine which deer forage species should be collected for analysis. Three forage species will be chosen for monitoring. Three samples from each species will be collected at twenty designated sampling locations. All twenty locations will be sampled at least twice during the site characterization phase.

Indicator species assist in detecting inadvertent releases of radioactivity and in monitoring any long-term radionuclide accumulation in the local environment. Small mammals (mice and rats) will be used by the radiological monitoring program as indicators of radionuclide concentrations in the biosphere. Merriam's kangaroo rat and the long-tailed pocket mouse are the designated indicator species for the program because they are typically the two most abundant and ubiquitous small mammal species on Yucca Mountain. Eight small mammal monitoring locations will be established in the vicinity of Yucca Mountain. At each location, trap lines will be arranged. The trap lines will be operated four times a year. Samples for radioanalysis will be collected two of the four times. The other two times, animals will only be marked. Lagomorphs (rabbits) were not included as an integral part of the radiological monitoring program because of their relative rarity on Yucca Mountain; however, systematic transect surveys will be conducted semiannually to collect data which will enable the program to determine when population densities are sufficient to permit sampling. To evaluate the feasibility of incorporating predators (coyotes, bobcats, etc.) into the program, scent-station surveys assessing the presence, relative abundance, and general distribution of predators will be performed four times a year.

Ambient radiation monitoring. Ambient radiation monitoring involves the monitoring of external radiation exposures. The radiological monitoring program will use integrating dosimeters, specifically thermoluminescent dosimeters (TLDs), to monitor any incremental changes in external radiation doses to key population groups in the program sampling area. The dosimeters will be placed at all environmental sampling stations. In addition to these locations, other TLD locations have been added to provide an accurate representation of current site conditions. Where TLDs are used, at least three will be provided for each location to permit averaging of the data and detection of faulty dosimeters. Quarterly exchange periods are planned. Various exposure rate instruments will also be used for continuous monitoring of the exposure rate as a function of time. An Aerial Measurements System (AMS) aerial survey is also being arranged for the Yucca Mountain area. An AMS survey provides detailed data analysis of gamma radiation levels in and around nuclear facilities. The AMS is operated for the DOE by EG&G, Inc. In situ gamma spectral analyses at most sampling locations will also be included as part of the ambient radiation monitoring of the radiological monitoring program. Current data from the NTS public monitoring program will also be available for the ambient radiation monitoring activity.

Other aspects of the radiological monitoring program's monitoring and data-gathering activities--the rules and regulations involved in their development; the assessment methodologies used to understand and categorize their data; the quality assurance procedures followed to ensure their accuracy and validity--are detailed in other sections of the RMP.

The primary participants in the radiological monitoring program will be the DOE Nevada Operations Office (DOE/NV) Waste Management Project Office (WMPO), the EPA NRAD, and the T&MSS Contractor (Science Applications International Corporation). Other involved groups will include the DOE/NV Health Physics and Environmental Division, EG&G/Energy Measurements (Santa Barbara Operations), the EPA Office of Radiation Programs, REECo, DOE/NV, and the State of Nevada. All activities in the program will have the approval of the WMPO and the concurrence of the DOE/NV.

ORGANIZATION OF THE RADIOLOGICAL MONITORING PLAN

The RMP has eight major parts (Figure 1-2) and eleven appendices. Section 1 provides introductory remarks and establishes the framework of the document. Section 2 provides a general discussion of the regulatory and control framework for the document. Section 3 provides a detailed discussion of the technical requirements and guidance mandating completion of the radiological monitoring activities discussed in the document. The manner in which the document implements data collection in support of issue resolution for the issues hierarchy as discussed in the SCP and the EPP is also addressed in Section 3. Section 4 provides details of the radiological monitoring activities and the activities relate to the requirements in Section 3. Section 5 sets forth the radiological analytical techniques used in collection of data for resolution of the issues in the issues hierarchy. Section 5 also addresses how these techniques fit within the regulatory framework described in Sections 2 and 3. Section 6 identifies non-monitoring data required to support resolution of the issues and discusses how these data will be collected. Section 7 addresses quality assurance, and Sections 8 and 9 address administrative concerns and their resolution within the program. Appendix A provides a description of NNWSI Project activities. Appendices B through G provide supplementary technical data, with Appendix E containing a tabular summary of the environmental monitoring program. Appendix H describes other plans which provide data to this program. Appendix I contains a listing of acronyms and abbreviations. Appendix J contains a glossary for the text, and Appendix K lists any changes made in the field monitoring activities.

1.0 INTRODUCTION AND PLAN SUMMARY

1.1 INTRODUCTION

The U.S. Department of Energy (DOE) is responsible for developing the Nation's first geologic repository for permanent disposal of high-level radioactive waste and spent nuclear fuel. The Nuclear Waste Policy Act (NWPA) of 1982 specifies the process for selecting a repository site and assigns primary responsibility for site selection and repository design, construction, and operation to DOE. Following the step-by-step process set forth in the original NWPA, the Secretary of Energy recommended three sites for extensive study ("site characterization"). On May 28, 1986, the President approved the Secretary's recommendations, establishing Yucca Mountain, Nevada, as one of the three sites to be characterized. In December 1987, Congress amended the NWPA to specify that Yucca Mountain would be studied to determine whether it meets stringent standards for isolating radionuclides. All site-specific activities at the other two sites were dicontinued at that time.

The Nevada Nuclear Waste Storage Investigations (NNWSI) Project is guided by the DOE's Office of Civilian Radioactive Waste Management (OCRWM) and is managed locally by DOE's Nevada Operations Office (DOE/NV). The Project Office and support contractors are conducting earth science and environmental studies of Yucca Mountain during site characterization as well as studying potential effects of the Project on the region near the site. This site characterization phase is scheduled to continue through the early 1990's. When testing is complete and if the site is found suitable, the Secretary will seek Presidential approval to submit an application to construct a repository to the Nuclear Regulatory Commission (NRC). The NRC then will decide whether the proposed site meets strict Federal regulations that prohibit a repository from posing a threat to the environment. If the NRC approves, the repository construction can begin.

If Yucca Mountain is (1) determined to be suitable by the DOE, (2) approved by the President, and (3) licensed by the NRC, then the Nevada Nuclear Waste Storage Investigations (NNWSI) Project will oversee the eight phases for the site. The eight phases (Figure 1-1) overlap in some cases and are composed of

1. Site selection (selection of sites for further characterization; completed May 28, 1986).

2. Site characterization.

3. Data gathering for preparation of the Environmental Impact Statement (EIS).

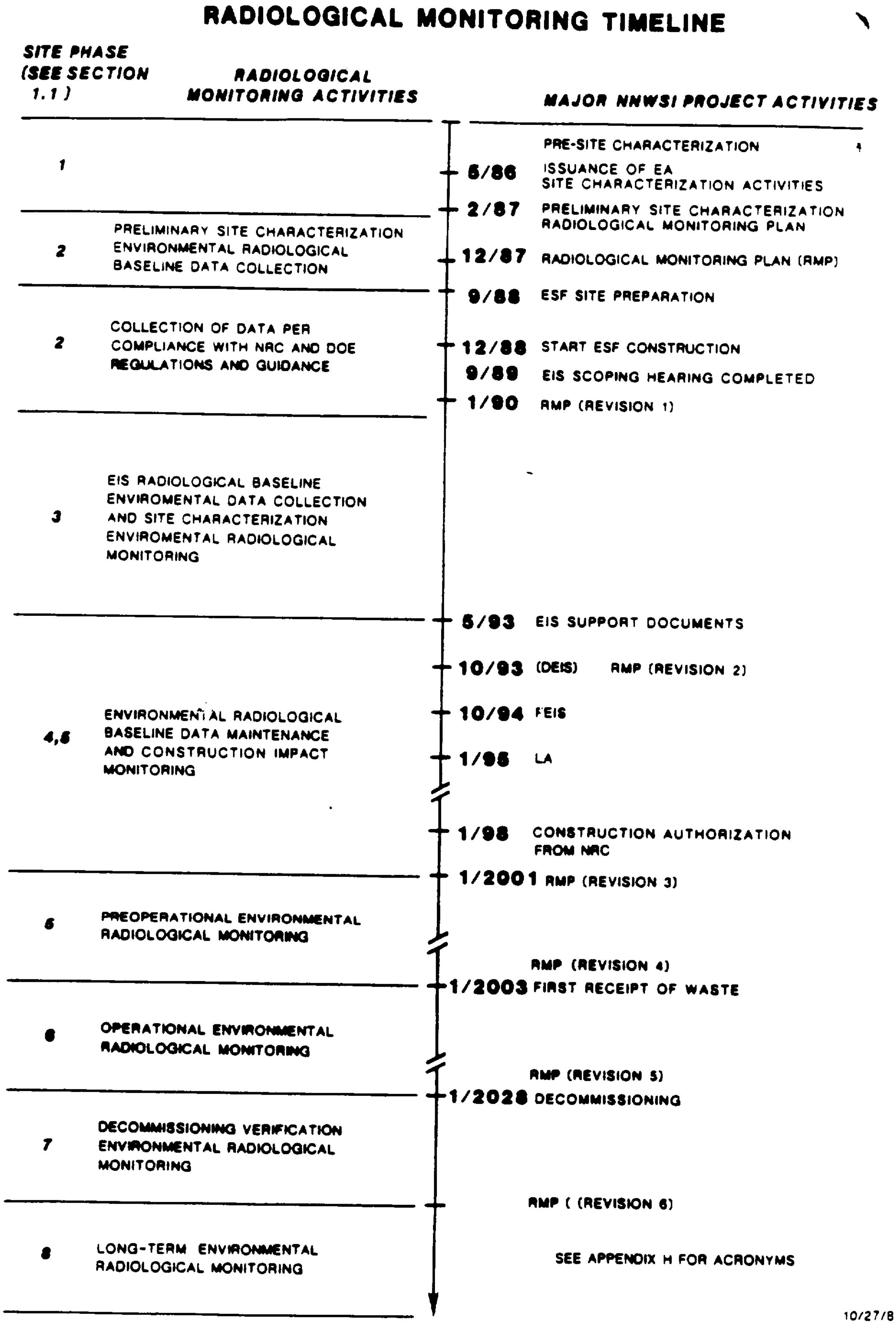


Figure 1-1. Radiological monitoring timeline.

4. EIS preparation and review (the NNWSI Project provides technical input to an Office of Civilian Radioactive Waste Management (OCRWM) contractor who will prepare the EIS) and Safety Analysis Report (SAR) preparation and review.

5. Construction authorization/Construction.

6. License to receive and possess/Operation.

7. Permanent closure and decommissioning.

8. Postclosure monitoring.

Details of the NNWSI Project activities are discussed in Appendix A.

To allow proper planning, the Radiological Monitoring Plan (RMP) addresses monitoring for all Project phases through site closure. During these phases, it is important to ensure compliance with applicable regulations, monitor the impacts of NNWSI Project activities, and gather data required by the NNWSI program. The environmental radiological monitoring activities necessary to support the phases of the NNWSI Project are summarized in Figure 1-1. Figure 1-1 depicts the major emphasis of RMP activities expected to occur during the eight Project phases noted above. Because of the uncertainty associated with the requirements that may be applied to future phases of the Project, the activities detailed in this revision of the RMP emphasize the site characterization phase. The RMP is a dynamic document with regular revisions planned to accommodate the various phases of the Project, and nonroutine revisions as necessary. Revisions will use the project which is available at the time of the revision. It should not be assumed that this document indicates the final outcome of the repository selection process. If the Yucca Mountain site is not licensed as the repository site, Phases 5, 6, and 8 will be eliminated (since they will not occur) and the schedule shortened.

The RMP describes the activities to collect data on the existing radiological environment in the Yucca Mountain area and to monitor any changes in these conditions as a function of time. It should be emphasised that neither radiological monitoring nor site characterisation activities will introduce radioactive waste into the Yucca Mountain environment. The only radioactive materials associated with radiological monitoring--and not already present in the environment--are contained radioactive sources which will be used for calibration or accuracy checking of instruments. These sources:

1. Contain extremely small quantities of radioactive material.

2. Are present in limited number.

3. Are carefully controlled by the T&MSS Radiological Field Programs Branch.

4. Must be disposed of at an authorised radioactive waste disposal site when no longer needed and, thus, will not remain at Yucca Mountain.

Other than these radiation sources used during the radiological monitoring activities described in this document, the only radioactive material which will be used at the site are part of activities commonly used in the mining, drilling, and construction industries. A few examples of the types of radioactive materials which might be present are standard well-logging instrumentation, hydrogeological tracers, weld analysis (non-destructive) radiographic equipment, and others.

The NNWSI Project does not plan to introduce radioactive waste into the Yucca Mountain area unless a license to operate the facility has been granted by the NRC (projected to be after 1998) and the DOE is fully satisfied with the adequacy of any facility constructed.

The RMP is the controlling document for the implementation of the Technical and Management Support Services (T&MSS) Contractor radiological monitoring activities in support of the NNWSI Project. This document replaces the Preliminary Site Characterization Radiological Monitoring Plan (PSCRMP), which addressed a few aspects of the RMP activities which required early implementation. The RMP describes the collection of required radiological data identified in the Radiological Compliance Guide (RCG), Site Characterization Plan (SCP) (DOE, 1988b), Environmental Program Plan (EPP), and other Project documents. Also included are the activities required by the PSCRMP. Detailed procedures are addressed in the Environmental Radiological Monitoring Technical Procedure Manual and its supporting appendices. The RMP complies with the requirements of the Waste Management Project Office (WMPO) Quality Assurance Program Plan (QAPP) and supporting documents, as well as with applicable NNWSI Project and T&MSS administrative procedures.

The RMP identifies and defines the control procedures for the radiological monitoring activities. The procedures are prepared as described in the Environmental Radiological Monitoring Technical Procedure Manual, Procedure BTP-ER-001. T&MSS issues the branch technical procedures as part of the controlled procedure manual, which is maintained in an updated, audited form by each user.

The monitoring equipment for the RMP will be owned by the DOE and operated either by Science Applications International Corporation (SAIC) under the SAIC T&MSS contract for the NNWSI Project, or by the Nuclear Radiation Assessment Division (NRAD) of the U.S. Environmental Protection Agency (EPA) in Las Vegas under an interagency agreement with the NNWSI Project through the Nevada Operations Office of the DOE (DOE/NV). Laboratory support to the RMP program will be provided by NRAD personnel in Las Vegas, Nevada.

1.2 PLAN SUMMARY

The RMP has eight major parts (Figure 1-2). Section 1 provides introductory remarks and establishes the framework of the document. Section 2 provides a general discussion of the regulatory and control framework for the document. Section 3 provides a detailed discussion of the technical requirements and guidance mandating completion of the activities discussed in the document. The manner in which the document implements data collection in support of issue resolution for the issues hierarchy as discussed in the Site

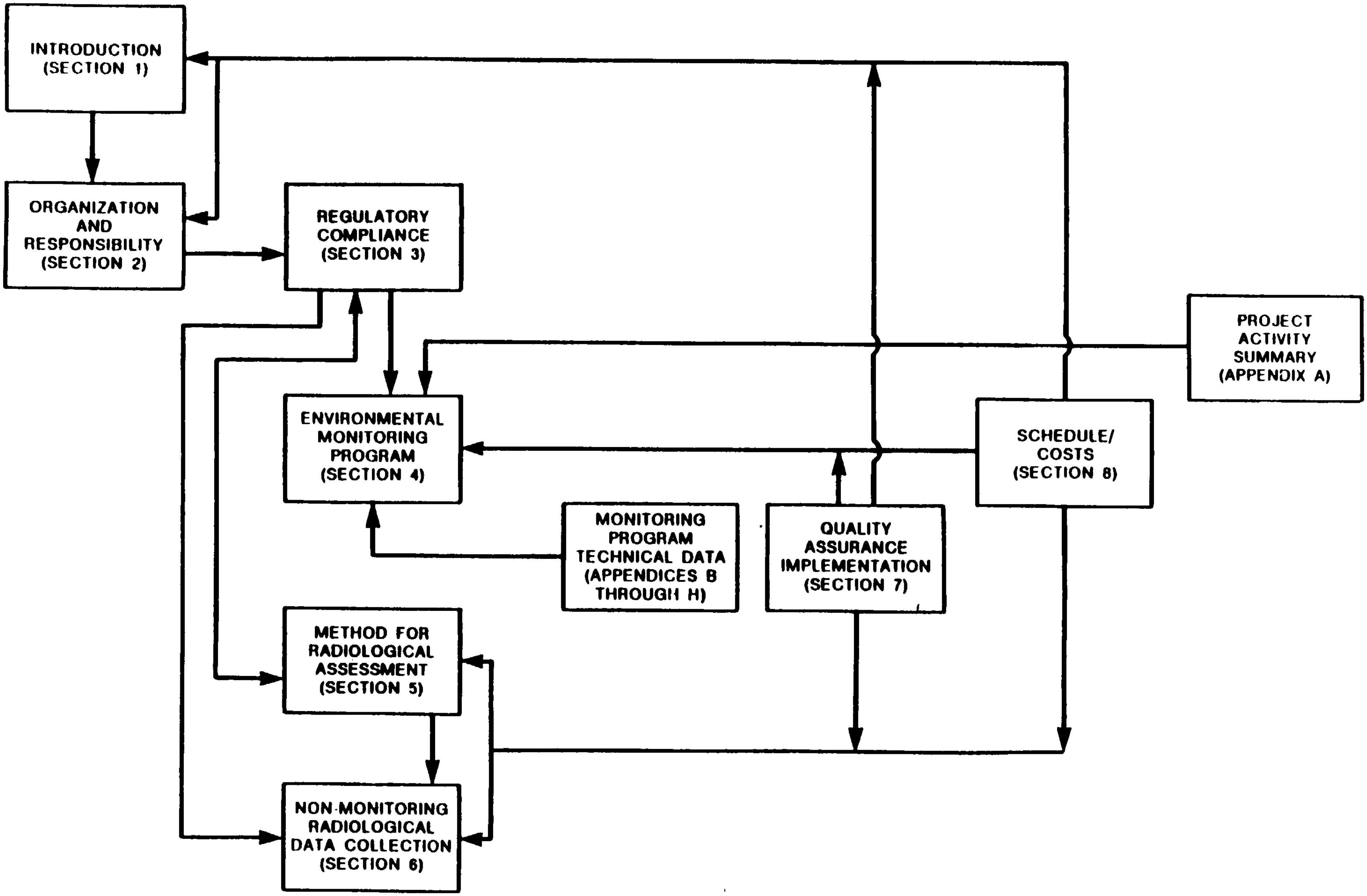


Figure 1-2. Information flow between sections of the RMP.

Characterization Plan (SCP) (DOE, 1988b) and the Environmental Program Plan (EPP) is also addressed. Section 4 provides details of the radiological monitoring activities and how the activities relate to the requirements in Section 3. Section 5 sets forth the radiological analytical techniques used in collection of data for resolution of the issues in the issues hierarchy. This section also addresses how these techniques fit within the regulatory framework in Sections 2 and 3. Section 6 identifies non-monitoring data required to support resolution of the issues and discusses how these data will be collected. Section 7 addresses quality assurance (QA), and Sections 8 and 9 address administrative concerns and their resolution within the program. Appendix A provides a description of NNWSI Project activities. Appendices B through G provide supplementary technical data, with Appendix E containing a tabular summary of the environmental monitoring program. Appendix H describes other plans which provide data to this program, Appendix I contains a listing of acronyms and abbreviations, Appendix J contains a glossary for the text, and Appendix K lists any changes made in the field monitoring activities. As stated earlier, the RMP acts as the controlling document for the radiological monitoring activities in support of the NNWSI Project.

2.0 ORGANIZATION AND RESPONSIBILITIES

2.1 REGULATORY RESPONSIBILITIES

Three Federal agencies have established rules, regulations, and orders that may affect the data collection and evaluation activities needed to ensure regulatory compliance and license a repository at Yucca Mountain:

- The Environmental Protection Agency (EPA) has promulgated standards governing the release of radioactive materials into the environment from high-level radioactive waste repositories following facility closure (40 CFR Part 191).

- The Nuclear Regulatory Commission (NRC) has established regulations for restricting exposure of workers and the public to radiological hazards (10 CFR Part 20). The NRC also (1) grants repository construction authorization and an operating license authorizing the receipt and possession of radioactive material, (2) ensures that licensed facilities with the potential for releasing radioactive materials to the environment are designed and operated in such a way that impacts on public health and safety and the environment are minimized, and (3) implements and enforces the EPA standards (10 CFR Part 60).

- The Department of Energy (DOE), through its Orders and regulations (10 CFR Part 960), has specified requirements that are applicable to the radiological monitoring program discussed in this document. The DOE requirements are applicable to activities in the site characterization phase.

2.2 ORGANIZATION AND RESPONSIBILITIES

The reporting structure for the radiological monitoring program is shown in Figure 2-1. Solid lines indicate the flow of technical direction and dashed lines indicate the flow of technical input and support. The Technical and Management Support Services (T&MSS) Radiological Field Program Branch (RFPB) Manager is responsible for implementation of all environmental radiological monitoring (ERM) activities with support from the Nuclear Radiation Assessment Division (NRAD). The Senior Health Physicist designated by the T&MSS Project Manager is responsible for providing appropriate technical input to the RFPB Manager. The ERM team and the Senior Health Physicist, at the direction of the RFPB Manager, will perform the various activities in conjunction with the NRAD. The RFPB Manager is responsible for coordination of these activities. The designated ERM team will be made up of specially trained personnel from the various branches of T&MSS. The NRAD team will be trained per NRAD procedures. The functions of other organization groups and individuals are discussed in Section 4.4.1.

Technical control, support, and direction is provided by the Waste Management Project Office's (WMPO's) Regulatory and Site Evaluations Branch Chief and the Projects and Systems Control Branch Chief. The Health Physics

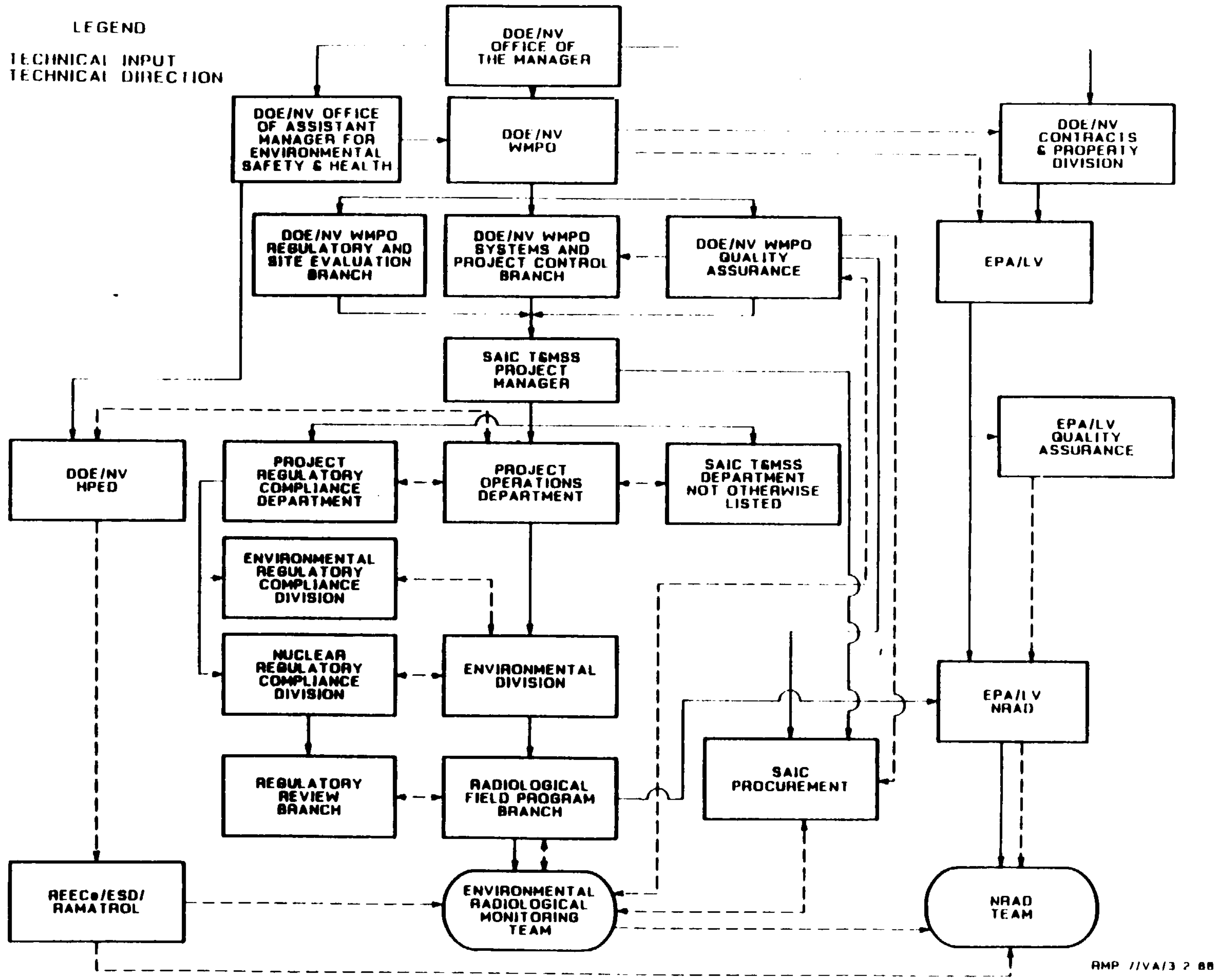


Figure 2-1. Environmental radiological monitoring activities organization chart.

and Environmental Division (HPED) of DOE/NV will also provide technical direction and support.

The WMPO Project Manager, the HPED Project Manager, the Division Director of the NRAD/EPA, and the T&MSS Project Manager are the final approval authorities for this plan. The approval authorities shall verify the adequacy of this program per their expertise.

Reynolds Electrical and Engineering Company (REECo) Radioactive Material Control (RAMATROL) provides onsite support for the control of radioactive material, and is responsible for receipt of radioactive material for the Nevada Test Site (NTS). The activities in the radiological monitoring program will be performed within the existing administrative, safety, and security structure at the NTS.

3.0 RADIOLOGICAL COMPLIANCE

Under the requirements of the Nuclear Waste Policy Act of 1982 (NWPA) as amended and Presidential decisions, the DOE is required to site, construct, operate, and decommission a geologic facility for the disposal of commercial and defense high-level radioactive waste, including spent fuel.

Other regulations and requirements are based on criteria established by the NRC (10 CFR Part 60), EPA (40 CFR Part 191), DOE (10 CFR Part 960), and DOE Orders. The State and Indian Tribes, in addition to their rights for consultation and cooperation, enforce certain Federal or State regulations. The applicable DOE, NRC, EPA, and other groups' regulations, requirements, and guidance which drive the collection and use of radiological monitoring data for this program during the various phases of the Project are addressed in the following sections. The final section addresses how this document fits into the document hierarchy of the NNWSI Project to support compliance with the applicable regulations and requirements.

The radiological monitoring and data collection activities at Yucca Mountain are intended to

1. Verify that adequate protection of the radiological health and safety of the public and workers and the environment is provided.

2. Support analyses to demonstrate with reasonable assurance that any impact on the health and safety of the public and workers or on the environment are within acceptable limits.

3. Provide data required for the completion of required program documentation (e.g., the Final Environmental Impact Statement (FEIS), Safety Analysis Report (SAR), Environmental Monitoring and Mitigation Report, and annual radiological environmental reports).

4. Provide data needed to demonstrate compliance with applicable requirements for design, construction, and operational activities.

5. Maintain consistency with existing Nevada Test Site (NTS) activities, thereby minimizing any potential conflicts and maximizing any potential benefits.

6. Allow for the detection and quantification of unplanned releases of radioactive materials.

7. Verify the accuracy of onsite radiological monitoring systems and release estimates (by comparing the analysis of the dispersion of release estimates with far-field actual field monitoring data).

8. Establish radiological baseline data for the site during site characterization, and monitor the impacts of site characterization activities.

9. Monitor the impact of construction on the baseline until initiation of the preoperational radiological monitoring program.

10. Verify the baseline conditions existing just before operation, which will be done in the preoperational radiological monitoring program.

11. Monitor the impact of the full facility operations, if implemented as specified in the Operational Radiological Monitoring Plan.

12. Monitor the site to assess the impact of decommissioning and verify the effectiveness of the decommissioning process.

13. Monitor (long-term) the facility after closure to verify repository performance.

14. Comply with appropriate technical and scientific guidance, standards, historical precedent, and practices.

3.1 REGULATORY APPLICABILITY

3.1.1 SITING

The activities associated with siting occur in the period preceding the license application. A list of these activities follows:

1. Data are collected to monitor the impacts of site characterization (DOE, 1988c).

2. Data are collected to satisfy requirements identified in the SCP to support siting decisions and preparation of the FEIS/SAR and the Environmental Program Plan (EPP).

3. Radiological data are collected and analyses performed to determine compliance with applicable regulations and requirements.

4. Radiological data are collected and analyses performed to assist facility design.

The primary regulatory authority during this phase is the DOE. Data collected in accordance with the Radiological Monitoring Plan (RMP) will be controlled in a manner consistent with the DOE Waste Management Project Office (WMPO) quality assurance (QA) and regulatory guidelines and requirements for environmental radiological monitoring activities. Consideration of future NRC regulatory guidelines will allow inclusion of these data in a data base to support licensing and National Environmental Policy Act (NEPA) activities. The applicable regulations addressed are summarized in the sections that follow. It should be noted that the NWPA exempts site characterization activities from formalized NEPA of 1969 (Public Law 91-190) documentation requirements. Instead, the NWPA has been interpreted to require monitoring and mitigation of adverse significant impacts to ensure that there is minimal impact from siting-related NNWSI Project activities.

3.1.1.1 Department of Energy (DOE) Orders and guidelines

Site characterization activities will be carried out in compliance with DOE Orders 5480.1A, Chapter XI, "Requirements for Radiation Protection;" 5484.1, "Environmental Protection, Safety, and Health Protection Formal Reporting Requirements;" 5484.1B, "Safety Analysis and Review System;" 5480.4, "Environmental Protection, Safety, and Health Protection Standards;" 5484.2, "Unusual Occurrence Reporting System;" and other applicable orders. The data required to comply with these Orders will be gathered using methods consistent with Corley and Corbit (1982) as specified in DOE Order 5480.4. This Order specifies statutory requirements which must be complied with (such as 40 CFR Part 141), and mandates the use of the Mine Safety Orders, Administrative Code, Title 8, Chapter 4, Subchapter 12, State of California, as the applicable mine safety regulations. The California regulations cite 30 CFR 57.5-37 for radon monitoring. Thus 30 CFR 57.5-37 is the applicable mine safety requirement for protection of workers from radon. In addition to other DOE guidance, DOE (1987f) is reflected in the development of this program.

The data collected from the activities described in the RMP will meet the guidance stated in Corley et al. (1981), Batchelder (1977), Elder (1986), Kathren (1980), and "Requirements for Radiological Effluent Monitoring and Environmental Surveillance" (attached to Walker, 1987). Quotes from Corley et al. (1981) or its proposed revision (Walker, 1987) are, essentially, the technical basis for various monitoring activities in Section 4.3 of this document.

In addition to the DOE guidance just cited, all other applicable DOE Orders will be followed in the development and implementation of this program. Particular emphasis will be placed on compliance with the requirements pertaining to public and worker health and safety and environmental protection described in the 5480 series of DOE Orders. The draft DOE Orders 5480.11, "Radiation Protection;" 5480.12, "General Environmental Protection Program Requirements;" and 5480.XX, "Radiation Protection of the Public and the Environment," have been considered in implementing DOE Orders. Note: Indications are that 5480.XX may actually be renumbered 5400.XX and 5480.12 may be renumbered 5400.1 (DOE, 1988).

3.1.1.2 Nuclear Regulatory Commission (NRC) regulations and guidelines

The NRC does not have regulatory authority during the siting phase, with the exception of concurrence in the use of radioactive material at the site as specified in the NWPA. However, the data generated during site characterization may be used in reports supporting the EIS and SAR or in demonstration of compliance with 10 CFR Part 60 and other parts included by reference (e.g., 10 CFR Part 20); thus, the data will be collected in a manner consistent with the NRC regulations, requirements, and guidance. The regulatory guides identified in Chang (1986) are assumed to be a reasonable assessment of appropriate guidance for the purposes of this radiological monitoring program. The guidance in Regulatory Guides 4.1, 4.6, 4.13, 8.2, 8.6, 8.7, 8.8, 8.9, 8.10, 8.11, 8.13, 8.15, 8.20, 8.25, 8.26, 8.27, 8.29, 1.109, 1.110, 1.111, 1.112, 1.113, 1.21, and 1.23 (see NRC and AEC listings in the References) is an integral part of the technical requirements implemented by the RMP. The program described in this document will consider any other applicable NRC branch or generic technical positions; when Regulatory Guides and technical positions applicable to 10 CFR Part 60 are issued, their requirements will be followed and this document will be revised as needed.

3.1.1.3 State regulations and state flow down/Environmental Protection Agency (EPA) regulations

State flow down/EPA regulations refers to Federal regulations which the EPA has authorized states to enforce through their own regulations. The only such regulations which are of concern to the radiological monitoring program at this time are the Clean Air Act (40 CFR Part 61) and regulations relating to the Safe Drinking Water Act, Public Law 93-523 as amended (SDWA, 1974; SDWAA, 1986). Note: The projected amendments to this act will be implemented as appropriate once promulgated.

3.1.1.3.1 The Clean Air Act

The activities conducted during site characterization will comply with the limits established in the Clean Air Act, specifically Subpart H of 40 CFR Part 61, and will therefore be consistent with Nevada Revised Statute 445.6605 and related statutes (State of Nevada, 1973). The Clean Air Act limits the yearly total dose to the public to less than 25 mrem/y whole body, and 75 mrem/y to any organ by the air pathway. The regulation requires the use of the modified versions of the AIRDOSE-EPA and RADRISK computerized risk assessment models (Moore, 1979; Dunning, 1980) or other approved methods to make the assessment. The WMPO reports compliance with this regulation directly to the DOE/NV Health Physics and Environmental Division (HPED), which then submits data for all of the Nevada Test Site to DOE/HQ. DOE/HQ then reports these results directly to the EPA.

3.1.1.3.2 The Safe Drinking Water Act (SDWA)

Radiological activities associated with site characterization that may require compliance with the SDWA are (1) the use of radioactive sources in well logging and (2) the injection of short-lived radionuclides (tracers) into the groundwater to support geohydrological monitoring. Requirements for well logging will be addressed by the applicable NRC or State license or by the DOE authorization possessed by the owner of the well-logging source. Consequently, they are not addressed further. The injection of short-lived radionuclides (tracers) into the water table is currently not planned (DOE, 1988b). However, if short-lived radioactive tracers are injected into the water table, this activity may be addressed pursuant to 40 CFR Part 144, since the enforcement activity has not been delegated to the State of Nevada by the EPA (DOE, 1988). The applicability of these regulations will be determined after consultation with the EPA.

The Project will also address State of Nevada regulations relating to the SDWA, specifically those regulations in Chapter 445 of the Nevada Administrative Code (State of Nevada, 1973).

During site characterization, RMP activities will also address collection of data to provide information needed in the future to demonstrate compliance with the SDWA during the preclosure and postclosure phases. Specific plans for compliance are still under evaluation. The regulations being evaluated include the following:

1. 40 CFR Part 124 and Parts 141-147.

2. Applicable parts of the Nevada Administrative Code, Chapter 445 (State of Nevada, 1973) implementing the SDWA.

3. Subpart X of 40 CFR (Sections 264.600 to 264.603).

Resolution of the applicability of various regulations will be addressed in future revisions of the Environmental Regulatory Compliance Plan for Site Characterization of the Yucca Mountain Site (ERCP) (DOE, 1988a) and the RMP.

3.1.1.3.3 Other State regulations

In addition to 10 CFR 30.12, the State of Nevada Regulations for Radiation Control (Nevada State Board of Health, 1980) specifically exempt the DOE and its contractor from licensing in Section 1.3.3. However, the DOE has notified the State Division of Health of DOE's authorization of T&MSS to "receive, own, possess, or use byproduct (radioactive) materials..." (Fitzsimmons, 1987).

3.1.2 CONSTRUCTION

Before construction of a repository can commence, a license application must be submitted to, and construction authorization received from, the NRC. Until a license to receive and possess has been issued, the DOE will remain the primary regulatory authority for overall radiological/environmental protection and safety activities, except as indicated in construction authorization constraints. The NRC will become the regulatory authority for facility construction activities through the construction authorization.

3.1.3 OPERATION

If Yucca Mountain is approved and licensed, then the operations phase will need to be addressed. When the NRC licenses the repository to receive high-level waste, the NRC regulations, 10 CFR Part 21 and 10 CFR Part 60, become applicable. Additional requirements may be included in the license as technical specifications. At this point, the NRC will have primary regulatory authority over all activities. With the exception of the NRC's enforcement authority (10 CFR Part 21), the regulatory environment will be essentially unchanged in any other way. In addition, the implementation of the Clean Air Act will fall under Subpart I of 40 CFR Part 61 and may require reporting to the State, the NRC, and directly to the EPA depending on the statutory requirements in existence at the time. At this time any requirements relative to the Safe Drinking Water Act must be implemented, based on resolution of the regulatory requirements discussed in Section 3.1.1.3.2.

3.1.4 PERMANENT CLOSURE/DECOMMISSIONING

When the NRC authorizes the permanent closure and decommissioning of the Yucca Mountain site, the technical specifications will be modified to reflect the requirements of the decommissioning plan. With the exception of the change in technical specifications, the regulatory requirements will be essentially the same.

3.1.5 POSTCLOSURE

If a repository is built at Yucca Mountain, then the postclosure monitoring phase will need to be addressed. If the NRC license is terminated after the facility is decommissioned, authority will revert to the DOE or, if so determined, to the State of Nevada. If the State of Nevada takes over responsibility, State of Nevada law and the requirements of the legal agreement between the DOE and the State of Nevada will control site activities. Presently, the regulatory environment for this phase is still being developed by other Project participants, the DOE, State and Tribes, and the NRC.

3.2 NNWSI PROJECT REQUIREMENTS

As part of the implementation of the NWPA, the NNWSI Project has (or will develop) various plans to control Project activities and ensure compliance with the provisions of the NWPA and applicable regulations. The NNWSI Project document hierarchy for the activities discussed in the RMP is illustrated in Figure 3-1. The various phases are controlled by different internal documents. The hierarchy shown is for the siting and construction phase. Limited documentation has been identified for later phases. This documentation will be discussed in later revisions of the RMP.

3.2.1 SITE CHARACTERIZATION AND CONSTRUCTION

The specific plans and documents controlling activities during site characterization and construction are shown in Figure 3-1, although during

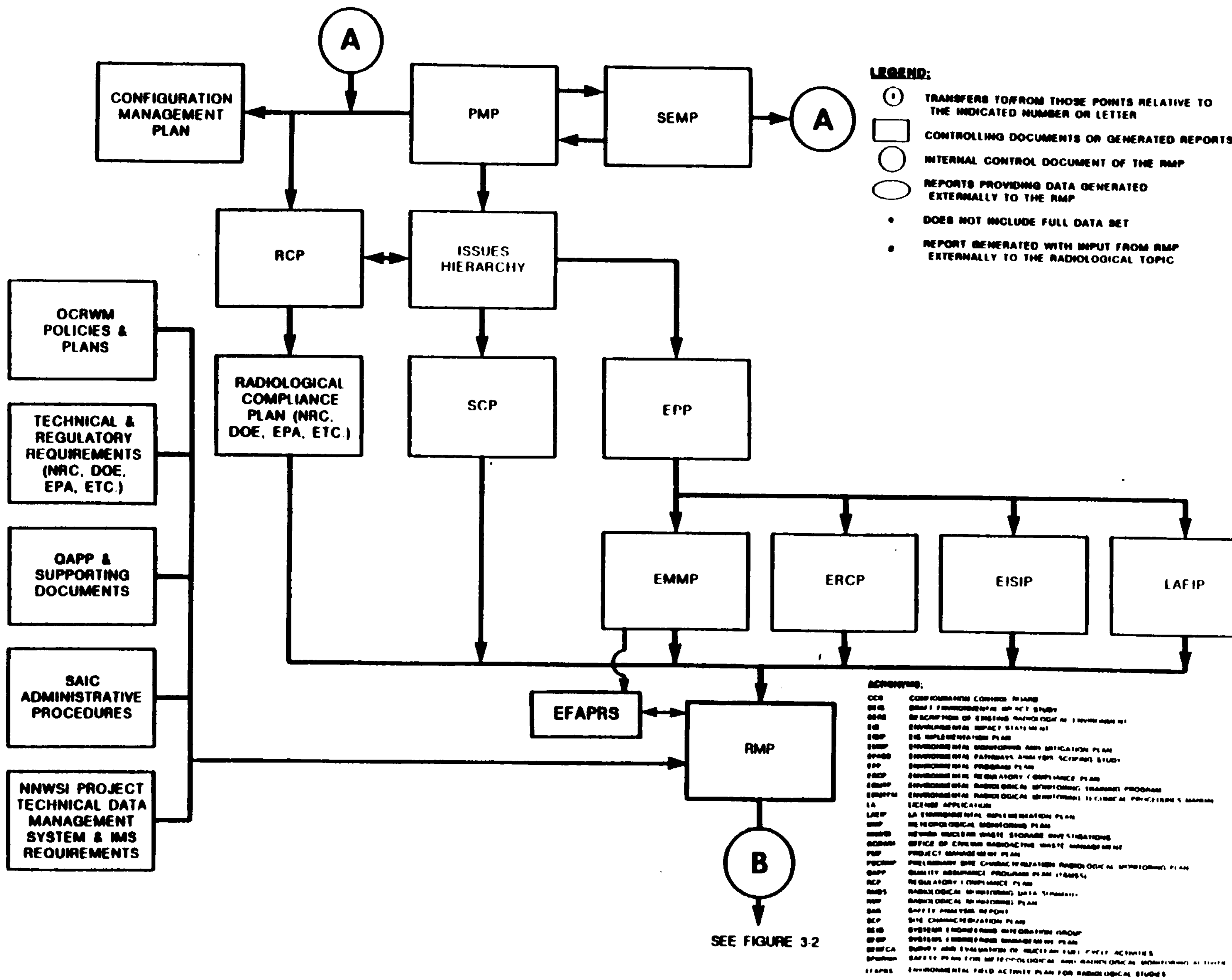
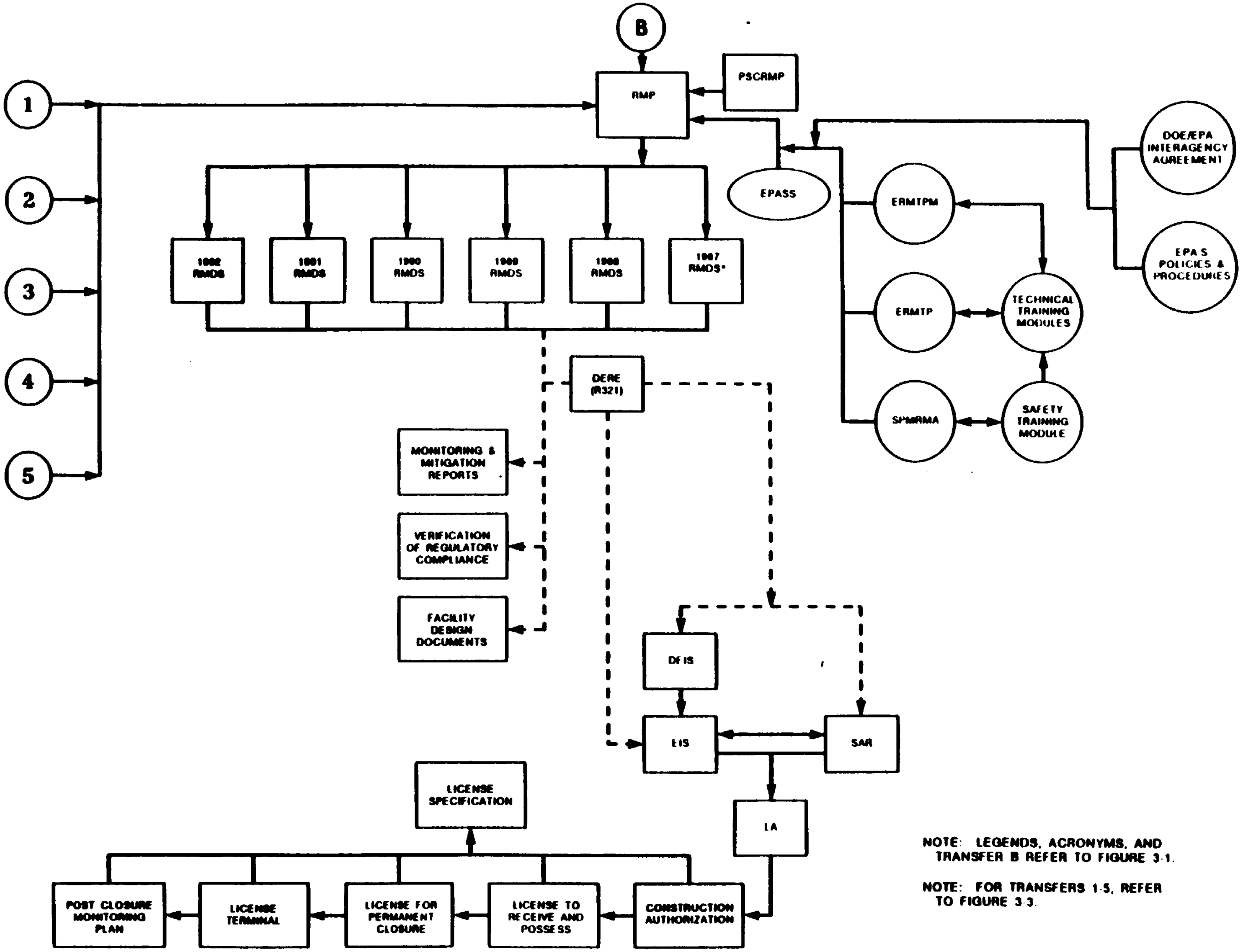


Figure 3-1. Site characterization document hierarchy.



NOTE: LEGENDS, ACRONYMS, AND TRANSFER B REFER TO FIGURE 3-1.

NOTE: FOR TRANSFERS 1-5, REFER TO FIGURE 3-3.

Figure 3-2. RMP documentation.

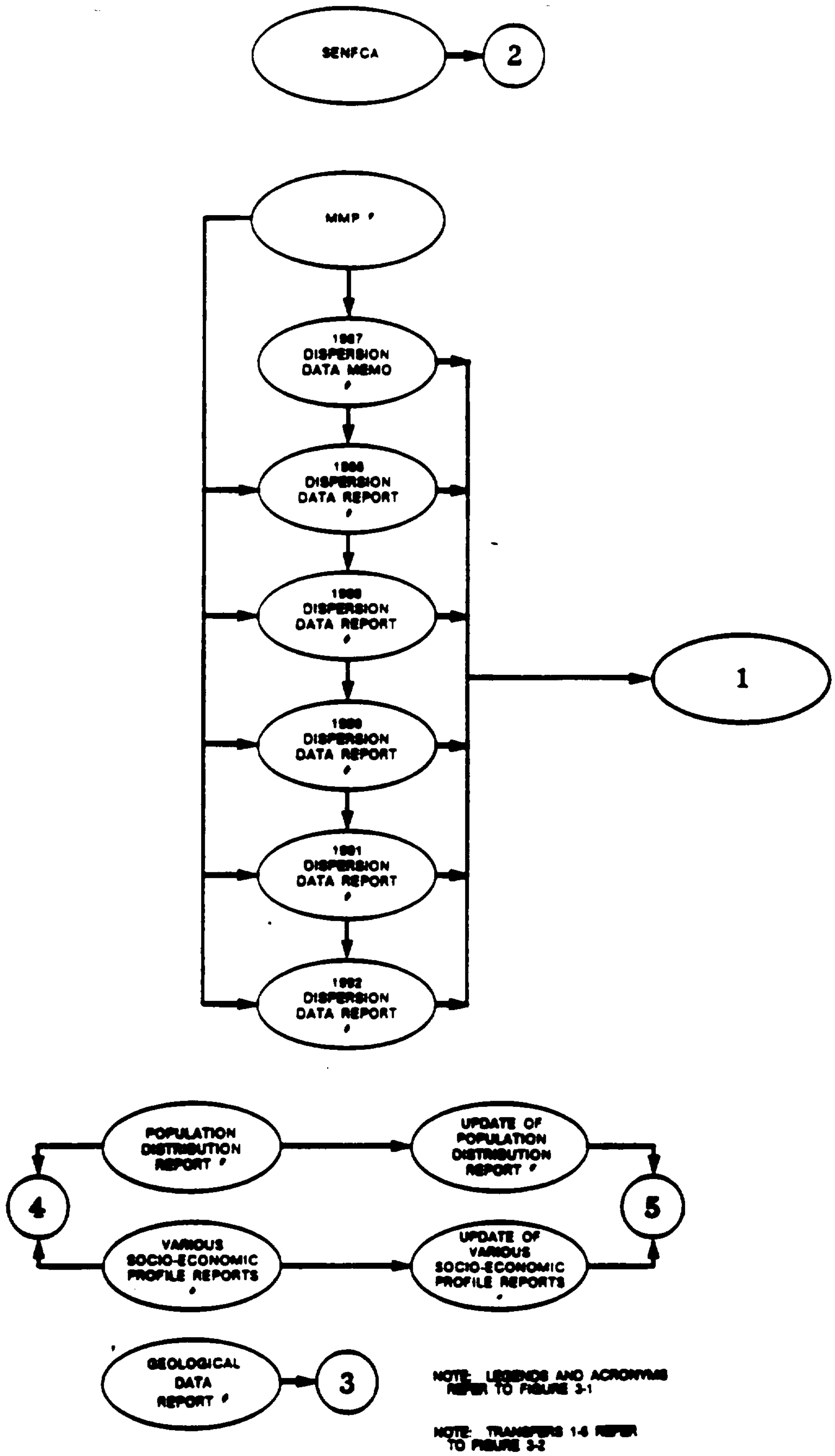


Figure 3-3. Nonradiological supporting technical reports.

construction the NRC construction authorization may also provide specific requirements. The RMP-generated and related documentation is shown in Figure 3-2. The nonradiological technical reports providing input to future RMP reports are illustrated in Figure 3-3. The primary controlling documents are the SCP and the Environmental Program Plan (EPP). No NEPA documentation beyond the existing Environmental Assessment (EA) (DOE, 1986a) is required for the site characterization and construction phase, aside from that addressed in the Environmental Monitoring and Mitigation Plan (EMMP) (DOE, 1988c). Each of the "input documents" specifies data requirements which are provided by this plan. The other documents which contain technical requirements or constraints on activities to ensure compliance with applicable regulations, orders, and guidance are also included in this figure.

3.2.2 OPERATION

During this phase, the specific plans and documents controlling activities will be the EIS and the license application, as shown in Figure 3-4.

3.2.3 PERMANENT CLOSURE/DECOMMISSIONING

During this phase, revisions to incorporate the decommissioning plans will be made to the controlling documents issued during operations; except for these revisions, the structure will remain basically the same.

3.2.4 POSTCLOSURE MONITORING

Responsibility, requirements, and control for the postclosure monitoring phase are presently not well-defined. As information becomes available, it will be added to this section.

3.3 REGULATORY AND OTHER REQUIREMENTS

This section addresses the regulatory requirements which establish the need and content of the radiological monitoring program. These include the various regulatory requirements described in Section 3.1 and the NNWSI Project requirements discussed in Section 3.2. The discussion considers the program for each of the major phases discussed previously (Figure 1-1).

The environmental impact assessment activities use the monitoring data to assess the impact of Project activities on the environment and the health and safety of the workers and the public. The activities will be atypical since this information is for a repository where both the period of interest (about 10,000 years) and the release pathways of interest are substantially longer than is characteristic of other nuclear facilities. The perceived hazards associated with the facility, as indicated by the interest in this siting in the political and public arena, are substantially greater than the

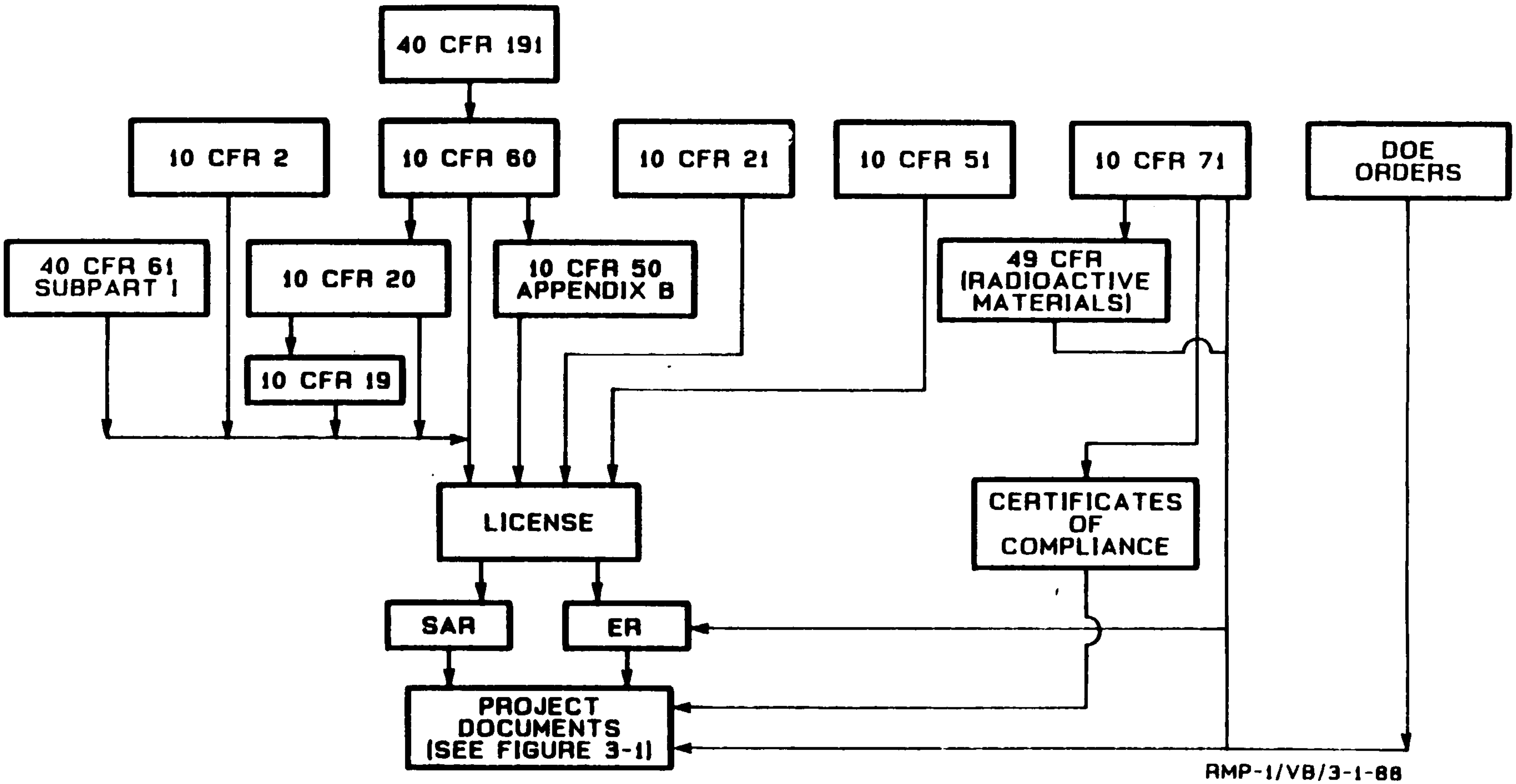


Figure 3-4. Document hierarchy for operations.

actual hazards, which are minimal (DOE, 1986b). The perceived hazards must be addressed to the extent practicable, and increased monitoring activities may be necessary. Another atypical characteristic is a significant potential for a time-dependent radiological background in the Yucca Mountain area from past NTS activities. This is due to the fact that activity is constantly moving from other areas into and out of the area of interest.

The basic precepts under which the radiological monitoring program was developed are to

1. Meet or exceed all NWPA, NRC, EPA, and DOE requirements for this activity.

2. Collect all environmental radiological data required to support NNWSI Project activities.

3. Produce and implement a program consistent with existing NTS environmental monitoring programs.

4. Minimize any potential impacts on other DOE activities in the area.

5. Monitor a sufficient range of parameters to identify any build-up, trends, or unexpected effects in the environment (including synergistic effects).

The following sections provide detailed descriptions of the requirements and scope of this program for each of the eight Project phases mentioned earlier.

3.3.1 REQUIREMENTS FOR MONITORING

3.3.1.1 Site characterization

The environmental data collected during the site characterization phase may be used to assist in establishing the baseline environmental radiological condition, monitoring the impacts of site characterization activities, completing Project activities and facility-design, and demonstrating regulatory compliance.

3.3.1.1.1 The Nuclear Waste Policy Act (NWPA) as amended and the site characterization phase

The DOE is required by Section 113(a) of the NWPA "to the maximum extent practicable and in consultation with the Governor of the State involved or the governing body of the affected Indian Tribe involved, to conduct site characterization activities in a manner that minimizes any significant adverse environmental impacts identified...." These site characterization activities must be conducted in compliance with applicable environmental regulations. Additional requirements concerning impacts that arise from the site characterization process are contained in the "Siting Guidelines," 10 CFR Part 960, issued by the Secretary of Energy in December 1984 (DOE, 1984) in accordance with Section 112(a) of the NWPA. Section 960.3-4 states that "environmental impacts shall be considered by the DOE throughout the site characterization, site selection, and repository development process" and that the "DOE shall mitigate significant adverse environmental impacts, to the extent practicable...."

In support of the recommendation for site characterization of the Yucca Mountain site, the DOE prepared an Environmental Assessment (DOE, 1986a) as required by Section 112 of the NWPA. The Yucca Mountain Environmental Assessment (EA) addressed all public comments received on the December 1984 draft EA during formal public hearings, as well as those comments submitted in writing. The impact assessments contained in the EA included professional judgements based on available information related to the activities to be conducted during the site characterization, and, therefore, to the probable effects of these activities on the environment. The EA concluded that no significant adverse environmental impacts are expected from site characterization activities.

The potential for significant adverse impacts from site characterization activities is established by either (1) explicit identification in Chapter 4 of the EA, or (2) a determination by the DOE that a single activity or a combination of activities has a sufficient degree of uncertainty and a resultant potential for significant adverse impact associated with it that warrants monitoring. Such determination may initially come as a result of the DOE review of the EA. The determination may also come in response to changes in the activities described in the SCP (DOE, 1986b), consideration of comments received on the SCP, and after consultation with the State of Nevada on the Environmental Monitoring and Mitigation Plan (EMMP) (DOE, 1988c). These impacts are discussed in Chapter 4 of the EMMP and will drive the monitoring and mitigation with respect to conducting site characterization activities.

The EA discussed only the preoperational impacts of radiological releases from repository construction. The release of radioactive elements from repository construction was estimated in Chapter 5 of the EA. Those releases were predicted to be a small fraction of natural background radiation, and were not considered a significant adverse environmental impact. A brief summary of the impact analyses performed in support of the EMMP is provided here.

There are four potential sources of radioactive materials at the Yucca Mountain site during site characterization:

1. Release of naturally occurring radionuclides from mining activities.

2. Discharge to the surface of groundwater containing radionuclides.

3. Resuspension of radioactive materials previously deposited during nuclear testing at the NTS.

4. Release of short-lived radioactive tracers as part of geohydrological modeling and the small potential for release of radioactive material during well-logging activities.

Because only a small volume of rock will be mined and only a small amount of groundwater will be released to the surface during site characterization, radioactive releases are estimated to be a small fraction of the natural background radiation and will not constitute a significant radiological impact. It is expected that the groundwater will contain only natural background radioactivity. The resuspension of previously deposited radioactive materials during site characterization is also expected to be small compared to natural background because of the low concentration of radioactive materials present. Nevertheless, because limited monitoring activity has occurred at and around the Yucca Mountain site, the EA analyses contain inherent uncertainties. To verify the previous assumption that there is no significant impact, monitoring is proposed in the areas of (1) radioactive material concentrations in air, soils, biota, and groundwater; and (2) external radiation background field. Note: RMP activities will reflect the requirements associated with any requirements or permits involved with the use of radioactive tracers. In addition, the impact of the use on other RMP activities will be evaluated and monitored.

These activities are mandated by the EMMP. However, the detailed implementation of the radiological monitoring requirements discussed in the NNWSI Project Environmental Field Activity Plan for Radiological Monitoring (and in more detail in Section 5.10, "Radiological Levels") will be addressed in this plan, the RMP, which consolidates all radiological monitoring activities.

The RMP does not address well-logging activities since these activities are addressed in the NRC or State license, or in the DOE authorization possessed by the owner of the well-logging sources. Potential impacts of these activities on other RMP activities will be evaluated and monitored.

3.3.1.1.2 Implementation of Environmental Protection Agency (EPA)/State regulations

The implementation of the Clean Air Act and the Safe Drinking Water Act are briefly discussed in the following sections.

3.3.1.1.2.1 Implementation of the Clean Air Act

The Clean Air Act, as specified by Subpart H of 40 CFR Part 61, applies to all DOE facilities except those "regulated under 40 CFR Parts 190, 191, or 192." Since no application has yet been made by the DOE for a license to receive and possess, the facility is regulated by DOE Orders. The Clean Air Act requirements for site characterization activities are specified in Subpart H (discussed in Section 3.1.1.3.1). However, when the operating license is granted, the NRC will be the regulatory authority, and the requirements in Subpart I rather than those in Subpart H will apply. The only changes in this chapter are the reporting authorities and what releases from surrounding facilities must be considered in the assessment of compliance.

Man-made releases. While establishing specific limits, Subpart H also sets reporting requirements. Subpart H states that "activities having emissions of radionuclides to air that do not exceed . . . a dose equivalent of 5 mrem/y to the whole body or 15 mrem/y to the critical organ of any member of the public residing or abiding at the point of maximum annual air concentration in the unrestricted area, are exempt from the reporting requirements of 40 CFR 61.10." Because NNWSI Project activities at Yucca Mountain are expected to result in doses substantially below these values, no specific reporting requirements to the EPA are anticipated. The Technical and Management Support Services (T&MSS) Contractor will take sufficient monitoring data to allow assessment of these doses, as specified in 40 CFR 61.93, and will document the analysis of these data in an annual Radiological Monitoring Data Summary. If it is determined that the limits of 40 CFR 61.10 may be exceeded, procedures will be implemented to comply with the reporting requirements of Subpart H (Section 3.1.1.3.1) and applicable DOE Orders implementing this requirement.

Radon/radon daughter product releases. Subpart H of 40 CFR 60.92 specifically excludes Rn-220, Rn-222, and their daughter products from the emission standards. Since radon emissions data are being taken for other purposes, good technical practice suggests it would be appropriate to evaluate the impact of these releases as well. Thus the Radiological Monitoring Data Summary will provide these data and compare the results to the requirements for stabilized uranium mill tailings given in 40 CFR 192.02(b)(2). These standards, used as guidance, are only for comparison purposes. These criteria were selected since they are EPA standards for uncontrolled radon releases to an outdoor environment. These standards provide indication of acceptable radon levels for public exposure. The Yucca Mountain releases are projected to be a small fraction of these values.

3.3.1.1.2.2 Implementation of the Safe Drinking Water Act

If radioactive tracers are used, the DOE will comply with the requirements (established for EPA enforcement of 40 CFR Part 144 and related regulations) related to the release of short-lived radioactive tracers. In addition, the NNWSI program will address applicable State regulations (State of Nevada, 1973). In ensuring that the use of radioactive tracers does not impact other RMP activities, the groundwater in the affected area will be monitored and sampled. The NNWSI Project will ensure radioactive releases comply with applicable regulations and requirements. In addition, the RMP activities will support any required demonstration of compliance. Where feasible, both up-gradient and down-gradient monitoring and sampling will be included as a routine part of the RMP activities.

In addition, the RMP groundwater sampling activities are designed to provide the background data needed to implement the requirements related to the Underground Injection Control Program (if applicable) of the Safe Drinking Water Act, 40 CFR Part 144, 40 CFR Part 146, and related regulations for the preclosure and postclosure phases. This includes consideration of permits issued under Subpart X of 40 CFR (40 CFR 264.601 to 40 CFR 264.603). Prior to the facility receiving radioactive waste, an appropriate operational groundwater monitoring and sampling activity will be implemented.

It should be noted that, consistent with (1) the draft DOE Order addressing radiological protection of the public discussed in Walker (1987), (2) 40 CFR Part 141, and (3) any applicable regulations by the State of Nevada (State of Nevada, 1973) and others, the program will monitor and sample drinking water sources not monitored and sampled by others. These monitoring and sampling programs will be consistent with applicable analytical requirements in the regulations and appropriate guidance.

3.3.1.1.3 Department of Energy (DOE) Orders

The DOE Orders, as modified by the NWPA for this Project,* contain the primary requirements applicable to site characterization activities. These requirements are set forth in DOE Order 5484.1 (Chapters III and IV), 5480.1B (specifically Chapter XI), 5480.4, and 5480.3.

3.3.1.1.3.1 <u>DOE Order 5484.1</u>

Section 1 of Chapter III states that an "environmental survey shall be conducted prior to actual start up of a new site, facility, or process which has potential for adverse environmental impacts, or which will... release...pollutants...the survey shall establish background levels of radioactive...pollutants; characterize pertinent environmental and ecological parameters; and identify potential pathways for human exposure or environmental impacts as a basis for determining the nature and extent of subsequent routine operational effluent and environmental monitoring programs."

Section 2 of Chapter III of this order states that an "environmental radioactivity monitoring program shall be maintained at existing sites...to determine:

1. Whether containment and control of releases of radioactivity from site operations are functioning as planned.

2. Whether and to what extent environmental levels of radioactivity and other pollutants, as appropriate, released from Department of Energy sites comply with applicable standards.

3. The overall impact of Department of Energy operations on the environment."

It is unclear whether the original intent of these requirements would apply to site characterization. However, given the nature of the NNWSI Project, it is presumed that this activity is covered under Sections 1 and 2 of Chapter III.

---

*An example of the modification is the elimination of some of the requirements for compliance with the National Environmental Policy Act (NEPA) for site characterization (see the Environmental Regulatory Compliance Plan (to be published)) and the imposition of NRC regulatory authority.

The requirements of Section 1 (relative to data collection needs before the initiation of significant site characterization activities) are addressed in the Preliminary Site Characterization Radiological Monitoring Plan (PSCRMP) (SAIC, 1987a). The analytical requirements are addressed in the RMP as well as in the PSCRMP. The annual Radiological Monitoring Report will document the required data.

The only potential measurable sources of release due to site characterization activities are (1) resuspension from the previously deposited materials near Yucca Mountain; (2) the release of radon and radon daughter products as a result of the mining activities; and (3) the release of small quantities of radioisotopes used for various tracer studies, well logging, or other SCP (DOE, 1988b) testing procedures. None of these sources is expected to result in significant offsite releases. DOE Order 5484.1, Section 5.f(14), states that the Heads of Field Organizations and other Contracting Officers "may grant an exemption from monitoring and reporting for those effluents which meet all of the following criteria:

1. Do not routinely contain and are not a potential source of accidental releases of significant quantities or concentrations of radioactivity or nonradioactive pollutants in relation to applicable standards.

2. Are of no health and safety or environmental significance.

3. Are not required to be maintained by other Federal, state, or local pollution control agencies or regulations." (The Operational and Environmental Safety Division will assist in the interpretation of "significant" as used above, and elsewhere in this Order, on a case-by-case basis as requested.)

This exemption is subject to the DOE Headquarters review. Based on these criteria, site characterization activities would appear to qualify for such an exemption, at least from the Environmental Monitoring Report requirements in Chapter III, Section 5, as long as an Environmental Summary is published as indicated in Chapter III, Section 4.c. The Environmental Summary will be included in the annual Radiological Monitoring Reports and the reporting exemption will be requested. It is presumed for the balance of this document that such an exemption will be granted.

Reporting requirements for the data collected by the RMP and the PSCRMP are specified in Chapter IV of DOE Order 5484.1. Chapter IV, Section 3.g, 4.c(1), 4.c(2), and 4.c(3) requirements will be followed.

3.3.1.1.3.2 <u>DOE Order 5480.1B</u>

DOE Order 5480.1B contains the environmental protection, safety, and health requirements. This order has several supporting orders which are to be issued (5480 series). Currently some of the existing chapters of 5480.1A are still in effect pending issuance of the revised orders. In addition, DOE Nevada Operations Office's Order NV 5480.1A-9 contains limits that result in the need for radiological monitoring.

To comply with personnel radiation exposure criteria in Sections 4.a and 4.b of Order 5480.1A, an assessment or bounding of the potential intake of radionuclides released or resuspended by NNWSI Project activities is necessary. To demonstrate such compliance, the data taken must indicate that the releases do not exceed (in fact, are an extremely small fraction of) the concentration specified in Attachment XI-1 of this chapter of the DOE Order.

DOE Order 5480.1A, Chapter XI, is being revised and applicable chapters are expected to be reissued as separate orders, including DOE Order 5480.11, "Radiation Protection;" DOE Order 5480.12, "General Environmental Protection Program Requirements for DOE Operations;" and DOE Order 5480.XX,* "Radiation Protection of the Public and the Environment."

Based on a review of these draft revisions and information on the potential resolution of comments, it would appear that no major revisions in the technical content of the RMP will be required. However, any required revisions will be made after these orders are formally issued.

3.3.1.1.3.3 DOE Order 5480.4

DOE Order 5480.4, Attachment 2, "Mandatory ES&H Standards (Policy Requirements)," Section 2.e.(8), cites the Mine Safety Orders, Administrative Code, Title 8, Chapter 4, Subchapter 12, State of California as the applicable mine safety regulations. The California regulation cites 30 CFR 57.5-37 for radon monitoring in terms of working levels (WL). 30 CFR 57.5-37 requires

> . . . (a) in all mines at least one sample shall be taken in exhaust mine air by a competent person to determine if concentrations of radon daughters are present. Sampling shall be done using suggested equipment and procedures described in Section 14.3 of ANSI N13.8-1973 . . . or equivalent procedures and equipment acceptable to the Administrator, Metal and Nonmetal Mine Safety and Health, Mine Safety and Health Administration . . . If concentrations of radon daughters in excess of 0.1 WL are found in an exhaust air sample, thereafter . . . (2) where uranium is not mined when radon daughter concentrations between 0.1 and 0.3 WL are found in an active working area, radon daughter concentration measurements representative of worker's breathing zone shall be determined at least every 3 months at random times until such time as the radon daughter concentrations in that area are below 0.1 WL, and annually thereafter. If concentrations of radon daughters are found in excess of 0.3 WL in an active working area radon daughter concentrations thereafter shall be determined at least weekly in that working area until such time as the weekly determinations in that area have been 0.3 WL or less for 5 consecutive weeks.
>
> (b) If concentrations of radon daughters less than 0.1 WL are found in an exhaust mine air sample thereafter; . . .
> (2) Where uranium is not mined - no further exhaust mine air sampling is required. . .

*Number to be determined.

The characteristics of radon/radon daughter products and the meaning of working levels are discussed in Appendix B.

Thus, limited radon monitoring in the mine or in the mine exhaust is required when the mine is initially opened, and may be needed through many of the site characterization activities, particularly when there are changes in mining activity or media type.

3.3.1.1.4 Nuclear Regulatory Commission (NRC) regulations

Since neither a construction authorization nor a license to receive and possess has been issued, the NRC does not regulate site characterization, although Section 113 in the NWPA requires preparation of a Site Characterization Plan (SCP) (DOE, 1988b) which must be submitted to the NRC for review and comment. The NRC must also concur in DOE's use of radioactive material brought to the site. This concurrence is implemented through the SCP review process. Although there is no direct regulation of site characterization activities, the activities are intended to collect data to

1. Prepare the Safety Analysis Report (SAR) for the NRC license application and DOE Environmental Impact Statement (EIS) which the NRC "will adopt to the extent practicable."

2. Demonstrate compliance with applicable NRC regulatory requirements.

3. Operate within the regulations of the NRC when a license is received.

The data required for preparation of an EIS (the same data as in the ER typically generated by NRC licensees) will be addressed in Section 3.3.1.1.6 and Section 4.

The primary regulatory requirements for this activity are in 10 CFR Part 60, which cites 10 CFR Part 20.

3.3.1.1.4.1 <u>10 CFR Part 60</u>

10 CFR 60.21(c) specifies the information which must be included in the SAR. Item (c) states the SAR must contain

(1) a description and assessment of the site at which the proposed geologic repository operations area is to be located with appropriate attention to those features of the site that might affect geologic repository operations area design and performance . . .

(2) A description and discussion of the design, both surface and subsurface, of the geologic repository operations area including: (1) the principal design criteria and their relationship to any general performance objectives promulgated by the Commission . . .

(7) A description of the program for control and monitoring of radioactive effluents and occupational radiation exposures to maintain such effluents and exposures in accordance with requirements . . .

(9) Plans for coping with radiological emergencies at any time prior to permanent closure and decontamination or dismantlement of surface facilities.

The reference to 10 CFR Part 20 will be discussed in the following section.

To meet the performance objectives, as specified in 10 CFR 60.111(a), the "geologic repository operations area shall be designed so that until permanent closure has been completed, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency."

The EPA regulation referred to is 40 CFR Part 191, which is implemented by the proposed revision to 10 CFR 60.111 published in the June 19, 1986, Federal Register. The revision specifies "[t]he annual dose equivalent to any member of the public outside the geologic repository operations area, resulting from the combination of (i) discharges of radioactive material and direct radiation from activities at the geologic repository operations area and (ii) uranium fuel cycle operations, shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other critical organ."

Because there is a potential for an elevated background to exist in the area from activities not associated with the nuclear fuel cycle, it is necessary to determine this background and exclude it from the calculation of the release from a repository. Thus an accurate environmental radiological baseline is needed to support the preparation of the SAR and facility design.

Section 60.112 requires compliance with the postclosure regulations in 40 CFR Part 191. The groundwater monitoring and sampling activities discussed in Section 4.3.5 of the RMP will collect the environmental radiological data required to evaluate compliance with the requirements specified in 40 CFR 191.16, "Groundwater Protection Requirements."

Based on past NRC requirements, the effluent monitoring program required to implement 10 CFR 60.131(a)(4) will consist of several parts, one of which is an environmental radiological monitoring program. Note: The balance of the monitoring program will be considered as part of the facility design criteria and will reflect NRC and DOE requirements and applicable guidance (e.g., ANSI N13.1). This environmental radiological monitoring program will be used to verify the performance of the other parts of the effluent monitoring program. Before implementing such a program, an environmental radiological baseline is required against which changes are measured. Because a potentially time-dependent radiological background exists at the site, the variation will need to be quantified so that the feasibility of and criteria for such a monitoring system can be developed. The baseline monitoring must accommodate the possibility of background changes resulting from ongoing NTS activities.

10 CFR 60.131(b)(4) (and probably 10 CFR 60 Subpart I, which is yet to be published) requires the collection of baseline data to support the radiological emergency plan (Emergency Response Plan). Integral to any such plan is the need to make field assessments of environmental deposition from any release and to define a need for remedial action. Thus the radiological monitoring program must supply an environmental radiological baseline so that change can be detected and quantified.

3.3.1.1.4.2 10 CFR Part 20

10 CFR 20.106 specifies the limits for the release of activity to unrestricted areas (exposure of the public). Although compliance with these regulations is not required during site characterization, it would appear appropriate to demonstrate that any release of radioactivity is within the limits of this regulation. The data collected during site characterization will also allow the NNWSI Project to demonstrate in the SAR and EIS that any elevated activity and natural radioactivity at the site will not affect the Project's ability to comply with these regulations.

3.3.1.1.5 Department of Energy (DOE) regulations (10 CFR Part 960)

10 CFR Part 960 contains the guidelines for the recommendation of sites for a nuclear waste repository. Since the Nuclear Waste Amendment to the NWPA has selected Yucca Mountain for evaluation as a potential repository site, those sections of this regulation, which address selection of the final repository site for recommendation to the President, may now provide part of the basis for DOE's evaluation of Yucca Mountain's adequacy as a repository site.

Section 960.3-1-5 states that an "[e]valuation of individual sites . . . shall be based on the postclosure and preclosure guidelines....The preclosure guidelines of Subpart D contain eleven technical guidelines separated into three groups that represent, in decreasing order of importance, preclosure radiological safety; environment, socioeconomics, and transportation; and ease and cost of siting, construction, operation, and closure."

In addition, the preclosure guidelines in 960.5-1(a)(1) specify that:

> (1) projected radiological exposures of the general public and any projected releases of radioactive materials to restricted and unrestricted areas during repository operation and closure shall meet the applicable safety requirements set forth in 10 CFR Part 20, 10 CFR Part 60, and 40 CFR 191, Subpart A (see Appendix II of this part) . . .
>
> (2) during repository siting, construction, operation, closure and decommissioning the public and the environment shall be adequately

protected from the hazards posed by the disposal of radioactive waste.

Appendix II specifies the limits in 40 CFR Part 191, 10 CFR 60.111, and 10 CFR Part 20 (addressed previously in Section 3.3.1.1.4.2) and mandates that exposure to the public be reduced to "as low as reasonably achievable" (ALARA). The data gathered to ensure compliance with DOE Orders (Section 3.3.1.1.3) will be sufficient to establish that exposures received due to the elevated background are ALARA.

Section 960.5-2-4 requires that data be collected during site characterization to demonstrate that "present projected effects from nearby industrial, transportation, and military installations and operations, including atomic energy defense activities, (1) will not significantly affect repository siting, construction, operation, closure, or decommissioning or can be accommodated by engineering measures and (2), when considered together with emissions from repository operation and closure, will not be likely to lead to radionuclide releases to an unrestricted area greater than those allowable under the requirements specified in 960.5-1(a)(a)."*

Resolution of Item 1 of Section 960.5 relative to DOE defense activities will be addressed by assessing the past and present impacts of such activities on the site using environmental monitoring field data and past NTS environmental radiological monitoring reports. These are the same data that will be required for the radiological baseline discussed in previous sections.

The resolution of Item 2 of Section 960.5 will be based on the collection of historical impacts data (Section 3.3.1.1.5), data from the field program mentioned previously, and environmental radiological monitoring data reports from all commercial nuclear activities within the area of interest.

3.3.1.1.6 National Environmental Policy Act (NEPA)

The NWPA (Section 114(a),(d), and (f)), 10 CFR 60.21, 10 CFR 960.3-4, DOE Order 5440.1c, and the NEPA require preparation of appropriate environmental impact assessment documentation, including an Environmental Impact Statement (EIS).

The scope of the EIS and the data to be gathered for it will be determined in Scoping Hearings held by the Office of Civilian Radioactive Waste Management or the NNWSI Project for this process. The exact requirements for this section will be included later based on the results of the EIS Scoping Hearings.

---

*NRC regulations require that radiation from non-fuel-cycle sources be subtracted from background, but DOE regulations (10 CFR Part 960) require all man-made radiation sources be included in the background.

Given past DOE and NRC EIS/Environmental Reports, it would appear that many of the data identified as requisites for other activities may be useful in EIS preparation. The data will be collected in a manner allowing their use in EIS preparation, if required. In fact, since the radiological background in the Yucca Mountain area is a potential time-dependent elevated background, the collection of such data starting in FY 88 may be prudent. Approximately five years' worth of data, rather than the normal two years, may be needed to characterize the site adequately. An FY 88 start date would provide these data in the time frame needed based on the January 1987 Draft Mission Plan Amendment.

For the balance of this document, reference to the collection of data in a manner consistent with the EIS process is intended to ensure that data collected for other activities will be useful in that same process. The data required for EIS preparation will be based on the scoping process. Appropriate portions of the data previously mentioned will be incorporated into the EIS data base based on the scoping process.

3.3.1.1.7 Standard practices

Another important reason for a comprehensive RMP, beyond the regulatory compliance requirements specified in the previous section, is that it is simply good operational practice. Such a program will provide data for:

1. Evaluation of the adequacy and effectiveness of the containment and effluent control systems applied to facilities and operations at the site.

2. Detection of rapid changes and evaluation of long-term trends of concentrations in the environment, with the intent to (a) detect failure or lack of proper control of releases, and (b) initiate appropriate actions.

3. Assessment of the actual or potential doses to man from radioactive materials or radiation released to the environment as a result of DOE operations, or the estimation of the probable limits of such doses.

4. Collection of data bearing on the history of contaminants released to the environment, particularly with the intent of discovering previously unconsidered pathways, synergistic effects, and modes of exposure.

5. Maintenance of a data base and capabilities for rapid evaluation and response to unusual releases of radioactivity.

6. Detection and evaluation of radioactivity from offsite sources to distinguish and compare the results of site operations.

7. Demonstration of compliance with applicable regulations and legal requirements concerning releases to the environment.

Furthermore, by gathering environmental radiological baseline data before the introduction of radioactivity into a new facility, any existing radiological impact can be correctly attributed. Otherwise, when activities which alter the baseline occur, it may not be possible to demonstrate the source of any radioactivity found outside the facility. By default, the facility would be presumed responsible. Correct attribution of responsibility may significantly reduce future costs and other impacts which could result from incorrectly assuming the source of the release to be the Yucca Mountain facility.

3.3.1.2 Construction

3.3.1.2.1 General

The radiological regulatory requirements applicable to construction remain essentially unchanged from those discussed in Section 3.3.1.1, except for those resulting from the NRC regulation of construction activities through issuance of a construction authorization. The NRC may also regulate other activities through specific conditions placed on the license application. There are no specific requirements for further collection of environmental radiological baseline data before initiation of the preoperational radiological monitoring program since the required data for the EIS have been collected. However, a limited amount of data will be taken throughout this period to (1) verify compliance with applicable regulations; (2) establish a link between the site characterization data and preoperational monitoring data; and (3) verify the trends in the background variations, if any, identified during the site characterization phase.

3.3.1.2.2 Preoperational monitoring

In addition to the requirements in Section 3.3.1.2.1, the environmental radiological baseline must be verified before initiation of operation. This verification is mandated by DOE Order 5484.1, Chapter III, Section 1. Currently, there are no requirements specified by the NRC for this kind of mined geologic repository program; however, past NRC practice requires collection of an environmental radiological baseline for all major activities. Examples of such requirements are Regulatory Guide 4.1, Section B, for nuclear power plants; and Regulatory Guide 4.14, Section B, for uranium mills.

3.3.1.3 Operations

When a license to receive and possess is granted to the DOE (operations phase), the NRC becomes the primary regulatory authority. DOE Orders become internal requirements which may still be implemented. There is also a change to implementation of Subpart I of 40 CFR Part 61 (Clean Air Act) rather than

Subpart H. This is essentially a change in the reporting system (Section 3.1.3). In addition, a program must be implemented consistent with the Safe Drinking Water Act discussed in Section 3.3.1.1.2.2.

When operations are initiated, the operational environmental radiological monitoring program is implemented. The program is similar to the pre-operational program, except the scope is typically reduced after the first year of operation.

The reduced-scope program is intended to provide a check on normal operations when facility activity has normalized following start-up. In the event of actual release, the scope of the program will increase substantially.

The program is an outgrowth of the regulations discussed in Section 3.3.1.1, and other requirements and guidance issued by the DOE and the NRC. Specifically, the operational program is based on:

1. DOE Order 5484.1, Chapter III, Section 2.

2. DOE Order 5480.1, Chapter XI, Section 4.b(2).

3. The NRC in 10 CFR 60.131(a)(4).

4. The NRC in Regulatory Guides for similar facilities, such as those referenced in Section 3.3.1.2.2 and those issued for this type of facility.

5. Corley and Corbit (1982) and Walker (1987) with the guidance recognized by both the DOE and the NRC.

6. Draft DOE guidance in 5480.XX and its attachments (DOE, 1987c).

3.3.1.4 Decommissioning

The monitoring requirements during the decommissioning phase are unlikely to differ very much from those for the operations phase (Section 3.3.1.3). However, specific activities in such a program would be revised to reflect (1) the change in activities; (2) compliance with the NRC licensing amendment allowing decommissioning; (3) provision of sufficient data to verify adequacy of the decommissioning activities to the NRC, thereby permitting the NRC to terminate the license (10 CFR 60.52 and 10 CFR 60.5); and (4) compliance with other applicable requirements promulgated before the decommissioning activities were initiated.

3.3.1.5 Postclosure monitoring

Monitoring of the decommissioned facility is required for a period of time to be determined. This monitoring cannot impact the integrity or reliability of the repository. The exact program and program participants have yet to be established. It is possible the program may be implemented by the DOE, the NRC, or some other outside agency, such as the EPA or the State. The monitoring is mandated in 40 CFR 191.14(b) and 10 CFR 60.51(a)(1). The data gathered throughout the program on the radiological conditions at the site, including any variations in the baseline values, will be used to develop this monitoring program.

3.3.2 NNWSI PROJECT-GENERATED REQUIREMENTS AND COMMITMENTS

The controlling documents for the NNWSI Project are the Project Management Plan (PMP) (DOE/NV, 1987a), the Configuration Management Plan (CMP), and the Systems Engineering Management Plan (SEMP) (DOE/NV, 1987b). However, the needs addressed by the RMP are specifically identified in the NNWSI Project Issues Hierarchy (DOE, 1986b) and the Regulatory Compliance Plan (RCP), two Project documents shown in Figure 3-1.

3.3.2.1 Issues hierarchy

The general issues hierarchy is prescribed by the OCRWM (DOE, 1986b). Therein key issues "are defined as the questions relating to the performance of the site and design" that must be resolved to demonstrate compliance with the applicable Federal regulations (including 10 CFR Part 60, 10 CFR Part 960, 40 CFR Part 191, and 10 CFR Part 20). Four key issues comprise the programmatic issues hierarchy:

Key Issue 1: Will the mined geologic disposal system at [site name] isolate the radioactive waste from the accessible environment after closure in accordance with the requirements set forth in 40 CFR Part 191, 10 CFR Part 60, and 10 CFR Part 960? . . .

Key Issue 2: Will the projected releases of radioactive materials to restricted and unrestricted areas and the resulting radiation exposures of the general public and workers during repository operation, closure, and decommissioning at [site name], meet applicable safety requirements set forth in 10 CFR Part 20, 10 CFR Part 60, 10 CFR Part 960, and 40 CFR Part 191? . . .

Key Issue 3: Can the mined geologic disposal system at [site name] be sited, constructed, operated, closed, and decommissioned, and can the associated transportation system be sited, constructed, and operated so that the quality of the environment will be protected and waste-transportation operations can be conducted without causing unacceptable risks to public health or safety? . . .

Note: The site-specific issues under Key Issue 3 will be finalized after environmental program planning efforts are complete and after the EIS Scoping Hearings. The NNWSI Project Issues Hierarchy will be amended at that time (Section 3.3.1.1.6).

Key Issue 4: Will the construction, operation (including retrieval), closure, and decommissioning of the mined geologic disposal system be feasible at [site name] on the basis of reasonably available technology, and will the associated costs be reasonable in accordance with the requirements set forth in 10 CFR Part 960?

Under these key issues are various issues or programs. Each issue or program is further defined at the Project level by sets of information needs or investigations. Note that general issues and information needs refer to environmental issues, while programs and investigations refer to geotechnical site characterization activities.

The RMP collects a very limited amount of data to support the resolution of Key Issue 1. The data collected will support resolution of the compliance with postclosure standards primarily in the first 1,000 years after closure and primarily as related to the groundwater systems. These RMP activities will be closely tied to the Environmental Field Study Plan for Water Resources and the site characterization plans identified in Appendix H. The issues in Key Issue 1 for which the RMP collects data include:

1. Will the mined geologic disposal system meet the system performance objective for limiting radionuclide releases to the accessible environment as required by 10 CFR 60.112 and 40 CFR 191.13?

2. Will the mined geologic disposal system meet the requirements for limiting individual doses in the accessible environment as required by 40 CFR 191.15?

3. Will the mined geologic disposal system meet the requirements for the protection of special sources of groundwater as required by 40 CFR 191.16?

4. Will the waste package meet the performance objective for containment as required by 10 CFR 60.113?

5. Will the waste package and repository engineered barrier systems meet the performance objective for radionuclide release rates as required by 10 CFR 60.113?

6. Do the data collected in order to describe the present and expected geohydrologic characteristics provide the information required by the design and performance issues?

A major portion of the data collected in this document will be used to support resolution of the issues which support preclosure radiological safety and compliance with applicable radiation protection limits (Key Issue 2). Limited input is also supplied to the geochemistry program and to support the higher level of findings required by the siting guidelines related to this area in Key Issue 2. The issues in Key Issue 2, for which the RMP collects data, include the following issues:

1. During repository operation, closure, and decommissioning, will (a) the expected average radiation dose received by members of the

public within any highly populated area be less than a small fraction of the allowable limits and (b) the expected radiation dose received by any member of the public in an unrestricted area be less than the allowable limits as required by 10 CFR 60.111, 40 CFR 191 Part A, and 10 CFR Part 20?

2. Can the repository be designed, constructed, operated, closed, and decommissioned in a manner that ensures the radiological safety of workers under normal operations as required by 10 CFR 60.111 and CFR Part 20?

3. Can the repository be designed, constructed, operated, closed, and decommissioned in such a way that credible accidents do not result in projected radiological exposures of the general public at the nearest boundary of the unrestricted area, or workers in the restricted area, in excess of applicable limiting values?

4. Have the characteristics and configurations of the repository been adequately established to (a) show compliance with the preclosure design criteria of 10 CFR 60.130 through 60.133 and (b) provide information for the resolution of the performance issues?

The population density and distribution program discussed in the SCP (DOE, 1988b) will collect the following information to support resolution of the previous issues:

1. Forecasts through operation and closure of the population of general public/members of the public in any highly populated area and in potential unrestricted areas; and forecasts of population in areas needed to assess public radiation exposures (Section 6 of the RMP).

2. Forecast of the number of workers through operation and closure, in potential restricted and unrestricted areas (Section 6 of the RMP, the Conceptual Design Report, and future design reports).

The meteorological program will provide

1. Meteorological conditions in the vicinity of the site (the Meteorological Monitoring Plan and Section 6 of the RMP).

2. Atmospheric and meteorological phenomena at potential locations of surface facilities (the Meteorological Monitoring Plan and Section 6 of the RMP).

3. Location of population centers relative to wind patterns in the general region of the site (the Meteorological Monitoring Plan and Section 6 of the RMP).

4. Support data for assessing the potential impacts of nearby installations and operations (Section 4 of the RMP with monitoring details in Section 4.3).

And, finally, the offsite installations program indicates the need for:

1. Collection of agricultural data required by the design and performance issues (Section 6 of the RMP).

2. Collection of cultural data required by the design and performance issues (Section 6 of the RMP).

The information needs associated with Key Issue 3 will not be finalized until the EIS Scoping Hearings are completed; however, as currently planned, the data to be collected include:

1. Potential levels of radionuclides and doses to which regional populations will be exposed for normal and accidental conditions, and their potential effects (Sections 4, 5, and 6 of the RMP).

2. Potential for environmental and transportation-related impacts to the natural resources, flora, and fauna (outlined in the environmental characterization issues) and to the public health and safety that cannot be mitigated or otherwise avoided (Sections 4, 5, and 6 of the RMP).

3. A detailed description of all sources of radioactivity associated with normal operations and expected operational occurrences (Section 4 of the RMP relative to currently existing sources).

4. A detailed description of all onsite and offsite environmental effluent monitoring systems (Section 4 of the RMP).

5. A detailed description of all solid, liquid, and gas effluents and emissions and associated waste processing systems, including a list of all EPA designated hazardous chemicals to be used at the site (Section 4 of the RMP for radiological effluents).

6. Present expected levels of background radiation (Section 4 of the RMP).

Furthermore, a detailed schedule of major site-related milestones and activities from the initiation of site activities through construction and decommissioning to the end of the post-surveillance period, including transportation (Sections 1 and 8.1 of the RMP), must be developed. The data collected in the radiological monitoring activities and associated analyses will also provide limited support to the resolution of other issues addressed by key issues when finalized.

3.3.2.1.1 Site Characterization Plan (SCP)

Each of the issues and information needs for Key Issues 1, 2, and 4 are addressed in the SCP (DOE, 1988c). Resolution of the information needs related to radiological monitoring activities is addressed in the RMP. The RMP provides either (1) a detailed discussion of the justification and implementation of the activities, or (2) a justification for activities conducted by others to provide required data (Section 6).

The SCP requires the preparation of scientific investigation plans to collect the required data. The RMP includes the scientific investigation plan for radiological monitoring activities (e.g., Section 4). The RMP is also a support document for scientific investigation plans which produce nonradiological data to support radiological activities which are prepared by others (e.g., Section 6). The data collection mandated by this document will support preparation of the NNWSI Project Site Suitability Report, EIS, SAR, and other documents.

Table 3-1 presents the data required, as well as the SCP section providing the information.

3.3.2.1.2 Environmental Program Plan (EPP)

This document is similar to the SCP (DOE, 1988c), except that it addresses Key Issue 3 rather than Key Issues 1, 2, and 4. In addition to supporting preparation of the EIS, Site Suitability Report, SAR, and related documents, the EPP will address (1) monitoring and mitigation activities, (2) compliance with applicable regulations, and (3) the procurement of required permits. The Environmental Monitoring and Mitigation Plan (EMMP) (DOE, 1988b) and the Environmental Regulatory Compliance Plan (ERCP) (DOE, 1988a) are currently being developed to implement these three activities. The first activity is addressed by the EMMP (Section 3.3.1.1.1 of this document) and the last two activities are addressed in the ERCP. Land access agreements and compliance with applicable nonradiological environmental regulations and requirements will also be addressed by the ERCP.

Further details on those RMP activities which address implementation of EMMP activities can be found in the Environmental Field Activity Plan for Radiological Studies (DOE, to be published). This document will be issued concurrently with the RMP and address those activities specifically required as a result of monitoring and mitigation activities.

3.3.2.2 Regulatory Compliance Plan (RCP)

The RCP (NNWSI Project, 1988) addresses the licensing related regulations which apply to the NNWSI Project and how they are to be implemented. A subset of this plan is the Radiological Compliance Guide which addresses all radiological-related licensing regulations, requirements, and guidance. The RCP also summarizes other applicable regulations, requirements, and guidance in this area, such as DOE Orders, State regulations, EPA guidance, National Council on Radiation Protection and Measurements (NCRP) guidance, and International Commission on Radiation Protection (ICRP) guidance.

3.3.2.3 Internal requirements and direction

In addition to the technical data needs discussed in Sections 3.3.2.1 and 3.3.2.2, the T&MSS activities are controlled by:

Table 3-1. Site Characterization Plan data requirements

Data requirement	SCP section
METEOROLOGICAL DATA	
Wind speeds	8.3.1.12.1, 8.3.1.12.2
Wind direction	8.3.1.12.1, 8.3.1.12.2
Atmospheric stability	8.3.1.12.1, 8.3.1.12.2
Mixing layer depth	8.3.1.12.1, 8.3.1.12.2
Average ambient temperature	8.3.1.12.1, 8.3.1.12.2
Atmospheric moisture	8.3.1.12.1, 8.3.1.12.2
Barometric pressure	8.3.1.12.1, 8.3.1.12.2
Precipitation type, amount, intensity, etc.	8.3.1.12.1, 8.3.1.12.2
Size and distance of topographic features from releases points	8.3.1.14.1
Meteorological data for offsite installations	8.3.1.12.1, 8.3.1.12.2
AGRICULTURAL DATA	
Bioaccumulation of radionuclides in terrestrial flora	8.3.1.13
Bioaccumulation of radionuclides in terrestrial fauna	8.3.1.13
Types and amounts of crops raised	8.3.1.13
Types and amounts of crops consumed	8.3.1.13
Types and amounts of animals raised	8.3.1.13
Types and amounts of animals consumed	8.3.1.13
Animal consumption of forage	8.3.1.13
Forage storage time	8.3.1.13
Grazing yield and period	8.3.1.13
Radius of crop and animal area	8.3.1.13

1. Office of Civilian Radioactive Waste Management (OCRWM) policies and plans.

2. The Waste Management Project Office (WMPO) Quality Assurance Program Plan (QAPP) and supporting documents.

3. The NNWSI Project Technical Data Management System and Information Management System (IMS).

4. The NNWSI Project Systems Engineering Management Plan (SEMP) (DOE/NV, 1987b).

5. Science Applications International Corporation (SAIC) administrative procedures and policies.

3.3.2.3.1 Office of Civilian Radioactive Waste Management (OCRWM) policies and plans

OCRWM policies and plans establish the basic criteria for all Project activities interacting with the NNWSI/DOE Project Office. The RMP's expected milestones are based on the Draft Mission Plan Amendment of January 1987 (DOE, 1987e). This document also implements the applicable section of the OCRWM Safety Plan (DOE, 1986d).

3.3.2.3.2 Waste Management Project Office (WMPO) Quality Assurance Program Plan (QAPP) and supporting documents

All activities are subject to the requirements of the WMPO QAPP (NNWSI Project, Controlled document b) and supporting documents. Satisfaction of these requirements is specifically addressed in Section 7 of this document and in SAIC (1986) with its associated NNWSI Project Quality Assurance Level Assignment Sheets.

3.3.2.3.3 NNWSI Project Technical Data Management System (DMS) and Information Management System (IMS)

The data collection and data reduction activities associated with this program will be conducted in a manner consistent with the requirements of the DMS. All reports, plans, procedures, and other documents will be controlled, issued, and distributed in a manner consistent with the IMS and the policies and procedures addressed in Sections 3.3.2.3.4 and 3.3.2.3.5.

3.3.2.3.4 NNWSI Project Systems Engineering Management Plan (SEMP)

The SEMP (DOE/NV, 1987b) will ensure that these activities are consistent with Project-wide activities, needs of the various Project participants, and needs of the Project as a whole. The administ:ative procedures outlined in the SEMP also require baselining (reference to establishing a controlled change system) of the requirements in the RMP and control of changes to these requirements.

3.3.2.3.5 Science Applications International Corporation (SAIC) administrative procedures and policies

The activities are completed as specified by the SAIC Administrative Procedures Guide and its supporting document, T&MSS Administrative and Technical Procedures. These procedures address the administrative requirements which are satisfied when completing the activities discussed in the RMP. The Environmental Radiological Monitoring Procedure Manual (SAIC, Controlled document) and the Safety Plan for Meteorological and Radiological Monitoring Activities (SAIC, 1986b--currently being reissued as Safety Plan for Project Operations Department Field Activities, SAIC, 1987c) are two of the documents addressing these requirements.

3.3.2.4 Implementation documentation

Based on the requirements in Section 3.3 (specifically, Section 3.3.1.1), various documents were issued to control the radiological monitoring activity directly (Figure 3-1). The primary documents are the RMP and the PSCRMP.

3.3.2.4.1 Technical and Management Support Services (T&MSS) activities

The requirements specified in these plans are directly controlled by the Environmental Radiological Monitoring Technical Procedures (SAIC, Controlled document) and the Safety Plan for Meteorological Monitoring and Radiological Monitoring Activities (SAIC, 1986b--see SAIC, 1987c) for T&MSS activities. This includes specific training of personnel per the environmental radiological monitoring training program.

3.3.2.4.2 Nuclear Radiation Assessment Division (NRAD) activities

In 1982, the EPA mandated that all laboratories analyzing environmental samples have a Quality Assurance (QA) Plan for that analysis so that the data obtained would be of known and defensible quality (i.e., that the bias and precision of the results be known with a specified confidence level). The offsite radiological monitoring program of the NRAD has operated under state-of-the-art QA procedures since the early 1960s, although formal quality assurance plans had not been written. Since 1982, a comprehensive QA Plan has been developed for each of the radiological surveillance networks operated by the NRAD. The laboratory also participates in intercomparison programs managed by the Environmental Measurements Laboratory (EML), the World Health Organization (WHO), and the EPA. Also, each operation from sample collection to analysis and reporting is covered by established, formal standard operating procedures.

As part of the NRAD participation in this program, a formal QA Program Plan will be prepared with the assistance of WMPO QA. This program will be consistent with the Nevada Nuclear Waste Storage Investigations Quality Assurance Plan (NNWSI Project, Controlled document a).

4.0 THE RADIOLOGICAL MONITORING PROGRAM

This section addresses the collection of radiological baseline data to satisfy the regulations, requirements, and guidance discussed in Section 3.0. The program described is for the site characterization phase, while the program for other phases will be detailed in later revisions. As well as establishing the radiological baseline, the proposed program will collect data necessary to

1. Characterize the work environment at the site.
2. Estimate potential impact of past and future NTS activities on present safety analysis and design activities.
3. Assist facility design (MacDougall, 1987) and prepare safety analysis reports.
4. Monitor the impacts of site characterization activities on the surrounding environment (Section 3.3.1.1).
5. Verify the feasibility of monitoring the environment for appropriate radionuclides.
6. Support decontamination and decommissioning of the facility.
7. Verify compliance with NRC, DOE, and NTS requirements.

The RMP will be revised, as needed. Specifically, a revision will be needed after the Environmental Impact Statement (EIS) scoping process is completed, to incorporate the environmental baseline data required for the EIS. The entire program will also be evaluated in terms of available data to determine if changes are justified. Several revisions currently planned are detailed in Section 8.2. Some of the data currently being collected may be identical to the data that will be identified during the EIS scoping process. All data will be collected in a manner allowing their use in establishing the EIS environmental baseline. Much of the program in the far-field (beyond 15 kilometers) area already exists as part of the Nuclear Radiation Assessment Division's (NRAD) ongoing activities to support DOE defense program activities at the Nevada Test Site (NTS). These data are available to the NNWSI Project. All relevant sampling locations are noted in the RMP, and any new locations added in support of the NNWSI Project will be identified. All near-field locations are strictly related to the NNWSI Project. The monitoring activities during site characterisation are designed to characterize the environment and identify and quantify any impacts on it.

4.1 REQUIREMENTS FOR THE RADIOLOGICAL MONITORING PROGRAM

The Nuclear Waste Policy Act (NWPA) as amended mandates that the DOE obtain a license for its commercial repository operations. To support this licensing process, the radiological monitoring program will comply with available NRC requirements and guidance. The DOE will also issue requirements and guidance, which must be met before the filing of the license application. Corley et al. (1981) and Walker (1987) are recommended as appropriate guidance by both the NRC and DOE, and this section will rely on those documents as the primary source of the technical justification for the selection of radiological monitoring methodologies. The technical basis presented in these sections is primarily a paraphrase of this DOE guidance.

4.2 SCOPE OF THE RADIOLOGICAL MONITORING PROGRAM

Data will be collected for this program to satisfy the objectives listed in Section 4.0. Each objective is addressed separately.

4.2.1 CHARACTERIZATION OF THE WORKSITE ENVIRONMENT

Two characteristics of the worksite environment will be addressed in this section: (1) the existing radioactivity concentrations in the background environment at the site, and (2) the potential radon emission from the site.

4.2.1.1 Existing background

The existing radiation levels and radioactivity concentration in the general environment are not expected to have any significant impact on worker health and safety. The radiological monitoring program has been established to determine the validity of these assumptions. Initial implementation of the program is underway as specified in Section 6.1 of the PSCRMP, which will be replaced by the RMP.

Implementation of the RMP will evaluate various potential exposure pathways to man:

1. Direct exposure to radiation.

2. The inhalation of resuspended radioactivity.

3. Worker and equipment contamination contribution to the pathways noted in Items 1 and 2.

4. Other indirect pathways such as ingestion of radioactivity.

The direct exposure pathway is not projected to be significant. Various NTS participants have identified and posted (or decontaminated) contaminated areas. There are presently no posted areas at the Yucca Mountain site. To confirm the insignificance of the direct exposure pathway, an array of passive radiation monitors, thermoluminescent dosimeters (TLDs), and gamma radiation monitors will be installed throughout the site to monitor direct radiation.

Airborne activity is currently being sampled by a continuous air sampler at the 60-meter meteorological tower as described in Section 8.1 of the PSCRMP. More samplers will be added as part of the radiological monitoring program implementation. The program's (Section 4.3.4) continuous air sampler will monitor airborne radioactivity present at the site, and will include collection of particulate size data for assessment of the inhalation hazard. Surface soil samples also will be taken to assess the radioactive material available for resuspension.

4.2.1.2 Radon emissions

To comply with DOE Order 5480.4, requiring adherence to the California Mine Safety Orders (30 CFR 57.5-3), it is necessary to monitor radon/radon daughters to ensure worker safety. 30 CFR 57.5-37 is being revised to include the radon from natural thorium as well as uranium decay series (Appendix B explains radon/radon daughter products). The surface mine environment, the ambient background, and the exhaust from the underground workings will be monitored for radon/radon daughters from the uranium and thorium series. These data will be used to assess and control potential worker exposure and to demonstrate compliance with the applicable regulations. This activity will fall within the operational health physics program when the facilities are constructed.

4.2.2 CHARACTERIZATION OF NEVADA TEST SITE (NTS) ACTIVITIES

It is essential to assess the impact of activities in the area surrounding the proposed Yucca Mountain facility to (1) fulfill the requirements of 10 CFR Part 960 (Section 3.3.1.1.5), (2) support preparation of a Safety Analysis Report (SAR), and (3) design a facility. NTS activities may have a radiological impact on the proposed Yucca Mountain facility. The radiological monitoring program will provide data to help quantify this impact. The information is needed to support potential design activities. Assessment of radiological conditions at the site will be performed by reviewing available documents, some of which are discussed in Section 4.3.1, and by collecting current data. These two data sets will then be used to document past and present conditions, and to project future conditions.

The radiological monitoring program will be implemented with the following environmental monitoring activities:

1. Determination of ambient airborne radionuclide concentrations in the Yucca Mountain area, including identification of potential sources and particle size distributions. These data will be used to establish intake-air filtration requirements, if any, and to project

off-normal conditions for design, safety analysis, and site evaluation.

2. Evaluation of the radioactivity concentrations in the groundwater to verify that the radiological water quality is acceptable for use in the facility. No radioactive material above natural background is expected to be present in the groundwater at Yucca Mountain. These data are being collected for resolution of other needs (discussed in Sections 3, 4.2.4, 4.2.5, and 4.2.6), but can also be used to verify the absence of contamination in the water supply.

3. Surface water and sedimentation analyses of the ephemeral stream in Fortymile Canyon/Wash. These data will be used to project both the impacts of past NTS activities and the radioactivity due to airborne deposition.

4. Performance of soil and driftwall sampling to establish the existing radiation background in the surface and underground work areas to support facility design and safety analysis activities. The primary purpose of driftwall sampling will be for radon/radon daughter product monitoring.

5. Biota sampling in the Yucca Mountain area to support the objectives of Items 2, 3, and 4, and to examine radioactivity already in the human food chain for the purpose of safety analysis and regulatory compliance.

4.2.3 FACILITY DESIGN AND SAFETY ANALYSIS REPORT (SAR) PREPARATION

The data requirements discussed in Section 4.2.2 and the ambient radiation data are needed for facility design and preparation of the SAR. Collection of these data is discussed in Section 4.3.8.

Radon exposure data will also be needed to design the facility and prepare the SAR. The radon data collected before the construction of the exploratory shaft (ES) and during ES activities will be used to assess the radon emission rate in the proposed underground facility at Yucca Mountain. The results from evaluation of these data will then be used in the design of the facility ventilation system and safety analysis activities. The data from soil and driftwall samples will be used to assist in the estimation of the radon emission rates and resuspension of existing radioactivity for ventilation system design. These data can also be used in the design of airborne radioactivity monitoring systems for the facility. Radon daughter products collected by air samplers interfere with accurate assessment of the airborne radioactivity concentrations from other sources.

4.2.4 MONITORING IMPACT(S) OF SITE CHARACTERIZATION

As discussed in Section 3.3.1.1.1, there is a need to monitor site characterization impacts in three major areas. The potential sources of radioactivity are resuspended activity from the soil and sediments around Yucca Mountain, release from a groundwater source to the surface, and radon release resulting from excavation. To assess radioactivity resuspension from the site, particulate air samples will be taken and the source (the soils and sediments) analyzed. Any potential release from groundwater to the surface will be evaluated to assess the potential impact, if any. Finally, the radon monitoring discussed in Section 4.3.4 will provide data to project offsite impacts of any radon release resulting from site characterization earth-disturbing activities.

4.2.5 FEASIBILITY OF RADIOLOGICAL MONITORING

Because there may already be a radiological background level in excess of typical background levels, it is necessary to quantify existing conditions to determine if they will interfere with the ability to monitor releases from the operating facility. Special problems may exist in accurately performing routine measurement of I-129, Tc-99, and C-14 in environmental samples. This concern will be specifically addressed in later sections. Finally, it will be necessary to choose and characterize a local indicator species. The indicator species is an animal whose range is closely limited to the area of interest and whose characteristics result in significant intake of radionuclides in the environment. This animal can be used to indicate the presence or absence of unsuspected release pathways. A further discussion of this concept is presented in Section 4.3.7.

4.2.6 DATA FOR DECONTAMINATION AND DECOMMISSIONING

Data or samples representing the original condition of the area will be needed for planning of decontamination and decommissioning activities. The required monitoring activities will be the same as those for site characterization described in Section 4.2.2, except that some locations may be changed and the number of locations altered. Soil, biota, and water samples must be archived specifically for this purpose. Samples will be archived in the NNWSI Project Sample Management Facility (SMF), where chain-of-custody will be maintained.

4.2.7 COMPLIANCE VERIFICATION

The radiological monitoring activities in the radiological monitoring program will allow the NNWSI Project to determine compliance with the DOE Orders and NTS requirements during site characterisation. These requirements cover the monitoring of effluents generated by the Project, including radiological emissions reporting and compliance requirements for the Clean Air Act.

The proposed revision of the DOE Orders for the protection of public health and safety and the environment (DOE Order 5480.XX) specifically prohibits the use of soil columns for the removal of radioactive material from liquids. It is required that no significant quantity of any liquid be released to the surface before the liquid's characteristics are well established. There should be no radioactivity above natural background in the groundwater in the Yucca Mountain area; this will be verified (by the REECo Environmental Sciences Laboratory or with approved field equipment) before release of significant quantities (a few gallons) of such water to the surface-water system. Samples will also be analyzed later as part of the routine RMP activities. The isotope of interest in this determination will be tritium.

4.2.8 COLLECTION OF DATA FOR THE ENVIRONMENTAL IMPACT STATEMENT (EIS)

The specific data required for preparation of the EIS will be identified during the EIS scoping process. Since approximately five years (or more) of data may be needed to establish any trends in the existing background at Yucca Mountain, the data taken in the activities discussed in Sections 4.2.1 to 4.2.6 should be collected over that interval of time. Given existing schedules, there will not be sufficient time to begin to collect these data after the EIS Scoping Hearings. It is expected that the data collected for site characterization activities will be similar to the data identified during EIS scoping. The data collected will be used, where appropriate, to supplement the data collected specifically for the EIS radiological baseline. Efforts will be made to keep the radiological monitoring activities discussed in Sections 4.2.1 to 4.2.6 consistent with the projected EIS radiological baseline data collection requirements and guidelines.

4.3 DESCRIPTION OF THE RADIOLOGICAL MONITORING PROGRAM

The radiological monitoring program is intended to gather environmental radiological data to satisfy the needs identified in Sections 3 and 4.2. Details of the program are based on applicable DOE, NRC, and EPA guidance and requirements. Guidance from various other groups (e.g., NCRP, ICRP), consensus standards, historical precedent, and industry practice will also be used in the program's development. The program specifically addresses the site characterization phase, and later phases will be discussed in subsequent revisions of this document.

4.3.1 SAMPLING INITIATION

The radiological monitoring program recognizes the fact that there may be an elevated background in the Yucca Mountain area from the deposition and resuspension of particulates from past NTS activities (Table 4-1). This background may be changing with time due to radioactive decay and the movement of radioactivity into and out of the area from other locations. It is presently unknown whether this source is changing, and, if so, in which direction (increasing or decreasing). In fact, the direction or rate of any changes may be highly dependent on radionuclide type. Consequently, it is important to characterize any changes in the source term and establish current conditions accurately.

Collection of background data typically requires two years at a pristine site for preparation of the EIS and prior to initiation of operation. This permits characterization of the current background's seasonal, statistical, and spatial variability (Corley et al., 1981; DOE, 1987d; and Regulatory Guide 4.1, Section C.1). Characterizing the variabilities will take substantially longer if the current background is changing with time. It is expected that any significant change in the current background should be identifiable from five years of data. These data will have to be collected for preparation of the EIS. Also, because it typically requires about one year to implement a program including procurement, training, and operational testing, the total time to establish an environmental background data base may be six years. This discussion does not address possible future unplanned releases at the NTS. It should be noted that site characterization activities are not expected to alter the radiological background conditions in the Yucca Mountain area.

An exception to this time requirement is characterization of the radon baseline. Because the radon parents have extremely long half-lives, the radon background at the site has not been affected by past NTS activities which released radionuclides. Consequently, two years of data collection prior to exploratory shaft construction and mining activities would be desirable to characterize the radon source term. It is possible that only one year of data may be collected because of NNWSI Project schedule constraints, and efforts are being made to maximize data collection within these constraints. The radon data collected using passive integrating radon monitors will be supplemented with continuous radon data to ensure adequate background information is obtained. The radon background data collection activities should be finished before shaft construction and mining activities. The effect on radon release rates of the weapons testing induced seismic activity would be characterized by this activity as well, if it exists. It is unlikely that any effect will be detected on the surface due to the small size of the effect, the diffusion rate of radon through the soils (Rogers, 1984), and the half-life of radon.

Details of the RMP monitoring activities will be discussed in the following sections, and each type of sampling and analysis will be addressed separately.

4.3.2 SAMPLING AREA

Based on the regulatory requirements and guidance, technical guidance, present NTS programs, public concern, and historical precedent, the general

Table 4-1. Example of NTS Environmental Monitoring Reports[a]

Title	Source	Document Number
Offsite Environmental Monitoring Report - Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1982	NRAD	EPA-600/4-83-032 (DOE/DP/0539-048)
Offsite Environmental Monitoring Report - Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1983	NRAD	EPA-600/4-84-040 (DOE/DP/0539-051)
Offsite Environmental Monitoring Report - Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1984	NRAD	EPA-600/4-85-035 (DOE/DP/00539-055)
Offsite Environmental Monitoring Report - Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1985	NRAD	EPA/600/4-86-022 (DOE/DP/00539-056)
Offsite Monitoring for the Mighty Oak Nuclear Test	NRAD	EPA/600/4-86-030 (DOE/DP/00539-057)
Offsite Environmental Monitoring Report - Radiation Monitoring Around United States Nuclear Test Areas, Calendar Year 1986	NRAD	EPA/600/4-87-017 (DOE/DP/00539-058)
Environmental Surveillance Report for the Nevada Test Site (January 1980 through December 1980)	REECo	DOE/NV/00410-64
Environmental Surveillance Report for the Nevada Test Site (January 1981 through December 1981)	REECo	DOE/NV/00410-67
Environmental Surveillance Report for the Nevada Test Site (January 1982 through December 1982)	REECo	DOE/NV/00410-076
Environmental Surveillance Report for the Nevada Test Site (January 1983 through December 1983)	REECo	DOE/NV/10327-4

Table 4-1. Example of NTS Environmental Monitoring Reports[a] (continued)

Title	Source	Document Number
Environmental Surveillance Report for the Nevada Test Site (January 1984 through December 1984)	REECo	DOE/NV/10327-19
Environmental Surveillance Report for the Nevada Test Site (January 1985 through December 1985)	REECo	DOE/NV/10327-28

[a]These documents do not address the Yucca Mountain hydrogeological regime. They relate to other NTS activities.

areas of interest for the radiological monitoring activities are (1) the area surrounding Yucca Mountain, and (2) (based on the 10 CFR 960.5-2-1 requirement for monitoring the newest highly populated urban area) the City of Las Vegas, Nevada. The NNWSI Project sampling activities will be directed toward monitoring the radiological exposure pathways to man in these areas.

4.3.2.1 Yucca Mountain area

The NRC recommends in Regulatory Guide 4.2 (Section 5.2.2) (NRC, 1976c) that the radiation exposure from nuclear power plant airborne releases should be modeled

> . . . at points of potential maximum concentration outside the site boundary, at points of estimated maximum individual exposure, and at points within a radial grid of sixteen 22-1/2-degree sectors centered on true north and extending to a distance of 50 miles from the station. A set of data points should be located within each sector at increments of 0.25 mile to a distance of 1 mile from the station, at increments of 0.5 mile from a distance of 1 to 5 miles, at increments of 2.5 miles from a distance of 5 to 10 miles, and at increments of 5 miles thereafter to a distance of 50 miles. Estimates of relative concentrations (χ/Q) for noble gas effluents and, if applicable, relative concentrations (χ/Q) depleted by deposition and relative deposition for radioiodine and particulate effluents should be provided at each of these grid points. In addition, average χ/Q values between all adjacent gridpoints along the radials should be provided.

This same distance (50 miles) is specified in Regulatory Guide 4.2, Section 5.2.2.1.1 (NRC, 1976c) for modeling releases into water pathways. Because one of the purposes of radiological monitoring of the environment is to verify the radiation exposure estimates already discussed in this paragraph, the 80-kilometer (50-mile) recommendation would apply to the RMP monitoring activities. Conti (1978) recommends the use of Corley and Denham (1977) (which cites the 50-mile radius) in addressing relevant pathways. The specific locations for various types of monitors and samplers are based on evaluation of the potential significant pathway to man within the monitoring area and the concern of the area residents. Details on the evaluation and identification of these pathways can be found in the Environmental Pathways Analysis Scoping Study (SAIC, to be issued).

The EPA mandates an 80-kilometer area in evaluation of the air pathway for compliance with the Clean Air Act. This is mandated through the codified version of AIRDOS-EPA (Moore, 1979) required in the regulations.

The DOE has similar guidance for analyses out to 80 kilometers specified in Elder et al. (1986). Furthermore, DOE guidance for environmental monitoring programs in Corley et al. (1981) indicates the same monitoring area. This guide is the 1981 revision of Corley and Denham (1977). Thus both the DOE and the NRC have the same basic guidance on the area of interest for a radiological environmental monitoring program.

As indicated in Section 3, historical precedent should also be considered when these programs are being established. The only comparable facility presently being built by the DOE in the United States is the Waste Isolation Pilot Plant (WIPP) in New Mexico. The WIPP Project facility is effectively a geologic repository for transuranic waste. The 80-kilometer (50-mile) boundary was used in the WIPP Final Environmental Impact Statement and Safety Analysis Report. The DOE Salt Repository Project Office was also considering this same area in its analyses (Waite et al., 1986).

Although Sarri and Hoffer (1984) considers possible monitoring beyond the 80-kilometer (50-mile) area, given the existing regulatory requirements and guidance previously discussed, the limited risk associated with the Project, and information provided in Jackson et al. (1984) (all of which indicates that doses at or beyond this distance are insignificant), intensive monitoring beyond 80 kilometers (50 miles) is not necessary. However, since agricultural activity is present in and around Pahrump, and since the community is one of a limited number of small population centers near the Yucca Mountain area, the monitoring activity boundary was extended four kilometers beyond the 80-kilometer distance to include that population center. Since the intensity of monitoring activity typically decreases with distance from the site, this decision is expected to have little impact on program cost. However, it may have significant benefit in demonstrating the NNWSI Project's interest in ensuring protection of public health and safety in the area.

The 84-kilometer radius and its internal grid are illustrated in Figure 4-1, and Table 4-2 provides details for the internal grid. Specific use is

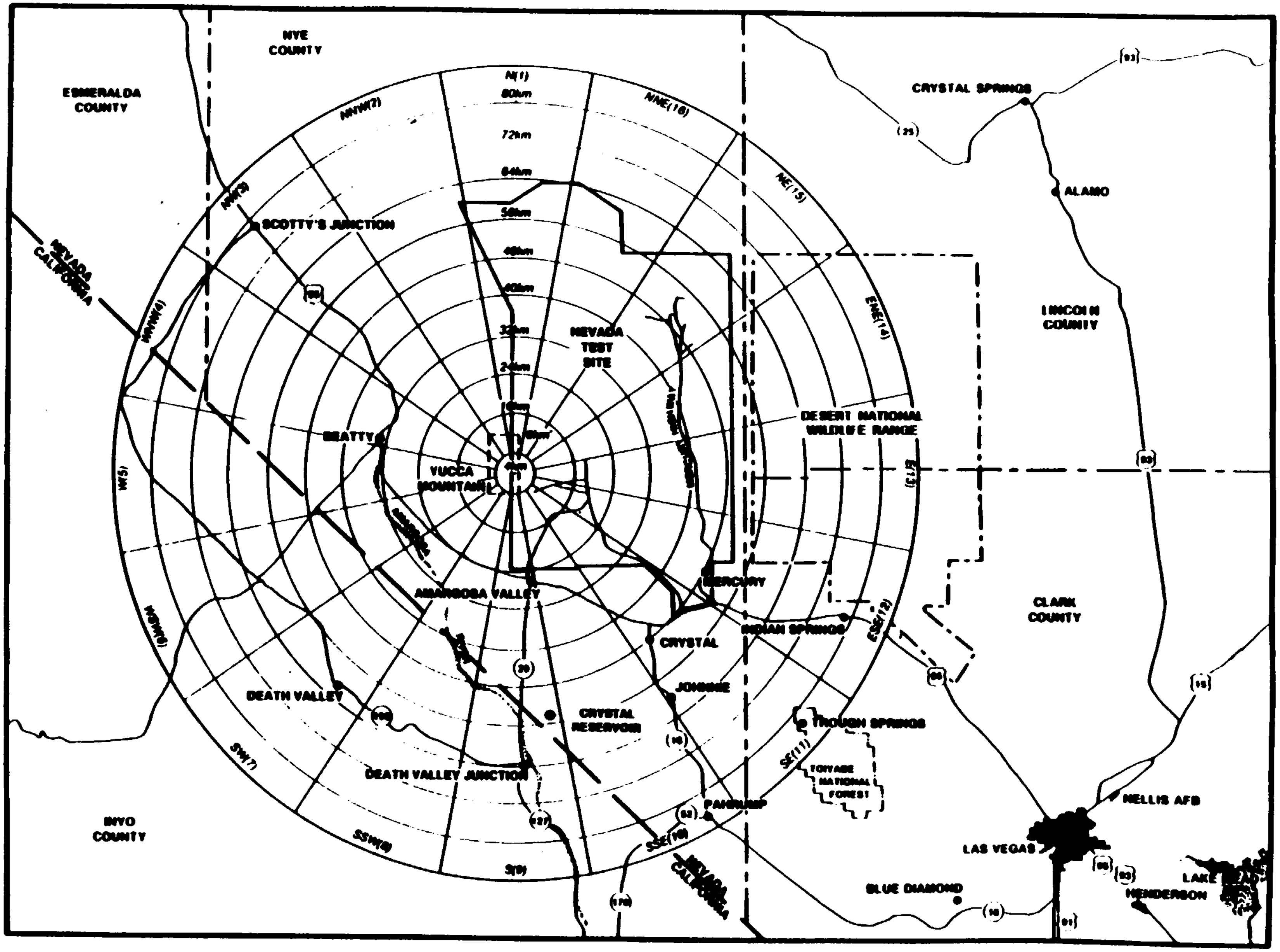


Figure 4-1. Yucca Mountain radiological grid.

Table 4-2. Yucca Mountain demographic grid for radiological analysis (page 1 of 2)[a]

Sample Grid Designation

Coordinates (X,Y)	Grid designation: Radial (km)	Grid designation: Section	Grid designation: AIRDOS[b]	Inner-boundary (I.B.): Distance (km)	Inner-boundary (I.B.): Angle (°E of N)	Outer-boundary (O.B.): Distance (km)	Outer-boundary (O.B.): Angle (°E of N)
1,1	2	N	1	0	348.75	4	11.25
1,2	2	NNW	2	0	326.25	4	348.75
1,3	2	NW	3	0	303.75	4	326.25
3,1	16	N	1	12	348.75	20	11.25

Table Detail

Radial designation: X-Coordinates [AIRDOS][b]	Radial (km)	I.B. (km)	O.B. (km)	Direction designation: Y-Coordinates [AIRDOS]	Section	Angle	I.B. (°E of N)	O.B. (inclusive)
1	2	0	4	1	N	0	348.75	11.25
2	8	4	12	2	NNW	337.5°	326.25	348.75
3	16	12	20	3	NW	315°	303.75	326.25
4	24	20	28	4	WNW	292.5°	281.25	303.75
5	32	28	36	5	W	270°	258.75	281.25
6	40	36	44	6	SSW	247.5°	236.25	258.75
7	48	44	52	7	SW	225°	213.75	236.25
8	56	52	60	8	WSW	202.5°	191.25	213.75
9	62	60	68	9	S	180°	168.75	191.25
10	72	68	76	10	SSE	157.5°	146.25	168.75
11	80	76	84	11	SE	135°	123.75	146.25
				12	ESE	112.5°	101.25	123.75

Table 4-2. Yucca Mountain demographic grid for radiological analysis (page 2 of 2)

Radial designation				Direction designation					
X-Coordinates [AIRDOS]	Radial (km)	I.B. (km)	O.B. (km)	Y-Coordinates [AIRDOS]	Section	Angle	I.B.	(°E of N)	O.B. (inclusive)
				13	E	90°	78.75		101.25
				14	ENE	67.5°	56.25		78.75
				15	NE	45°	33.75		56.25
				16	NNE	22.5°	11.25		33.75

[a]The X-coordinate refers to the radial designation and the Y-coordinate refers to the direction designation from the Table Detail. These are essentially polar coordinates with the angle specified in 22.5° sections. These are referred to in the designation of location in the AIRDOS-EPA computer program (Moore, 1979).

[b]AIRDOS number is the directional section number assigned to a segment for data input to the computer program AIRDOS-EPA.

made of the grid in Section 6. Major areas of interest within the grid are the communities (population centers) of Mercury (on the NTS), Amargosa Valley, Beatty, Scotty's Junction, Death Valley, Death Valley Junction, Johnnie, Pahrump, and Indian Springs. The major agricultural activities are found in Beatty, Pahrump, and between Amargosa Valley and Death Valley Junction. The only significant surface-water sources are the Amargosa River (highly alkaline), Crystal Reservoir (not used for irrigation) and various springs in the Ash Meadows and the Trough Springs areas (all of which are relatively small). Ephemeral surface-water bodies also exist; the most important of these is Fortymile Wash, which is located just east of the site and extends south towards U.S. Highway 95 near Amargosa Valley.

4.3.2.2 Las Vegas area

A very limited amount of environmental monitoring data may be collected in the Las Vegas area (even though Las Vegas is well over 100 km away) to satisfy 10 CFR 960.5-2-1, which requires demonstration that "during repository operation and closure, (1) the expected average radiation dose to members of the public within any highly populated area will not be likely to exceed a small fraction of the limits allowable under the requirements specified in section 960.5-1(a)(1)...."

4.3.3 SOURCES OF RADIOACTIVITY

Potential sources of radioactivity in the environment at Yucca Mountain before receipt of nuclear waste are

1. Resuspended radioactive materials originally present in the soils or attached to the biota.

2. Radioactive particulates released by other NTS activities or resuspended from other NTS locations.

3. Radioactive gases (H-3, C-14, various radioactive iodine isotopes) released by NTS activities from other NTS locations which may, with time, become associated with soils, surface water, or the biota.

4. Radioactive releases from the commercial low-level waste disposal activities located near Beatty, Nevada. The major indicators of releases are similar to those from the NTS (Items 2 and 3).

5. Planned releases of short-lived radionuclide tracers and the potential for accidental release of longer-lived radionuclides used during site characterization activities at Yucca Mountain and associated with well-logging and hydrological modeling activities.

6. Radioactive material dissolved or suspended in the groundwater or surface-water systems from past NTS activities. (The groundwater source may be essentially zero due to the travel time required for the water to reach the saturated zone, radionuclide transport rate

in the unsaturated and saturated zones, radionuclide decay rates, past NTS data referenced in Table 4-1, and projected groundwater flow paths.)

7. Radioactive material dissolved or suspended in the groundwater or surface-water systems from natural sources of radioactivity.

8. Radon/radon daughter products (see Appendix B for further discussion) released to the atmosphere, including existing release rates, enhanced release rates resulting from excavation activities, and enhanced release rates resulting from mining activities.

9. Natural radioactive material present in the soils or incorporated into the biota.

10. Worldwide fallout.

11. Naturally occurring radionuclides (e.g., Be-7, K-40).

Activity in the Yucca Mountain area is expected to be predominately either naturally occurring or from NTS activities; neither of these is expected to be large. The contribution from the nearby commercial low-level waste disposal activity is also expected to be negligible since it has very limited releases and is 40 kilometers (22 miles) away. The impact of the facility will be verified. The radionuclides of interest are summarized in Table 4-3. The radionuclides were selected based on several criteria:

1. The significant radionuclides based on the Environmental Pathway Analysis Scoping Study for the Yucca Mountain Site (EPASS) (SAIC, to be issued) which may be derived from the various NTS activities.

2. The significant radionuclides based on the EPASS which will be present at the site when operations are initiated.

3. Radionuclides specifically addressed in the long-term release limits (40 CFR Part 191, Appendix A, Table 1) of the EPA's criteria for geologic disposal of high-level waste, to provide comparison data for long- term assessments.

4. Radon/radon daughter products per the 30 CFR Part 57 criteria for worker exposure. Comparison to the public exposure criteria for uranium mills and mill tailings (40 CFR 192.12, 192.32, and 192.41) will also be used.

5. Radionuclides of significant half-lives or existing in significant quantities in spent fuel or high-level waste (references noted in Table 4-3).

6. Naturally occurring radionuclides will allow a check of the quality of the sample analysis, since these radionuclides are present in the samples as part of the natural environment.

Table 4-3. Radionuclides of interest (page 1 of 4)

Radionuclides	NTS[a]	Spent fuel[d] > 0.01% 10 years	Spent fuel[d] > 1% 10,000 years	HLW	Naturally occurring[b]	40 CFR 191 Table 2	Emissions[c]	Reference (See page 4 of table)
H-3	x						β (0.0186)	5, 6
Be-7					x		γ	
C-14					x	x	β (.156)	4
K-40					x		β, γ	
Fe-55		x					TC, x-rays	1
Co-60		x		x			β, γ	2
Ni-59			x				EC, x-rays	1
Ni-63		x		x			β (0.067)	1, 2
Kr-85	x	x					β, γ	1, 5, 6
Sr-89	0							5,6
Sr-90/Y-90	x	x		x		x	β	1, 2, 4, 6
Zr-93/Nb-93m				x			β (.06) x-rays	2
Tc-99			x	x		x	β (.292)	1, 2, 4
Ru-106/Rh-106		x					β, γ	1
Sn-126/Sb-126m/ Sb-126						x	γ, β	2, 4
Sb-125/Te-125m		x					β, γ	1
I-129						x	β (.15) γ (.04) x-rays	4
I-131	0						β, γ	6
I-133	0						β, γ	6
I-135	0						β, γ	6
Xe-133	0						β, γ	5, 6
Xe-133m	0						γ	6
Xe-135	0						β, γ	6
Cs-134		x		x			β, γ	2
Cs-135						x	β (.21)	4
Cs-137/Ba-137m	x	x		x		x	β, γ	1, 2, 4, 6

Table 4-3. Radionuclides of interest (page 2 of 4)

Radionuclides	Source: NTS[a]	Source: Spent fuel[d] > 0.01% 10 years	Source: Spent fuel[d] > 1% 10,000 years	Source: HLW	Source: Naturally occurring[b]	Source: 40 CFR 191 Table 2	Emissions[c]	Reference (See page 4 of table)
Ce-144/Pr-144		x					β, γ	1
Pm-147		x					β (.224)	1
Sm-151		x		x			β (.076) γ (.022)	1, 2
Eu-154		x					β, γ	1
Eu-155		x					β, γ	1
Rn-220/D					x		α, β, γ	3
Rn-222/D					x		α, β, γ	3
Ra-226			x		x	x	α	1, 4
Th-230					x	x	α, γ	4
Th-232					x	x	α	4
U-233					x	x	α	4
U-234			x		x	x	α	1, 4
U-235					x	x	α	4
U-236						x	α	4
U-238[e]	x	x	x		x	x	α	4
Np-237						x	α	1, 4
Np-239			x				β, γ	1
Pu-238	x	x		x		x	α	1, 2, 4
Pu-239	x	x	x			x	α	1, 4, 6
Pu-240	x	x	x			x	α	1, 4
Pu-241	x	x		x			β, x-rays	1, 2
Pu-242						x	α	1, 4
Am-241	x	x				x	α	1, 4
Am-243			x				α	1, 4
Cm-243		x					α	1
Cm-244		x					α	1

Table 4-3. Radionuclides of interest (page 3 of 4)

	Source							
		Spent fuel[d]						
Radionuclides	NTS[a]	> 0.01% 10 years	> 1% 10,000 years	HLW	Naturally occurring[b]	40 CFR 191 Table 2	Emmissions[c]	Reference (See page 4 of table)

Footnotes

[a]The "0" indicates these radionuclides are not asssociated with projected NNWSI activities but may be associated with Nevada Test Site (NTS) activities and could interfere with projected monitoring activities. Radionuclides not identified with a "0" also occur in potential waste forms for disposal at a repository. This is based on data reported in the annual environmental reports. It is projected that slight concentrations of all isotopes listed may be present.

[b]These are naturally occurring radionuclides which must be addressed per 30 CFR 57. Note other naturally occurring radionuclides (K-40 and Be-7) will be included in the analysis to allow evaluation of the analytical techniques.

[c]α = Alpha radiation, β = Beta radiation, and γ = gamma radiation. The energy values in MeV are provided for low energy β radiation as an indication of the difficulty in measurement. Also γ and x-ray emitting radionuclides, except the energy (in MeV) indicated, will be detected using gamma spectral measurements.

[d]Percent of total activity per fuel element.

[e]U-238 is not included in the actual percent of activity assessment due to its low specific activity. However, it is a very significant mass fraction, so it is included.

Table 4-3. Radionuclides of interest (page 4 of 4)

Reference Number Indicated Above	Source
1	ORNL/TM-9591/V1&2, Tables 3-5, 3-6, 3-7, 3-8, 3-9, 3-10.
	NOTE: >0.01% for 10 year old fuel. All listed isotopes to 10,000 year old fuel.
2	DP-1606, Rev. 1 (August 1983). Table 5 and Table 11.
	NOTE: >0.01%
3	NCRP Report 50, Section 2.3.5.
4	40 CFR Part 191, Table 2.
5	EPA/600/4-86-030. (Source of analytical interferences)
6	EPA/600/4-86/022. (Source of analytical interferences)

The specific analyses performed on samples (in other words, the radionuclides for which the various samples are analyzed) are discussed in the following sections and in Appendix E.

4.3.4 AIRBORNE MONITORING

The radiological monitoring program will include activities to monitor airborne radioactive particulates, radioiodine, tritium, and inert gases. These activities are discussed in the balance of this section.

4.3.4.1 Bases for monitoring airborne radioactivity

As indicated in Corley et al. (1981) and Walker (1987), the four categories of airborne radionuclides that should be considered for measurement in air sampling systems are particulates, gases (principally the inert gases), halogens (principally radioiodines), and tritium. Consideration of these airborne categories is important for environmental sampling and measurement because the categories account for most of the radioactive materials released from any site. The balance of this section describes the recommendation of Corley et al. (1981) and Walker (1987) relative to airborne radioactivity monitoring.

Because air is a primary exposure pathway to humans, air sampling should be conducted to evaluate potential doses to offsite inhabitants from inhaled radionuclides or from external radiation. Inhalation of airborne radionuclides, either directly from the source (facility) effluent or from resuspension following deposition, may result in radionuclide absorption by the lung or gastrointestinal tract. Human exposure may also result via (1) direct exposure to radiation originating in the plume or from ground deposition, (2) ingestion of contaminated foodstuffs or water, or (3) absorption of tritium through the skin.

Airborne radioactivity may be in either gaseous or particulate form. Radioactive materials in particulate form can result in radiation exposures to individuals both from inhalation and, externally, by deposition on soil and vegetation. Although particle-size range is a broad spectrum, only particles with diameters of about 0.01 to 10 microns (inhalable particles) are important in assessing internal deposition of particulates. The optimum size for deposition in the deep lung tends to be in the range from 0.01 to 3 microns (respirable particles). Deposition in the deep lung is typically the most important factor in assessing radiological risks by the inhalation pathway for long-lived radionuclides. One micron particulate diameter is often used as an assumed basis for dose assessments (ICRP (1979), pp. 23-27). However, most filters used for air sampling will collect particulates with diameters well beyond the respirable range. The efficiency of filters used to collect particulate materials should be considered when calculating the concentration of radionuclides in any air that is sampled. If releases of particulate materials could contribute significantly to human doses, measurements of particle size should be made.

Inert-gas analysis (e.g., Kr-85 and Xe-133) can be performed by sequential collection of an air sample by compression or cryogenic techniques, separation and purification of krypton and xenon by adsorption on chromatographic columns, and liquid scintillation counting (Grossman and Holloway, 1985; Trevethan and Price, 1985). Radon/radon daughter products are typically measured directly in the field, as described in the PSCRMP.

Atmospheric releases of halogens, specifically radioiodine, can expose the thyroid and whole-body via several exposure pathways including inhalation, immersion (direct radiation) (Section 4.3.8), and ingestion (milk and other foodstuffs) (Section 4.3.7). The inhalation pathway is normally assessed by air sampling. The external radiation component is assessed along with other external radiation sources by dosimeters (as described in Section 4.3.8).

Environmental tritium can be found as a gas and as tritiated water vapor. In terms of exposure potential, tritiated water vapor yields a dose equivalent approximately 25,000 times that of an elemental concentration of tritium gas. For this reason, tritium sampling techniques employ methods that collect moisture from the air.

4.3.4.2 Location of air monitoring stations

Location of the air monitoring stations requires consideration of various technical factors which are discussed in the following sections.

4.3.4.2.1 Basis for determining the location of air samplers/monitors

DOE guidance (Corley et al., 1981) indicates that locations will be selected to measure radionuclide concentrations that may be inhaled by the population surrounding a nuclear facility. Special care must be taken with selection of background sampling and measurement locations for air. A minimum distance of 15 to 20 kilometers from the release point in the least prevalent wind direction is suggested for background sampling.

The DOE requires that far-field (beyond 15 kilometers) air samplers be employed unless it is established at some time in the future that releases result in an annual whole-body dose equivalent less than 1 mrem (organ dose equivalent less than 3 mrem) to the maximally exposed individual.* If they are not to be used, NRC concurrence with the elimination of these specific samplers may be needed. Because of the nature of present and future NNWSI Project activities, far-field air samplers are required for the following locations: a background or control location; locations of maximum predicted ground-level concentration from stack (or vent) releases, averaged over a

*This is currently being revised by the DOE in terms of the new ICRP (1977) and ICRP (1979) dosimetric models, probably in terms of dose equivalance.

period of one year where members of the public reside or abide; and locations in the nearest community within a 15-kilometer radius of the site. For sites larger than a few kilometers in radius, the maximum predicted concentrations may actually be onsite. Therefore, Yucca Mountain near-field sampling will be included to predict maximum concentration(s) and to help interpret the far-field sample results. Assuming the requirements similar to those applied to power reactors are applied to this facility, the required minimum number of air samplers in the location of predicted maximum airborne concentrations is three (Table 1 of Conti et al., 1978).

Radon/radon daughter product sampling activities will be restricted to the near-field area. Far-field sampling would provide data on offsite (far-field) natural sources and would be essentially useless.

The method developed and evaluated by Waite (1973a,b) was used to determine the number and placement of current air sampling stations and will be used to revise placements as needed when facility locations are established. Waite's method entails consideration of demographic and meteorological data for the site, the distance to local population centers, their population, and the wind frequency distribution. Since projected exposure data are not available, monitoring data will be collected based on limiting case meteorological assumptions and Table 4-4.

Unless site-specific conditions exist to justify otherwise (none have presently been identified), the sample(s) at each air sampling station will be collected at a height of 1 to 1.5 meters above ground level in a location free from unusual localized effects or other conditions (e.g., proximity of a large building, vehicular traffic) that could result in artificially high or low concentrations. Where possible, locations will also be selected to avoid areas where large-particle (nonrespirable) fugitive dusts can dominate the sample (Ludwig, 1976). Implementation of this DOE guidance will satisfy the guidance in Conti et al. (1978) and that indicated in Section 4.3.2.1.

4.3.4.2.2 Location of air samplers/monitors

The radiological monitoring program for airborne radioactivity for Yucca Mountain is described in this section and conforms to the DOE guidance discussed in Section 4.3.4.1.

The primary considerations used in locating the air samplers for the site characterization phase are

1. The existing potential sources of radioactivity to the north and east of the Yucca Mountain site from DOE defense programs and past activities.

Table 4-4. Criteria for environmental surveillance

Topic	Criteria
Ingestion or inhalation pathways	All environmental media shall be routinely sampled and analyzed (for the critical radionuclides to dose) if the annual total effective dose equivalent from the site of origin as determined by site-specific radiation exposure pathway analysis, exceeds: (a) 1 mrem to offsite individuals or critical population groups; or (b) 100 person-rem collective effective dose equivalent per million individuals of the population within 80 km.
External radiation (including immersion and submersion doses)	Routine penetrating radiation measurements shall be performed at those sites that, as determined by site-specific exposures pathway analysis, might result in an annual dose equivalent of site origin, if the total exceeds: (a) 5 mrem to the whole-body or 15 mrem to the skin of offsite individuals or critical population groups; or (b) 100 person-rem collective effective dose equivalent per million individuals of the population within 80 km.
Pathway measurements	Actual measurements on two media for each critical radionuclide/pathway combination, one of which might be the effluent stream, shall be performed as part of the site routine effluent monitoring and environmental surveillance program.
Use of control data	Measurements shall be based on statistically significant differences between the point of measurement and background (or control) data.
Unplanned releases	Provisions shall be made, as appropriate, for the detection and quantification of unplanned releases of radionuclides to the environment.

2. The prevalent wind directions (based on the wind rose at the potential repository site), with winds predominantly from the NW to N and S to SSE (Figures 4-2 and 4-3).*

3. The major agricultural area in the section from SSE to SW of the site (EPASS).

4. The topography of the near field (Figure 4-4).

5. The population distribution of the immediate area (most of the population within 84 kilometers of the site is located on or south of U.S. Highway 95).

6. Significant present and future NNWSI Project activities in the area.

7. The location of the existing PSCRMP air sampling station and the air sampling station associated with the weapons testing program (Table 4-4).

8. Location of existing power and meteorological stations (Figure 4-4).

9. The potential future radionuclide release points will be in the exploratory shaft area and the facility area for the final design (Figure 4-4).

Figure 4-5 summarizes the proposed air sampling locations in the near-field area. The solid black squares represent air sampling stations in Figure 4-5. Figure 4-6 summarizes the location of the proposed air sampling locations in the far-field area. In Figure 4-6, the open squares indicate the locations of existing EPA sampling stations, the black squares in the triangles indicate the location of some of the existing REECo air samplers (Gonzalez, 1986) at which NNWSI Project samplers will be installed, the black square in the diamond is a proposed location on Air Force land which will require the consent of the Air Force, and the plain solid black squares are other proposed locations. The basis for the air sampling locations is summarized in Table 4-5. Note that the only new far-field air sampling stations being added to the current NTS program are stations 15, 16, 19, and 25 to monitor the Amargosa Farms area, and stations 21, 23, and 26 to provide data on an unmonitored section of the wind rose. Power is available at stations 21 and 26. The near-field air sampling system is designed to characterize any airborne radioactivity concentration moving into or out of the Yucca Mountain area.

In addition to those air monitoring stations that will be associated with RMP activities, the EPA operates a number of stations to support other NTS activities (Figures 4-7 and 4-8). Data from those locations will be

---

*Complete data on the meteorological conditions in the near-field area can be obtained from the "NNWSI Project First Annual Meteorological Data Report" (to be published).

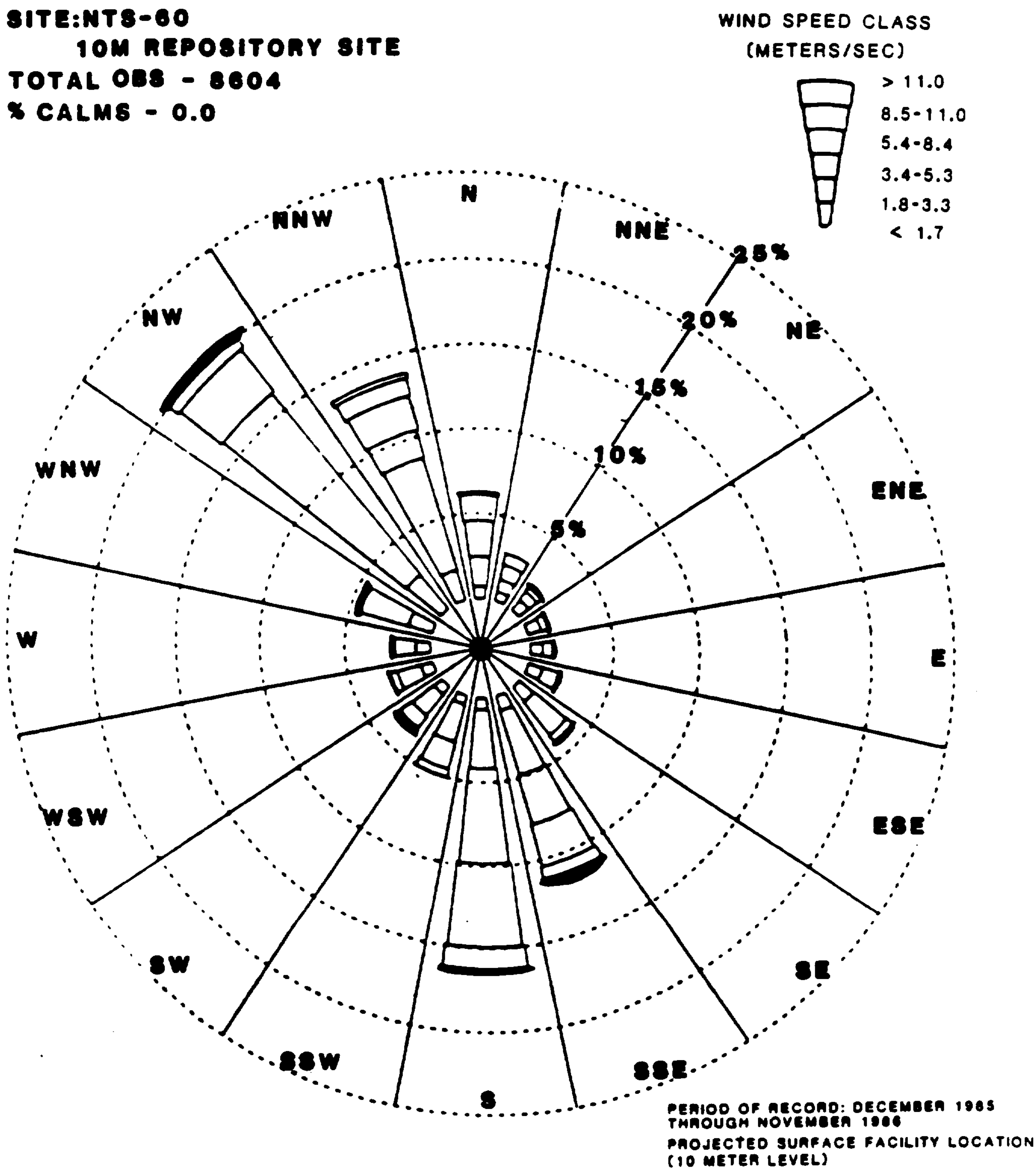


Figure 4-2. Annual wind rose for the 60-meter tower at the repository site (10-meter level).

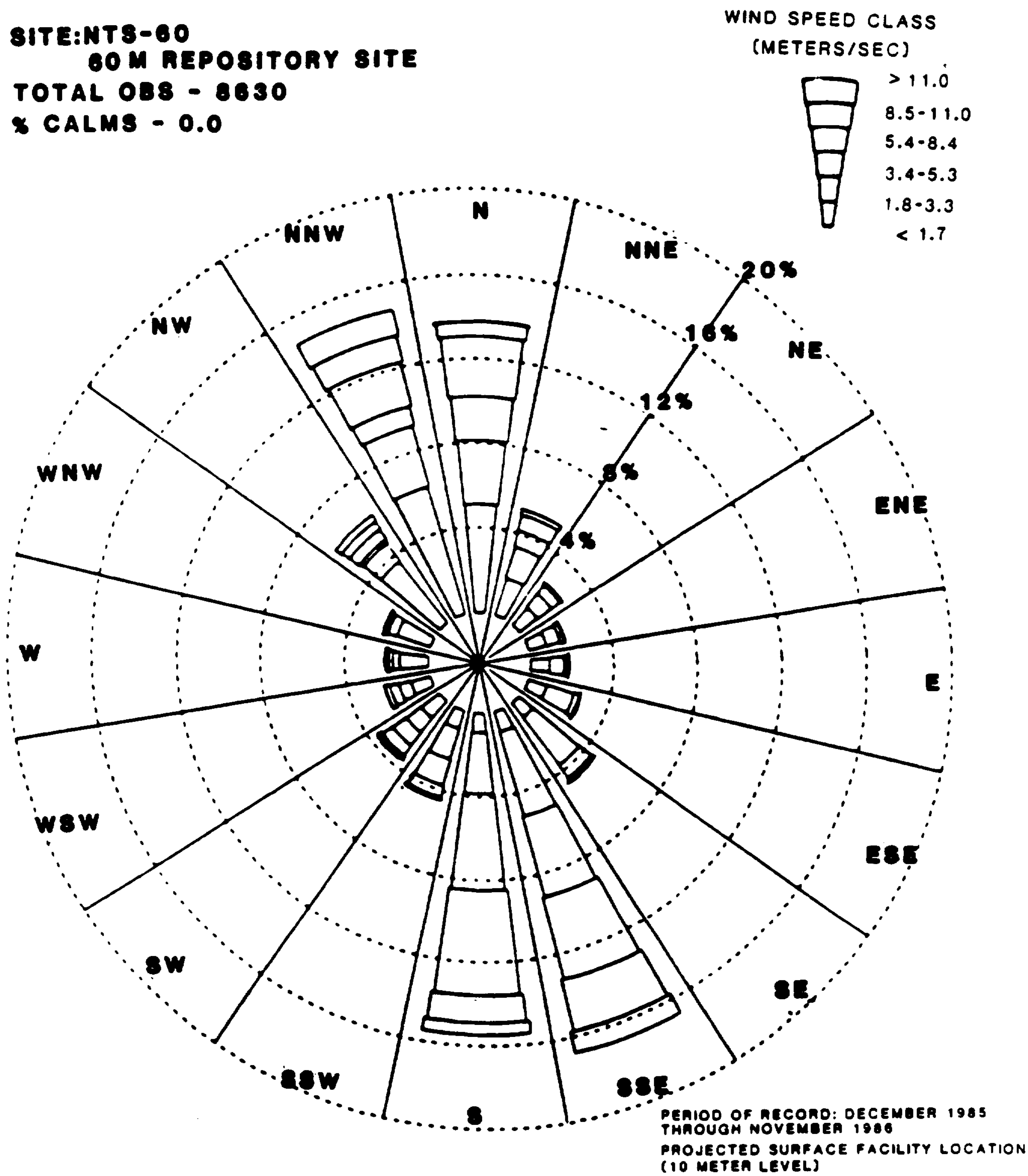


Figure 4-3. Annual wind rose for the 60-meter tower at the repository site (60-meter level).

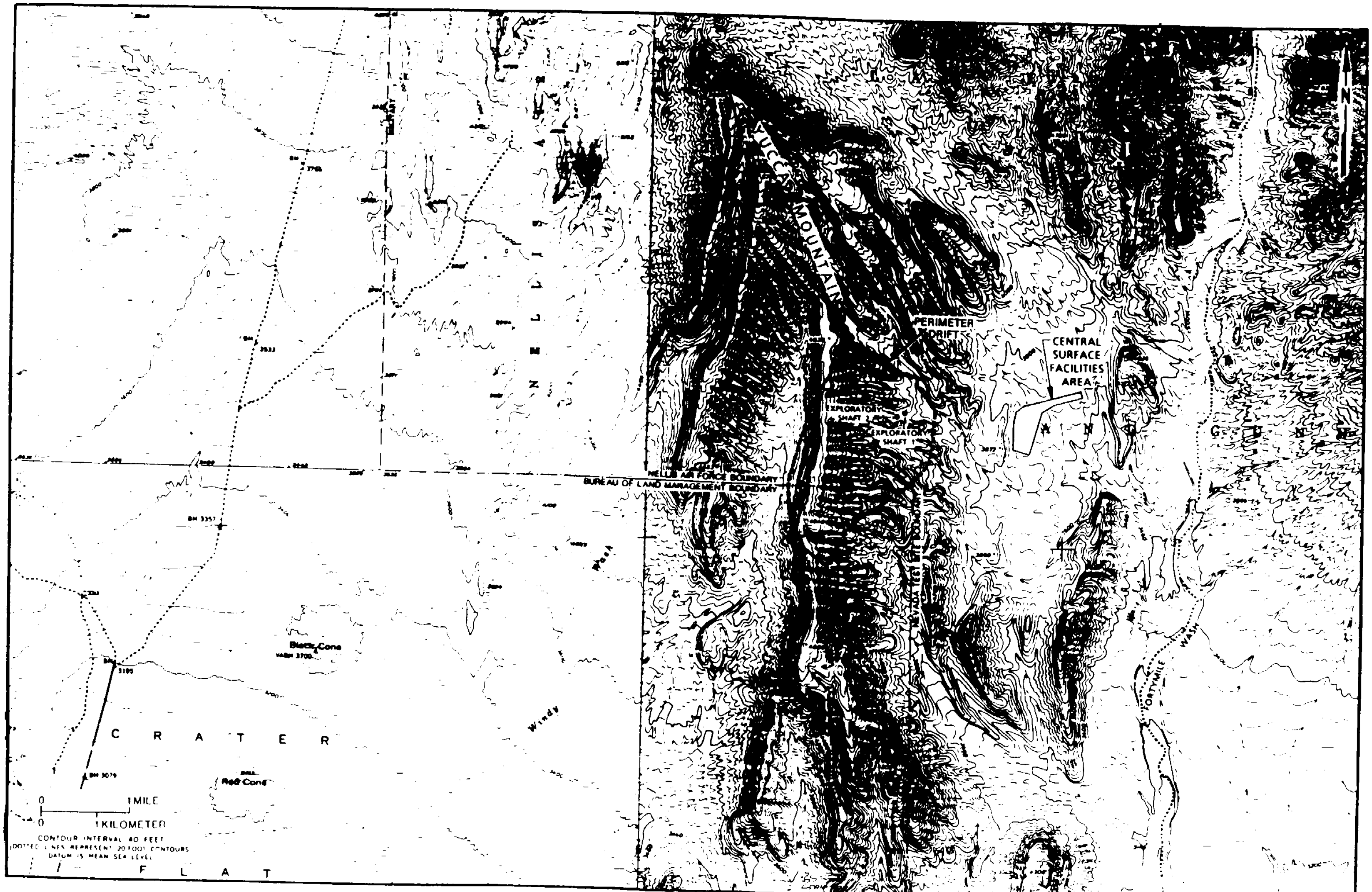


Figure 4-4. Yucca Mountain near-field topography.

4-27

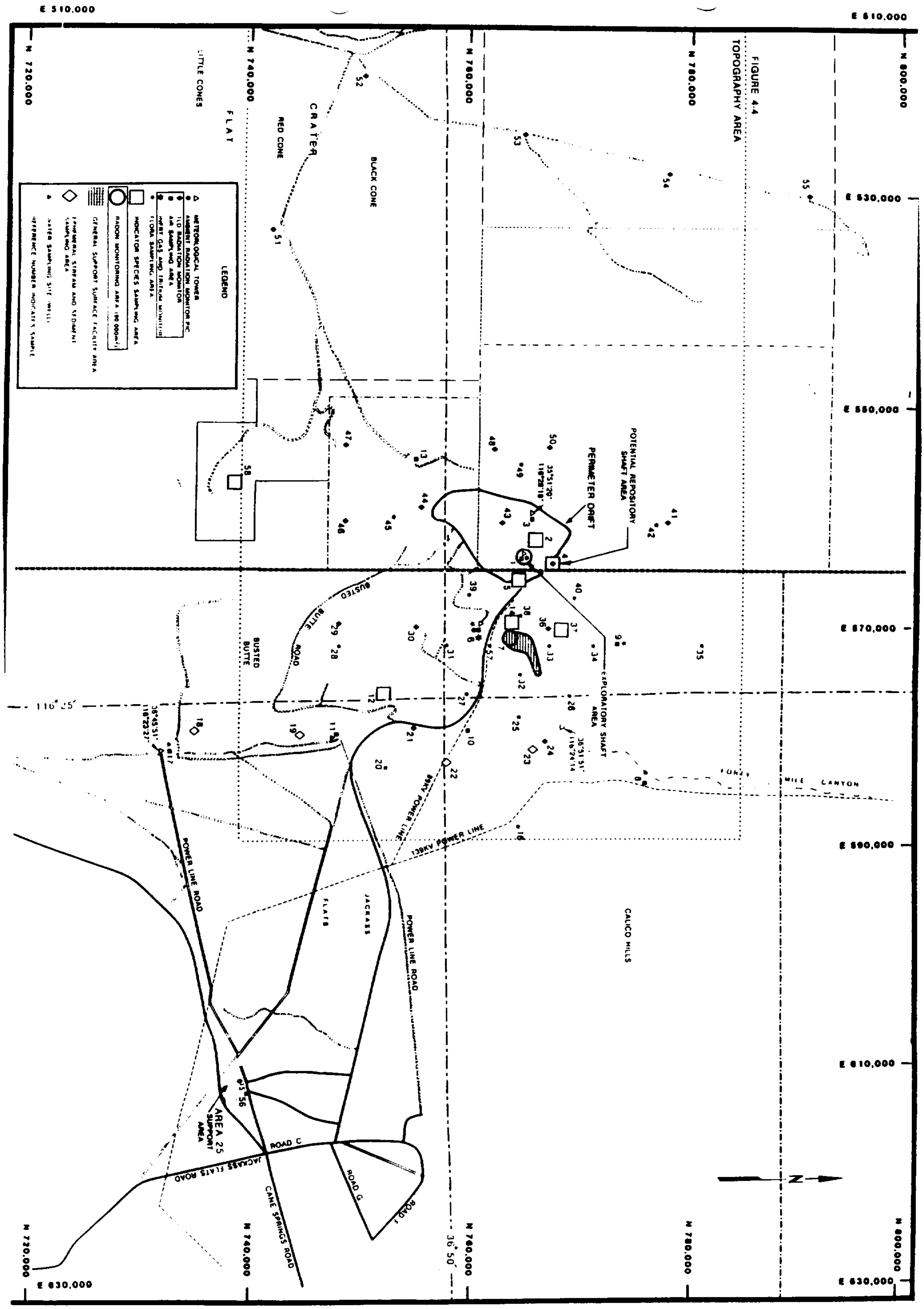


Figure 4-5. Near-field sampling locations

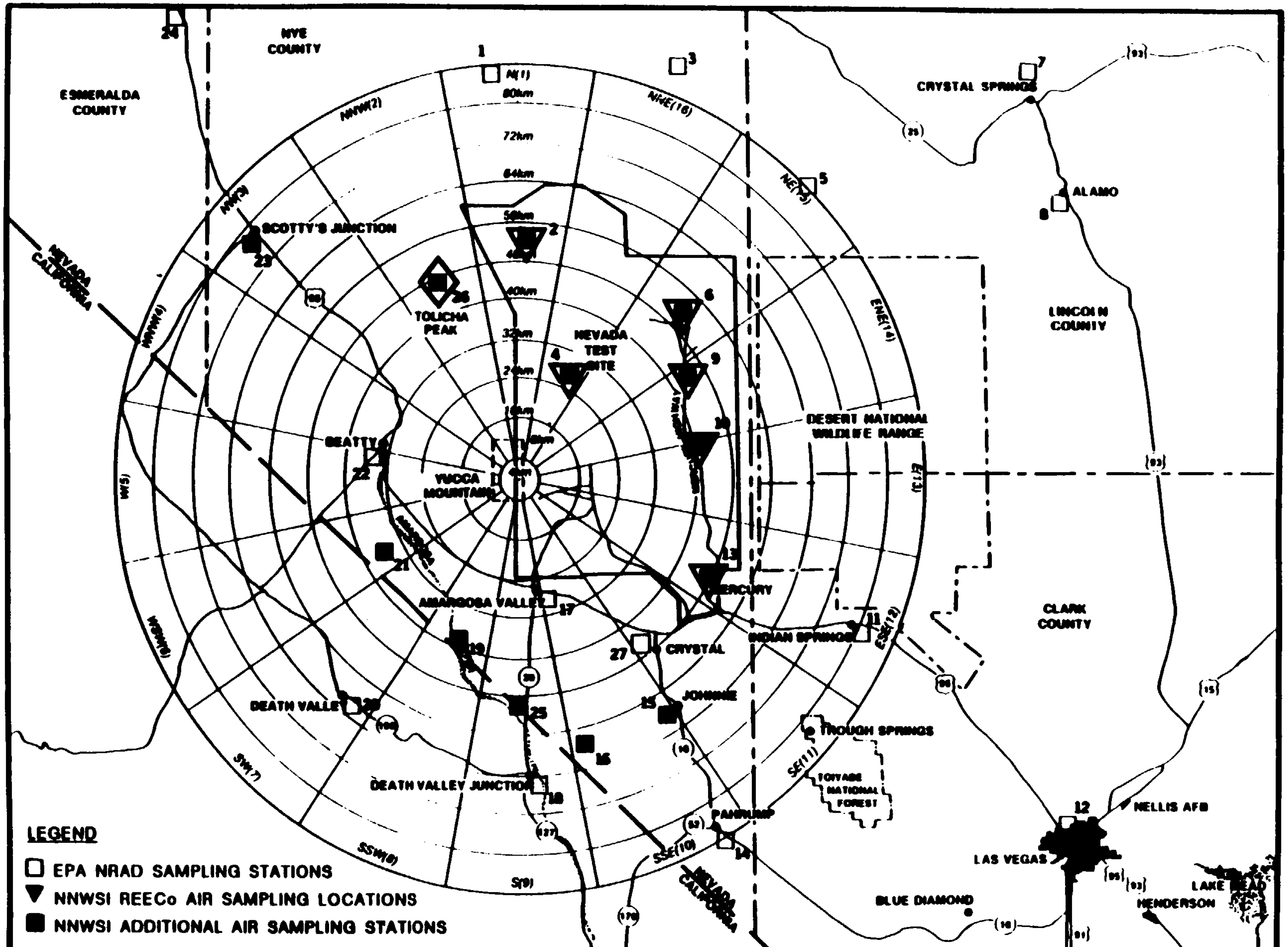


Figure 4-6. Far-field air sampling locations.

Table 4-5. Air sampling stations[a]

Station numbers[b]	Justification
NEAR FIELD[c]	
8, 9, 10, 11, 17	Monitor the concentration of potential airborne radioactivity from NTS source
6[d]	Monitor concentration at the surface facility area
1	Monitor concentration at the exploratory shaft area
3	Monitor concentration on top of Yucca Mountain due to topography
13	Monitor concentration moving offsite from easterly winds
FAR FIELD[e]	
2, 4, 6, 9, 10, 13	Monitor existing potential concentration leaving the Yucca Mountain area based on existing REECo monitoring
14[d], 15, 16, 18, 2, 19, 25, 27[f]	Monitor primary agricultural and rural population area
7, 8, 11[d], 14[d], 15, 17[d], 18, 20, 22[e,d]	Monitor existing concentration at nearby population centers
21, 23, 26	Monitor significant area of the wind rose not covered by other monitoring in this RMP program
1, 3, 5[d], 7, 8[d], 23, 24	Supplement concentration data for an area where the population is very low, but limited data exists using data from the existing EPA program
12[d]	Monitor closest urban area

[a]Appendix E provides details of the entire sampling program.
[b]Non-routine particle-size samples are taken at these locations.
[c]Figure 4-5.
[d]Includes tritium and noble gas samplers.
[e]Figures 4-6 and 4-7.
[f]An EPA monitoring location recently established and not listed in referenced EPA documentation.

Figure 4-7. EPA Air Surveillance Network stations.

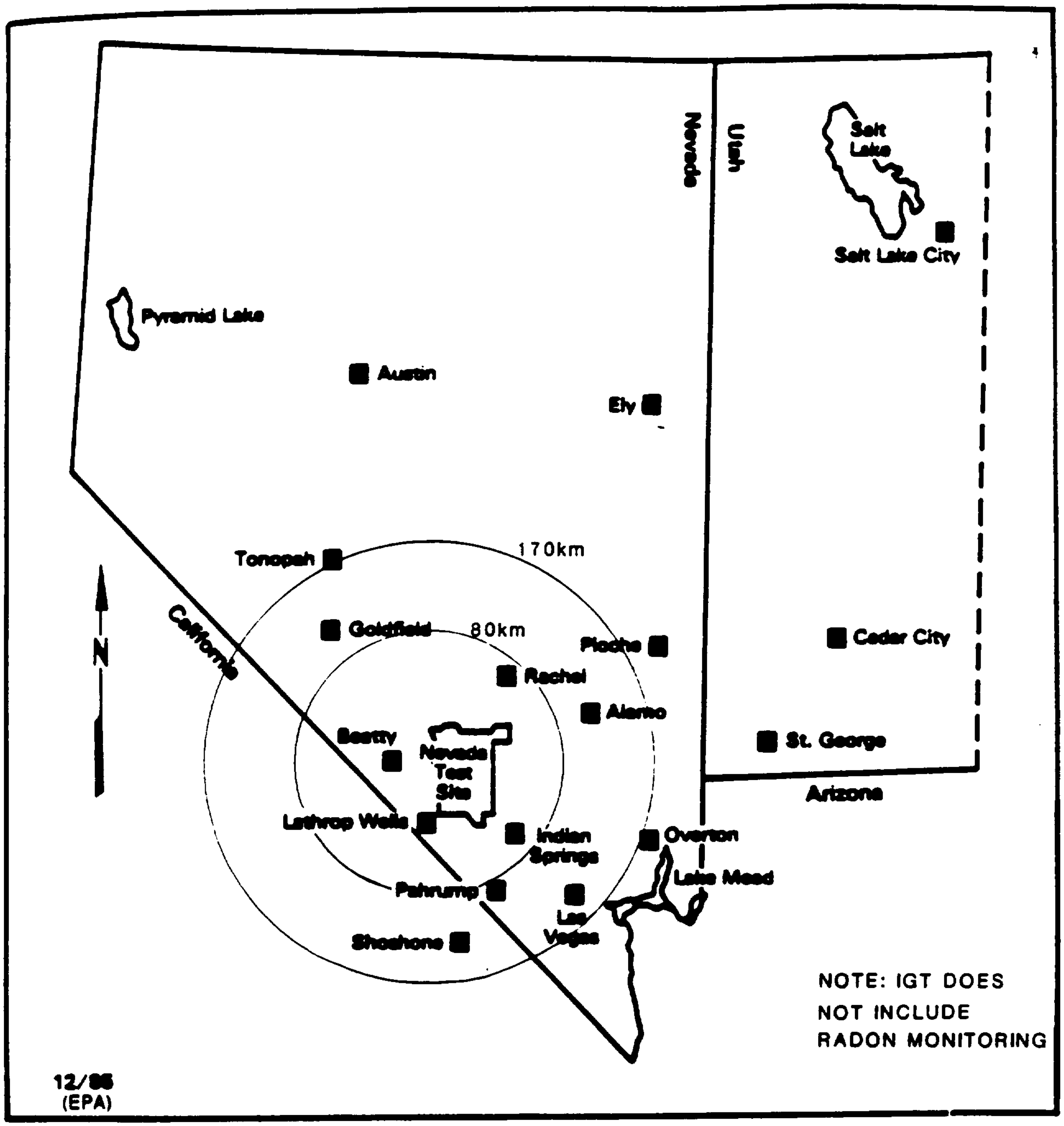


Figure 4-8. Inert gas and tritium surveillance network sampling locations.

available for the radiological monitoring program. Also, on the NTS, REECo operates a large air sampling grid as described by Gonzalez (1986). Supporting data from these air monitoring programs will be available for evaluation of the NNWSI Project activities.

When the program is revised at the preoperational phase, an air sampling configuration based on meteorological data and topography will be laid out around potential sources. Representative data will be collected at the site characterization phase and preoperational phase sampling locations and then the site characterization station that is not part of the new configuration can be eliminated. The current configuration, in addition to monitoring site characterization, is designed to provide data on existing site conditions and how they may be changing. During this period, some of the sources will be outside the near-field area.

4.3.4.3 Sample collection frequency

It is essential that appropriate sampling frequencies be identified. With the exception of particulate size sampling, this discussion addresses sample change frequency, since sample collection activities are essentially continuous.

Based on DOE guidance (Corley et al., 1981; and Walker, 1987), the frequency of collection for air samples is adjusted to take into account the limitations of the sample collectors, the capabilities of the air movers, and the physical problem of retrieving samples from each location on a fixed frequency. Typically, frequency of collection is every one to two weeks. Dust loading of the filter will generally determine the sampling period. Dust loading increases the differential pressure across the filter to a point where the equipment can no longer ensure a constant flow rate.

Since reducing the sampling period also reduces the total activity on the sample, measurement of airborne radioactivity concentrations can become less sensitive. The common practice, especially for the longer-lived radionuclides, has been to composite filters from several locations or successive time periods for subsequent analysis, taking advantage of the larger volume of air sampled to achieve the desired sensitivity. Compositing is appropriate since the applicable standards pertain to annual average concentrations, and comparison of annual averages to the standards is desirable. Also, averages for successive years can be compared for detection of general trends. However, compositing does not permit a ready correlation of environmental concentrations with the releases from a given facility, nor does it provide a reliable indication of an elevated release of short duration (because of dilution with uncontaminated or low-level samples). Therefore, the air samples will be individually subjected to a screening level analysis for gross alpha and beta activity. Unless unusually high activity is detected, the samples will then be analyzed as quarterly composites to provide additional data on the seasonal variations. If unusually high activity is detected, the individual sample will be analyzed per Table 4-6, rather than as part of the quarterly composite. Typical activity will be based on data generated at the beginning of this program and the action levels indicated in

Table 4-6. Air sample analyses[a]

Sample	Analyses
Particulate filter media	Gross Alpha and Beta Counting Gamma Spectral Analysis Alpha Spectral Analysis or specific analyses for Po-210, Pb-210, Th-230, Np-237, Ra-226, Pu-238, Pu-239, Pu-240, Am-241, Am-243, Th-232, Cm-243, and Cm-244 Total Uranium Analysis[b] Specific Isotopic Analyses for Sr-90, Sr-89, Tc-99, and Pu-241
Charcoal cartridge	Gamma Spectral Analysis
Inert gas monitor	Gas chromatography and liquid scintillation counting
Tritium monitor	Tritium
Flora	C-14
Radon monitoring[c]	Continuous Radon Monitor Passive Track Etch™ Monitor (Radon Monitor) Augmented Track Etch™ Monitor (Radon Daughter Product Monitor) Working Level Measurements

[a]Appendix E provides detailed summary of sampling program.
[b]Non-routine isotopic uranium analyses will be performed.
[c]See Appendix B for a discussion of radon/radon daughters and working levels.

the attachments to DOE Order 5480.XX. Any unusually high activity will be reported to the DOE/NV Health Physics and Environmental Division (HPED) and evaluated to determine if further actions are appropriate.

The limitations of the inert-gas collection system stem from the gas storage capacity of the sampler. Based on this, the sampling frequency for inert gases will be weekly.

For air sampling of gaseous iodide, the available tradeoff between sensitivity and frequency of sample removal is governed primarily by the fact that "breakthrough" can occur with the charcoal cartridges used for radioiodine collection. These breakthrough phenomena can be based on flow rate, total volume, activity, or a combination of these. The exchange frequency for these samples will be determined by the capabilities of the most technically feasible and cost effective sampling techniques for radioiodine having the required sensitivity.

Iodine sampling will be conducted in a manner consistent with the DOE's NTS practices using activated charcoal cartridges following the particulate air sample filter media in a continuous air sampler. Because the EPA has emphasized its concern with I-129 in 40 CFR Part 191, measurements should be made on an annual basis at site-perimeter and control stations to characterize the local site environs. It is also recommended that the relationship between I-129 and natural iodine (I-127) be determined so changes in iodine uptake rate versus changes in radionuclide concentrations can be separated. However, it is assumed that because of the extremely long half-life of I-129, its accumulation (if any) in the environment will be better observed in animal thyroids or milk (Smith, 1977) rather than air (Section 4.3.7). In fact, the EPASS indicates that milk is the limiting pathway for I-129.

As indicated by the DOE guidance previously discussed, the sampling frequencies are dependent on radionuclide type, chemical form, and equipment. As a result, the frequency of air sample collection will be discussed in the sections addressing each type of air sampling/monitoring system. These air sampling activities are essentially continuous, and the question is one of collection frequency.

4.3.4.4 Air sampling/monitoring systems

Five separate activities (based on the characteristics of the media to be collected) will make up airborne radioactivity sampling: airborne particulate sampling, iodine sampling, C-14 sampling (CO_2), tritium sampling, and inert-gas sampling/monitoring. Because the iodine sampling system will be an integral part of the particulate samplers, these activities will be discussed together. Inert-gas and tritium sampling will be discussed separately since the required monitoring/sampling equipment is different from that required for particulate and iodine sampling. It should also be noted that the ambient airborne radiation data (Section 4.3.8) will be used for cloud immersion dose assessment.

4.3.4.4.1 Particulate and iodine sampling

Most of the radioactive material associated with present and future activities at Yucca Mountain will probably be attached to nonradioactive particulate material. The radionuclides identified in Table 4-6 are specifically addressed in the analyses of particulate samples, except for the radioiodine, inert gases, radon/radon daughters, and tritium.

Iodine isotopes (I-131, I-133, and I-135) will be specifically addressed in the analysis of the activated charcoal cartridges. The I-131, I-133, and I-135 will not be related to NNWSI Project activities due to their short half-lives, but might be released by NTS activities. The monitoring activity for particulates and iodine has been initiated at location 6 (Figure 4-5).

This activity is described in the Preliminary Site Characterization Radiological Monitoring Plan (PSCRMP). I-129 sampling is currently not feasible in air. Possible methods of analysis will be evaluated. In addition, ambient concentration will be evaluated using a natural concentrator (beef thyroids and milk). This is discussed further in Section 4.3.7.1.1.

The samplers used to collect the samples are consistent with those used in ongoing NTS activities and will be calibrated in a manner consistent with Regulatory Guide 8.25. The basic parts of the sampler are shown in Figure 4-9. The sampler uses a glass-fiber filtration medium which will have a collection efficiency of at least .995 (penetration efficiency .005) for 0.3 micron particulates at a face velocity of 50 cm/sec. The differential pressure across the filter at a flow rate of 50 cm/sec is less than 40 mm Hg 50 cm/sec. The activated charcoal cartridge is impregnated with 5 percent triethylene diamine to improve the retention of iodine. The sampler is capable of maintaining a constant flow rate of 3 cfm through the filters with dust loadings equivalent to coverage of 50 percent of the filter's surface.

The particulate samples (filter media) will be individually counted for gross alpha and beta. A delay of at least 72 hours prior to counting allows for the decay of the radon daughter products collected. A quarterly composite of the samples will then be analyzed as described in Table 4-6. If unusual amounts of activity (significant activity above background) are detected during the gross alpha and beta counting, the sample will be analyzed separately rather than as part of the quarterly composite. This analysis will be initiated within five days of the gross counting. If the analyses indicate high concentration or unusual isotopes, the Waste Management Project Office (WMPO) and HPED will be notified. Appropriate protective action will be taken and every effort will be made to determine the source of the activity.

Sample analyses will be performed by the EPA Nuclear Radiation Assessment Division (NRAD) Laboratory, which is also responsible for conducting the Environmental Radioactivity Laboratory Intercomparison Studies Program. This program is operated by the Environmental Monitoring Systems Laboratory (EMSL) in Las Vegas, Nevada. The analyses will be conducted according to the EMSL's established procedures and will be consistent with NRC and DOE requirements. Typically, the analyses and minimal detectable activity reporting are consistent with the recommendations of the EML in Harley (1986), NRC (1979), Corley et al. (1981), Conti (1978), NCRP (1984), ORP (1980), and Currie (1984).

As previously mentioned, airborne radioactive particulates are typically attached to nonradioactive carrier media. The behavior of these particulates is a function of their size, shape, and mass. They can be characterized in terms of their mean aerodynamic equivalent diameter (AED), which is based on their behavior in the airstream. The AED specifies the diameter of a spherical particle with a density of 1 gram per cubic centimeter which would behave in the same manner as the actual particles (Hidy, 1984). The AED can be used to estimate (1) deposition and retention patterns in the lungs, (2) the ground deposition velocity, and (3) the potential for resuspensions.

The AEDs will be determined by using either a high flow-rate cascade impactor with the characteristic attributed to a Sierra-ERC Tag described in Table B-16 of Lioy (1983), or a low flow-rate cascade impactor with characteristics consistent with a Sierra-Series 210 ambient cascade impactor. A

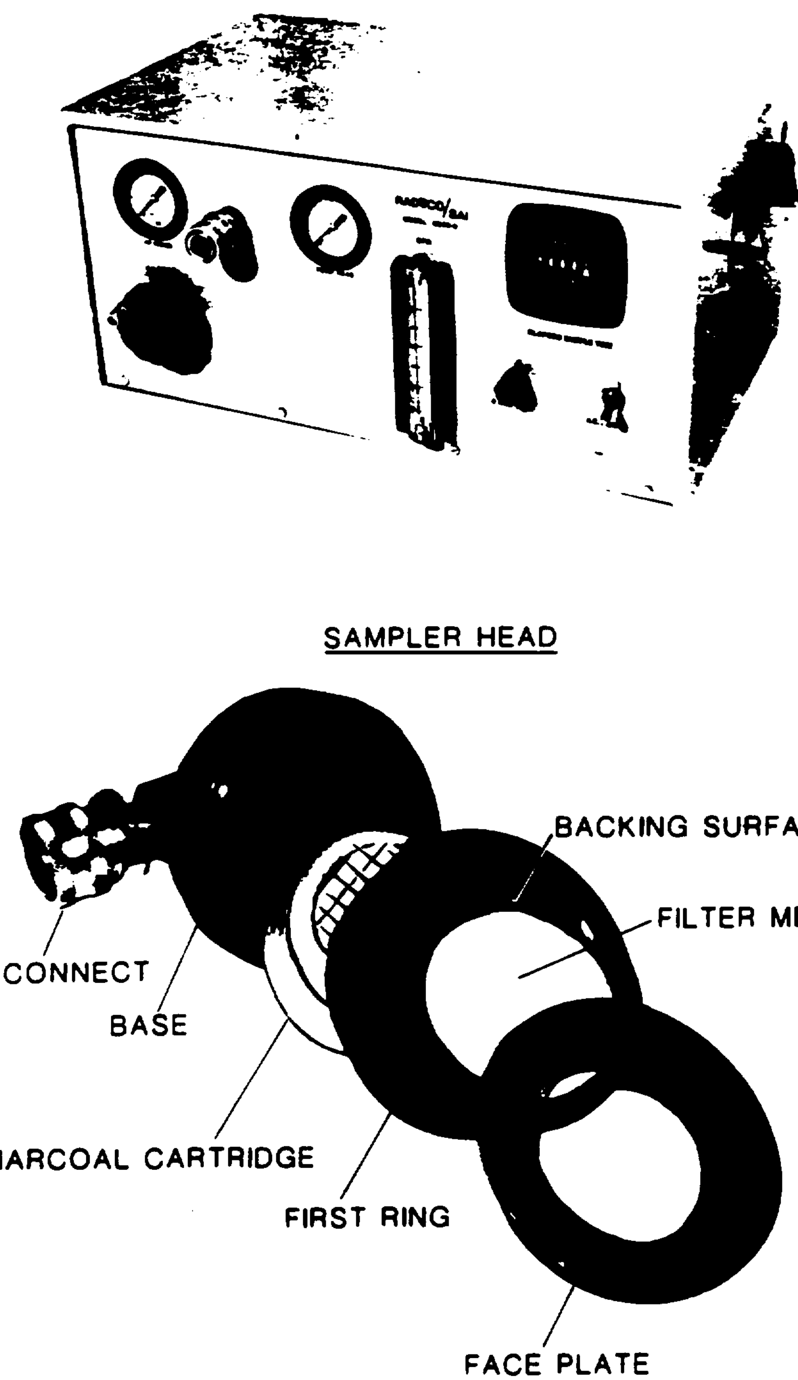


Figure 4-9. Continuous air sampler.

sample will be obtained at several sampling locations every quarter to be used for the particle size characterization.

Particle size samples collected with the cascade impactor will be analyzed individually after the weight fraction of particles has been determined. The radiological analyses typically performed on these samples will be the same as those for the quarterly composite particulate samples. To assess individual particle size, as well as AED, a very small percentage of these samples may also be analyzed using electron microscopy and other specialized techniques.

4.3.4.4.2 Tritium and inert-gas sampling

Because of the very small impact the Yucca Mountain facility should have on the existing tritium and inert-gas concentrations, and because of the high quality of the existing EPA program, the sampling scheme for tritium and inert gases will be very limited. The specifics of the radon, tritium, and inert-gas (non-radon) sampling and monitoring program are presented in subsequent sections. All references to inert gases in this section specifically exclude radon and radon daughters, except for the discussion presented in Section 4.3.4.4.2.2.

4.3.4.4.2.1 Tritium and inert-gas (non-radon) samplers

In addition to the existing EPA station shown in Figure 4-8 and the Yucca Mountain site location shown in Figure 4-5, two temporary samplers will be initially located at stations 21 and 25 of Figure 4-6. Later on, these samplers will be moved to various other locations (primarily in the east-southeast (ESE) to West (W) section of the grid) to determine if additional samplers are needed to characterize the dispersion of tritium and non-radon inert gases due to meteorological, topographic, source, or other effects. Additional permanent samplers will be added to the program as needed to adequately characterize the environment based on these results.

Both the equipment currently in use by the NRAD in sampling tritium and the equipment being evaluated by the NRAD for inert-gas sampling will be used in the radiological monitoring activities. This equipment is described in the following paragraphs.

Tritium sampler. The tritium sampler consists of a moisture trap, a "fish pump" (aquarium aerator), a thermograph (recording thermometer), a miniature rotometer (air-flow gauge), and appropriate tubing -- all inside a compact refrigerator. Outside, there is a small, screened inlet attached to a tube that carries air into the refrigerator. The fish pump draws air through the screened inlet into the refrigerator through the moisture trap, and expels it from the refrigerator. The refrigerator keeps the moisture trap at a uniform temperature. The moisture in the air is collected in the moisture trap as water, which contains any tritium present in the form of tritiated water. The recording thermometer provides both an instantaneous reading and a record of the temperature inside the refrigerator.

A technician removes the moisture trap at appropriate intervals, usually weekly, replacing it with a fresh trap. The Environmental Radiological Monitoring (ERM) Team and the NRAD take the full trap, containing the moisture sample, to the NRAD Laboratory where the sample is analyzed for tritium.

The sampler's design is illustrated in Figure 4-10. Figure 4-11 is a photograph of an NRAD tritium and inert-gas sampling station. The small refrigerator contains the tritium sampler.

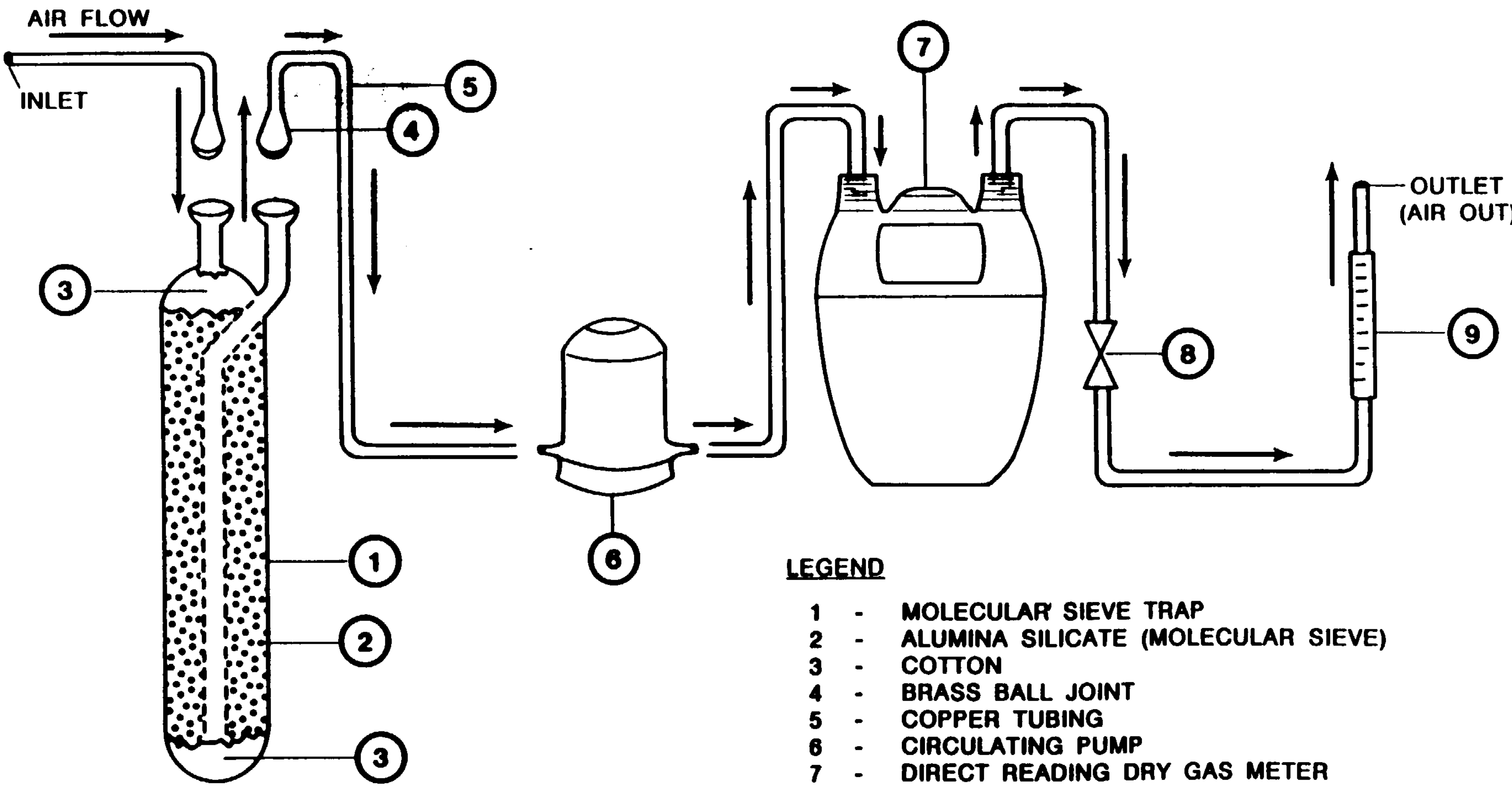
Inert-gas sampler. This discussion is from Andrews (1977). The inert gases will be collected as a whole-air sample which can be separated for analysis in the laboratory. A laboratory technique has been developed making it possible to do quantitative analysis for the radionuclides of interest with a sample volume of 0.5 to 1 cubic meter (m^3) of air. The method selected to provide the simplest operation in the field is compression of the air sample for ease of transport. Frequency of collection is weekly. Because of desires to collect split samples for backup or duplicate laboratory analysis, the sampler is designed for a collection rate of 2 m^3 per week, or about 3.3 cm^3 per second at standard temperature and pressure (STP 0°C, 1 MPa). The air is to be collected as two samples of 1 m^3 each. The basic design of the sampler calls for a primary collection tank which can be filled steadily at the design flow rate of the compressor used to fill the primary tank. Then the sample pressure tanks are periodically filled using a pressure-activated switch and automatic valves to remove air from the primary tank. The basic system is shown in Figure 4-12. A pressure of 3.25 MPa permits sampling periods longer than 168 hours, if necessary, while still providing an adequate safety factor.

Sample volume is determined from the net weight of air collected. The pressure tanks are evacuated in the laboratory and tare weights are measured. In the laboratory, the full tanks are weighed and the net weight is divided by the weight of one cubic meter of air (1293 g) to obtain the volume under standard conditions.

4.3.4.4.2.2 Radon/radon daughter product samplers

The radon monitoring activity focuses on monitoring of airborne radon and its daughter products. Since the daughter product concentration varies with time until equilibrium is reached, this activity is typically measured in a special unit called a working level (WL) (Appendix B provides additional explanation). Figures 4-13 and 4-14 provide detailed layouts of the area. The air underground will be monitored for radon/radon daughter products in the main drifts and near the working face. Air-flow data for the underground area will be collected to allow evaluation of the radon data. The existing aboveground radon monitoring program is described in the PSCRMP. The inert-gas sampling program described in Section 4.3.4.4.2.1 will also provide radon data on the air sampled.

In addition, the possibility of evaluating radon concentrations in G-tunnel and in various drillholes in Area 25 will be evaluated to provide early data on radon emanation from tuff. The drillhole data may also provide information to support seismic geological evaluations.



LEGEND

1 - MOLECULAR SIEVE TRAP
2 - ALUMINA SILICATE (MOLECULAR SIEVE)
3 - COTTON
4 - BRASS BALL JOINT
5 - COPPER TUBING
6 - CIRCULATING PUMP
7 - DIRECT READING DRY GAS METER
8 - AIR CONTROL VALVE
9 - 0-700 cc/MIN. FLOWMETER

NOTE: SEE TABLE 4.3.4-4 FOR ADDITIONAL DATA ON THIS EQUIPMENT

Figure 4-10. Tritium air sampler.

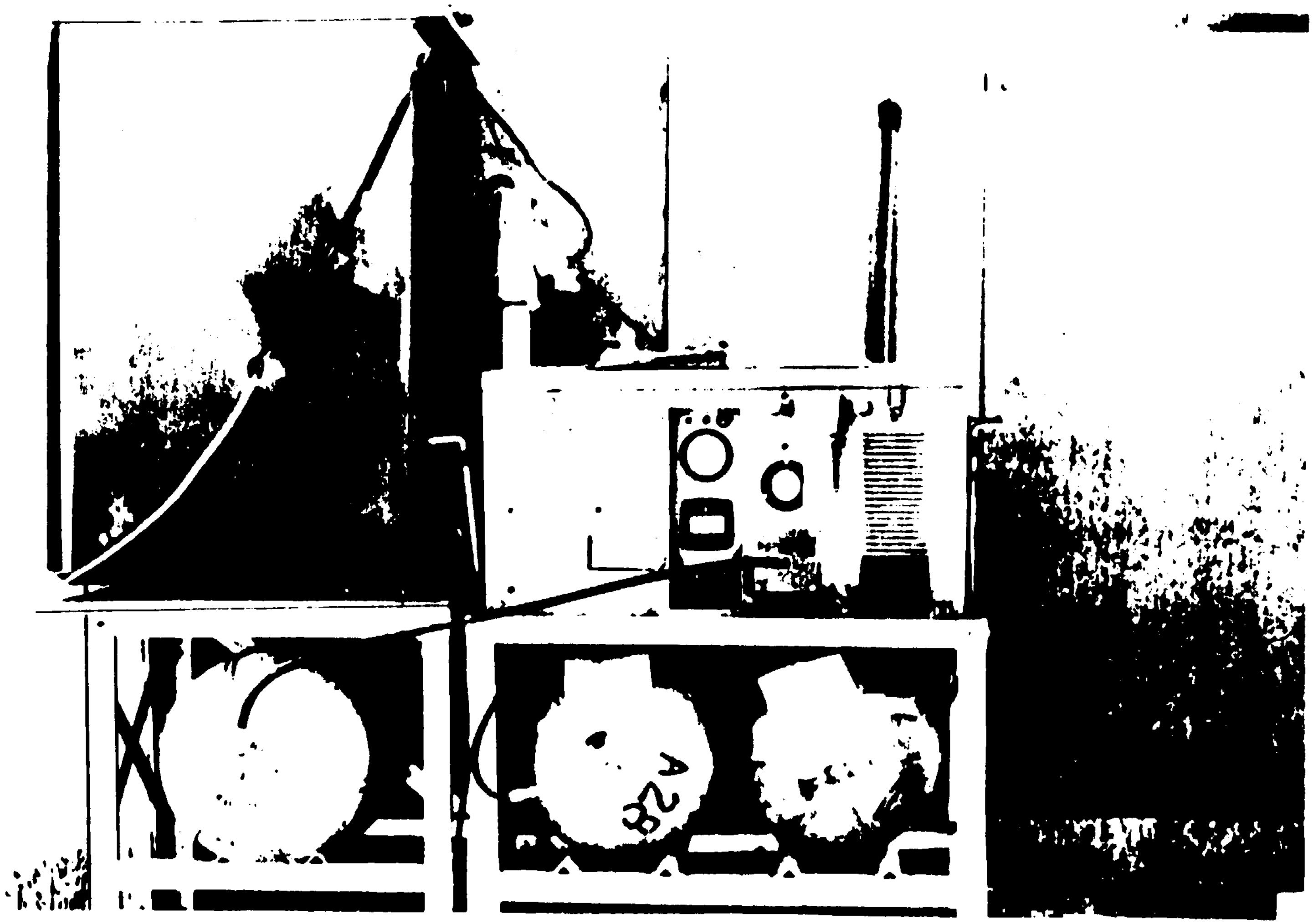


Figure 4-11. Tritium and inert-gas sampling.

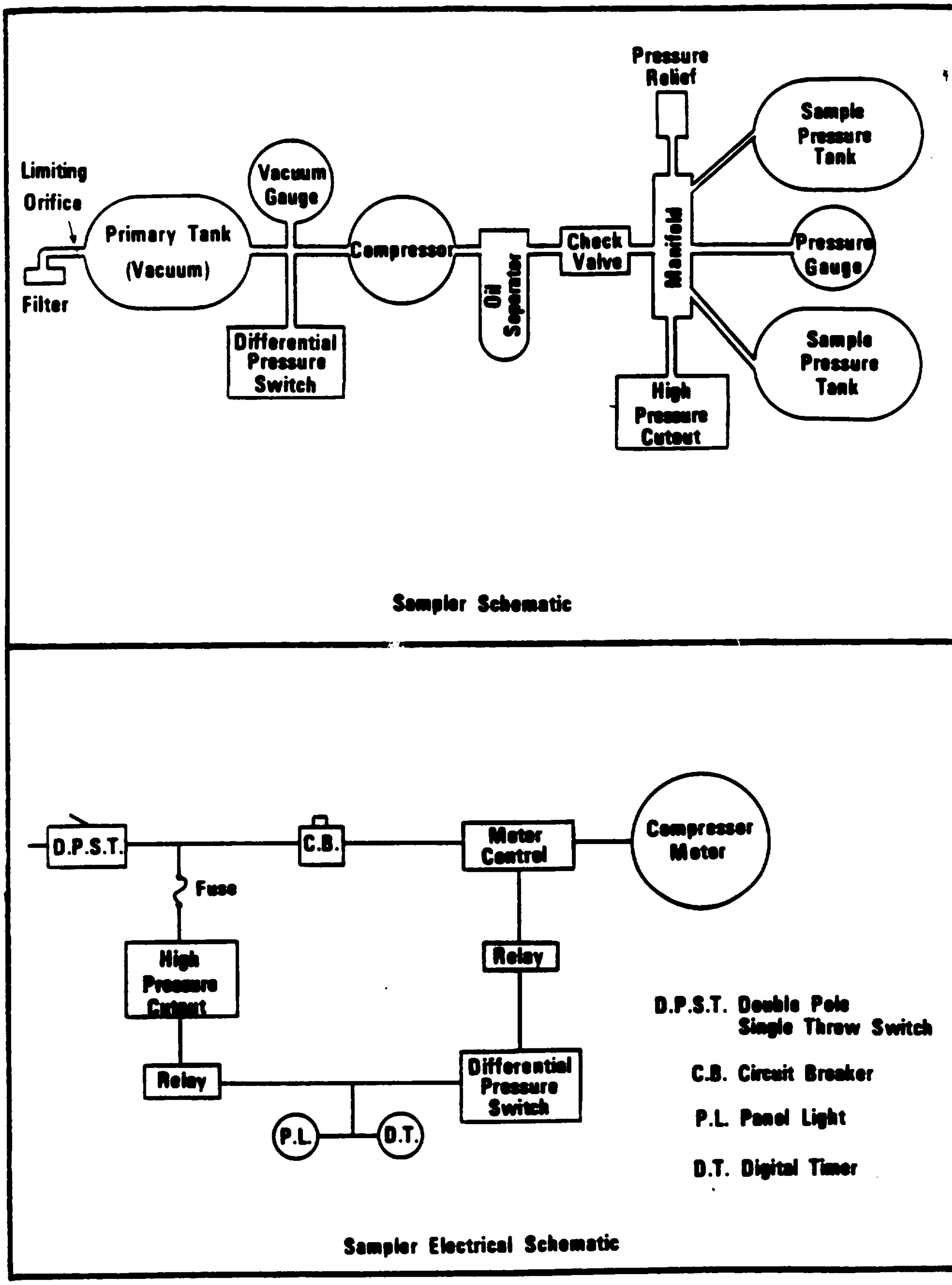


Figure 4-12. Inert-gas sampling system.

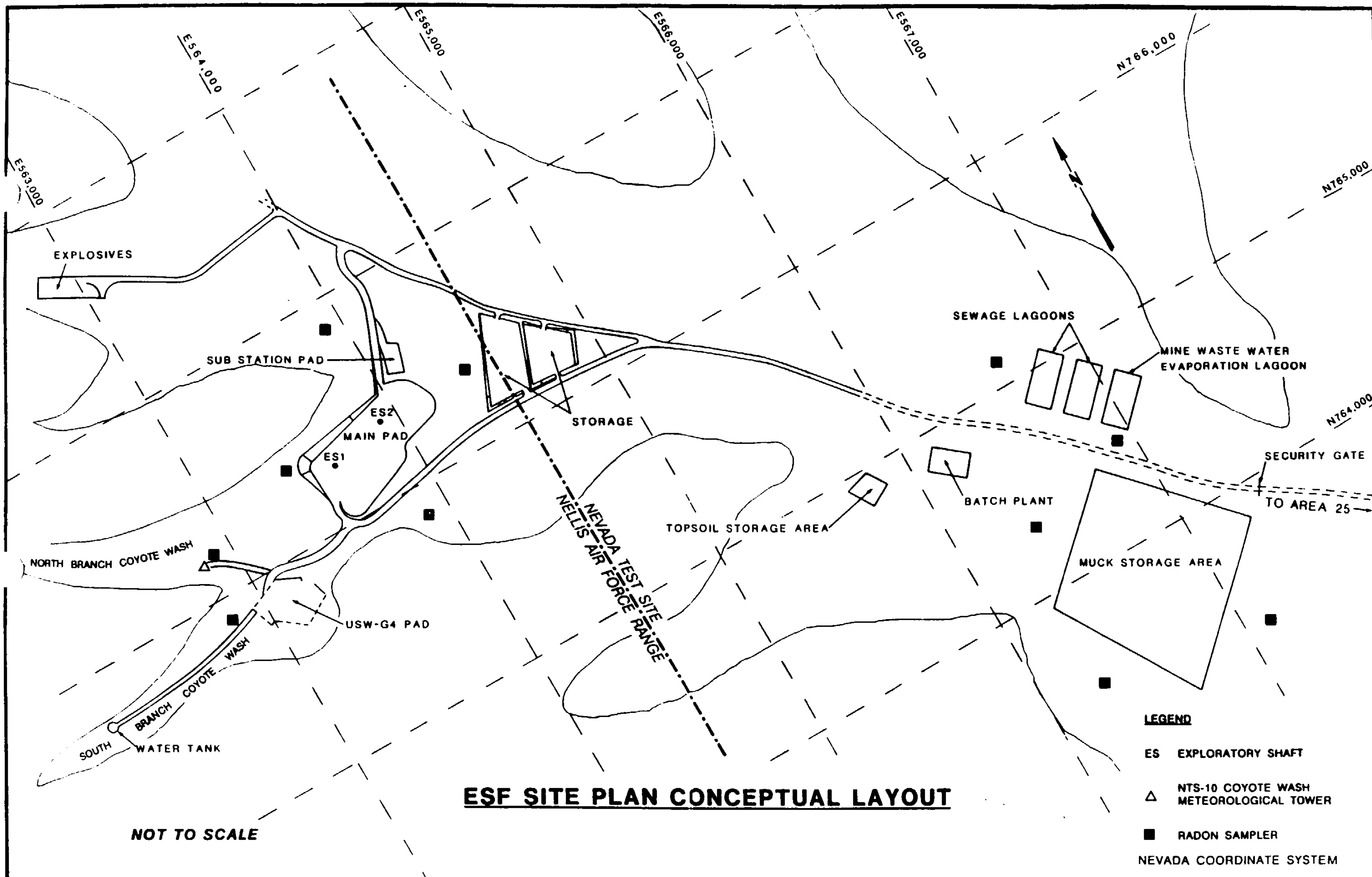


Figure 4-13. Draft ESF radon sampling locations.

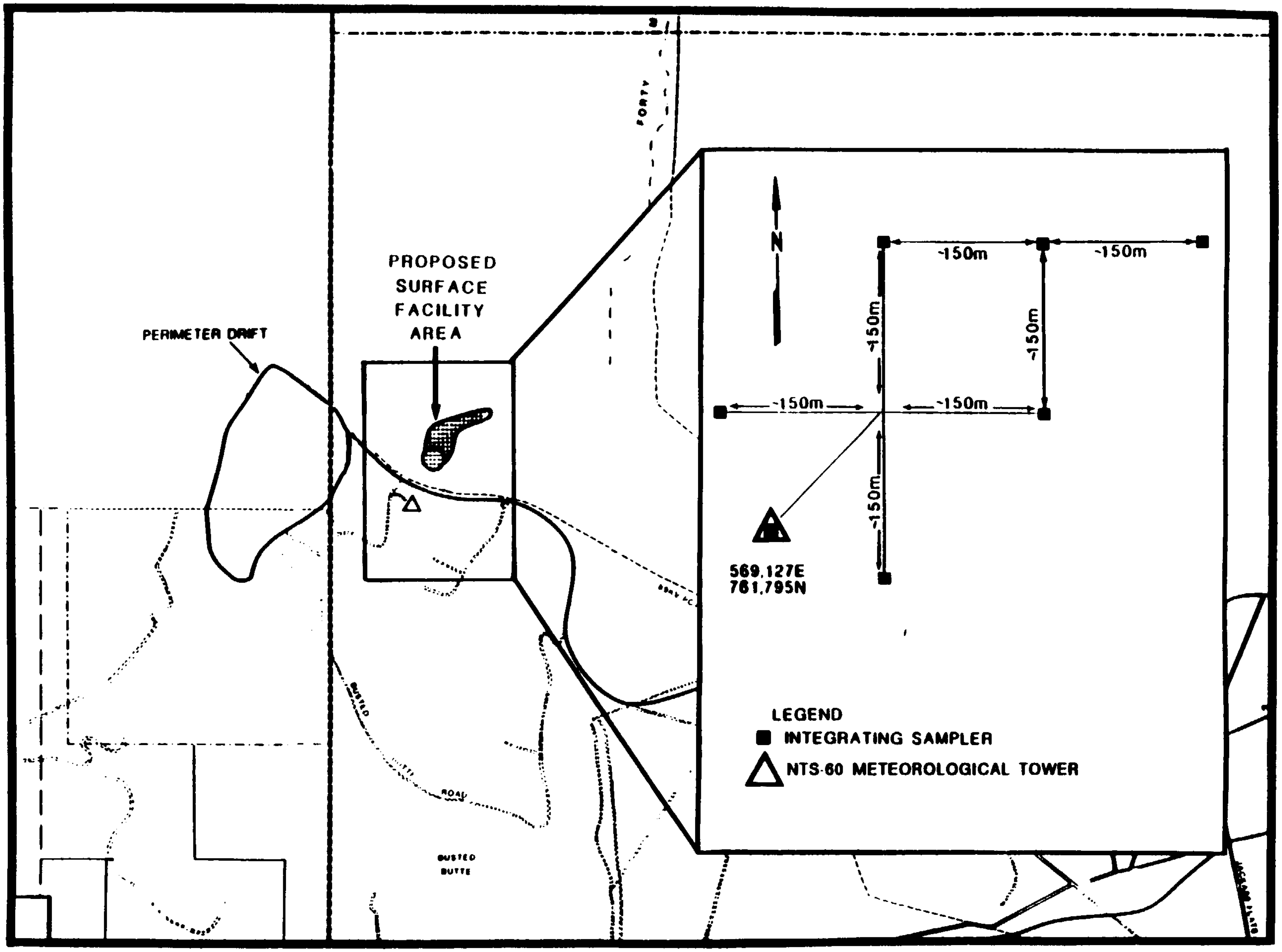


Figure 4-14. Proposed surface facility: Radon monitoring areas.

The samplers or monitors considered for radon monitoring can be divided into three basic classes: grab samplers, time-integrating samplers, and continuous monitors. Grab samplers are not useful for establishing average background levels because they provide data only for a short period of collection. Time-integrating samplers provide data on the average radon concentration over the period of collection, and are well-suited to assess average background radon levels. However, because the monthly time frame obscures cyclic diurnal variations as well as variations due to meteorological effects and site activities, time-integrating samplers will not provide all the information needed. Continuous monitors provide detailed data on radon concentration as a function of time, but they are relatively insensitive and very expensive; therefore, the number used will be limited.

To provide the necessary information, the most cost-effective method (Section 5.2 of the PSCRMP) would be to use time-integrating samplers for most measurements. The augmented super Track Etch™* system, if it is available, will be used to provide data on radon daughter product concentrations. In addition, data on radon concentrations will be taken at the same locations using a standard Track Etch™ device. This will provide data on both components of interest in assessing radon impacts, which is important since radon and its daughters will not be in equilibrium in most open air meteorological conditions. Because of limited industry experience with the various integrating samplers, two types (one standard Track Etch™ system and one augmented Track Etch™ system) will be used to verify system reproducibility. The standard Track Etch™ device will measure integrated radon concentrations, while the augmented device will measure integrated radon daughter product concentrations. These samplers will be supplemented by three continuous radon monitors (CRMs). The CRMs will provide data on the diurnal radon variation and will allow correlations with meteorological data for determining radon releases from the exploratory shaft. One of these CRM units, with different modifications, will also be used to make underground grab samples to assess the radon daughter product working level (Appendix B).

The basic strategy will involve the use of three CRMs at (1) the primary underground release point (exploratory shaft), (2) the 60-meter tower, and (3) intermittently at the various other locations. CRMs will also be used to measure actual hourly variations in radon concentrations. The Track Etch™ samplers will be located around the projected location of the surface facilities (Figure 4-14), the muck pile, and the shaft (Figure 4-13) to supplement the CRM data. This strategy provides a continuous evaluation of emissions from the primary source (the shafts and mined material) and integrated data on ambient radon/radon daughter product levels in the environment.

Track Etch™ samplers will be placed in the major drifts underground to monitor ambient radon concentrations in the general working environment. Working level measurements (grab samples) will be made near the working face (an explanation of working level measurements may be found in Appendix B). These radon monitoring activities will not only provide environmental data,

---

*Track Etch™ is a registered trademark of the Terradex Corporation.

but will also monitor the potential sources of operationally enhanced radon releases. In addition, this radon monitoring provides the data necessary for facility ventilation system design and facility air monitoring/equipment selection. The CRM data allows correlation of radon concentrations with work activities (mining), ventilation rates, and meteorological data.

The radon monitoring network is intended to establish a baseline and measure the future changes in the radon levels near the exploratory shaft. Since the primary purpose of one of the CRMs is to measure the release of radon as a result of shaft sinking and mining activities and to allow correlation of the data with the meteorological conditions, a CRM will be located at the shaft exhaust when shaft sinking begins. This CRM will also be used to establish diurnal (if detectable) variation in the radon baseline in the exploratory shaft area (Figure 4-13) and other areas. A second CRM will be used to monitor the radon baseline in an area well away from the mining activities (Figure 4-14) discussed further in the balance of this section. During the early period covered by the PSCRMP, only one monitor was available, so it was alternated quarterly between the exploratory shaft (when land access was obtained) and the 60-meter tower locations. The quarterly period is used to correlate with the integrating samplers.

The integrating samplers will be located typically around the area of interest (Figures 4-13 and 4-14) on a four-point compass rose. To minimize their interference with other site characterization activities, they will be located at least 65 meters from the area of interest. This will also allow reasonable dispersion of the radon plume to minimize directional effects.

Figure 4-13 shows the positions of the integrating samplers around the exploratory shaft. The inclusion of the extra integrating sampler on the western side of the shaft is due to the two canyons coming down Yucca Mountain towards the shaft. These canyons will serve as channels for air flow. To support exploratory shaft radon/radon daughter product monitoring activities, a constant radon baseline for the Yucca Mountain area will be taken in the area surrounding the projected location of the surface facility (Figure 4-14). A sampler near the 60-meter meteorological tower will allow correlation with meteorological data and provide a reference point. The distance between a sampler and the projected surface facility location is about 150 meters (Figure 4-14). Figure 4-13 shows the four-point compass rose around the muck storage area to monitor radon evolution from the broken tuff. An additional sampler is located west of the mine waste-water percolation pond to allow determination of any contributing emissions from this source.

4.3.4.4.3 C-14 sampling (CO_2)

The program will evaluate current technology for the sampling of airborne C-14, typically in the form of CO_2 (Section 6.3.2).

New activities, if appropriate, will be proposed after this evaluation. Currently, the monitoring of CO_2 is based on C-14 content in flora. Since C-14 rapidly comes to equilibrium in the environment, the new growth on plants will provide an excellent indicator of C-14 concentrations in the environment. Thus a limited number of flora samples will be taken at locations 6 and 13 in Figure 4-5 and locations 11, 19, 22, 26, and 27 in Figure 4-6. These samples will be collected in the same manner as other biota samples (Section 4.3.7.2) except that only new growth will be gathered and no species discrimination will be required. Limited sampling will be required since CO_2 is gaseous and rapidly disperses through the atmosphere.

4.3.5 WATER SAMPLING

Corley et al. (1981) describes and justifies the water surveillance requirements at nuclear facilities. The principal exposure pathways from waterborne radionuclides to individuals (or groups of individuals) in the environment from waterborne radionuclides are ingestion of drinking water; consumption of fish, ducks, or other aquatic species; and the consumption of irrigated crops. Of secondary importance are external radiation dose contributions from surface water (swimming, boating, water skiing), sediment deposits along the shoreline, or deposits on an irrigated field. The radiation doses from these external sources are generally orders of magnitude less than doses from ingestion pathways (Denham et al., 1974; Soldat, 1971).

As a consequence of the desert ecosystem within which the site is located, the potential for radioactive material from Yucca Mountain reaching man through the water pathway is very small. Water pathways at Yucca Mountain may include:

1. Ephemeral streams and catch basins.
2. Groundwater.
3. Airborne deposition to the Amargosa River or streams.
4. Reservoirs or ponds supplied from groundwater sources.

No liquid effluent will be released to a surface-water source, because there are no through-flowing streams in the Yucca Mountain area. There is a large ephemeral stream (Fortymile Wash) located just east of the site. Appendix E provides summary information, listing all sampling locations and pertinent sampling activities associated with each sample.

Routine laboratory determinations from water samples usually include gross alpha and beta, tritium, radiostrontium, gamma spectrometry, and specific radio-chemical analysis for other selected nuclides. Alpha spectrometry may also be included, depending on potential release of alpha contaminants or the results of the screening. In addition to total activity analysis, it may be desirable to measure the distribution of activity between soluble and suspended materials, as well as the chemical form of a radionuclide.

4.3.5.1 Locations

Collection of water samples at the designated locations discussed in the following sections is based on site-specific conditions and guidance documents (DOE, NRC, and EPA). The proposed Yucca Mountain repository site hydrologic conditions are generally characterized by low precipitation, no perennial streams, few springs, rapid runoff during heavy precipitation (ephemeral streams), limited/intermittent catch basins, and deep underground aquifers (Alkali Flat-Furnace Creek Ranch groundwater basin). Other conditions such as local meteorology and absence of liquid effluent releases to surface-water sources are also important to the selection of water sampling locations.

4.3.5.1.1 Surface water and sediment

Surface-water background samples will be collected routinely at a representative unaffected control location to provide background data for comparison with data from affected stations. The open diamond symbols in Figure 4-15 represent locations where ephemeral stream samples will be collected. These four stations are located in Fortymile Wash just east of the Yucca Mountain site. Other far-field surface-water sources sampled are indicated by open or solid square symbols in Figure 4-16. The open square symbols represent existing EPA locations where the sampling is primarily for evaluation of groundwater. Surface-water samples will be collected at these locations, if available. The solid squares are proposed additional locations to support the activities of the NNWSI Project. Since experience, analysis, and operating design will be used to ensure that no significant release will be made to surface waters, the surveillance program relies to a large extent on the existing EPA samplers for water sampling.

A field survey will be made of catch basins in the near-field area surrounding the Yucca Mountain site (within 16 kilometers). Since these catch basins are major sources of water for the wildlife, a representative sampling of water from these basins will be made. Care will be taken not to disturb the sediments, branch, and rocks in these basins as they may have archaeological significance. Depending on available water volume in the catch basin, aliquots from several catch basins may have to be composited to obtain a sufficient volume of water for analysis. The composited samples will be handled in a manner similar to other water samples.

Sediment samples are usually taken in conjunction with certain surface-water samples and are used to evaluate the buildup of insoluble radionuclides. The most appropriate times for sampling are before and just after a spring run-off. Sediment samples will be taken at all surface-water and ephemeral stream locations.

4.3.5.1.2 Drinking water

Drinking water sources in the far-field area are springs (limited in number) or wells (groundwater). Grab samples of drinking water supplies from nearby communities will be collected. The nearest urban area (Las Vegas) and its primary drinking water supply (Lake Mead) will be included in this program. Lake Mead is currently being sampled by the NRAD. Drinking and groundwater samples are being obtained from station 56 (shown in Figure 4-15)

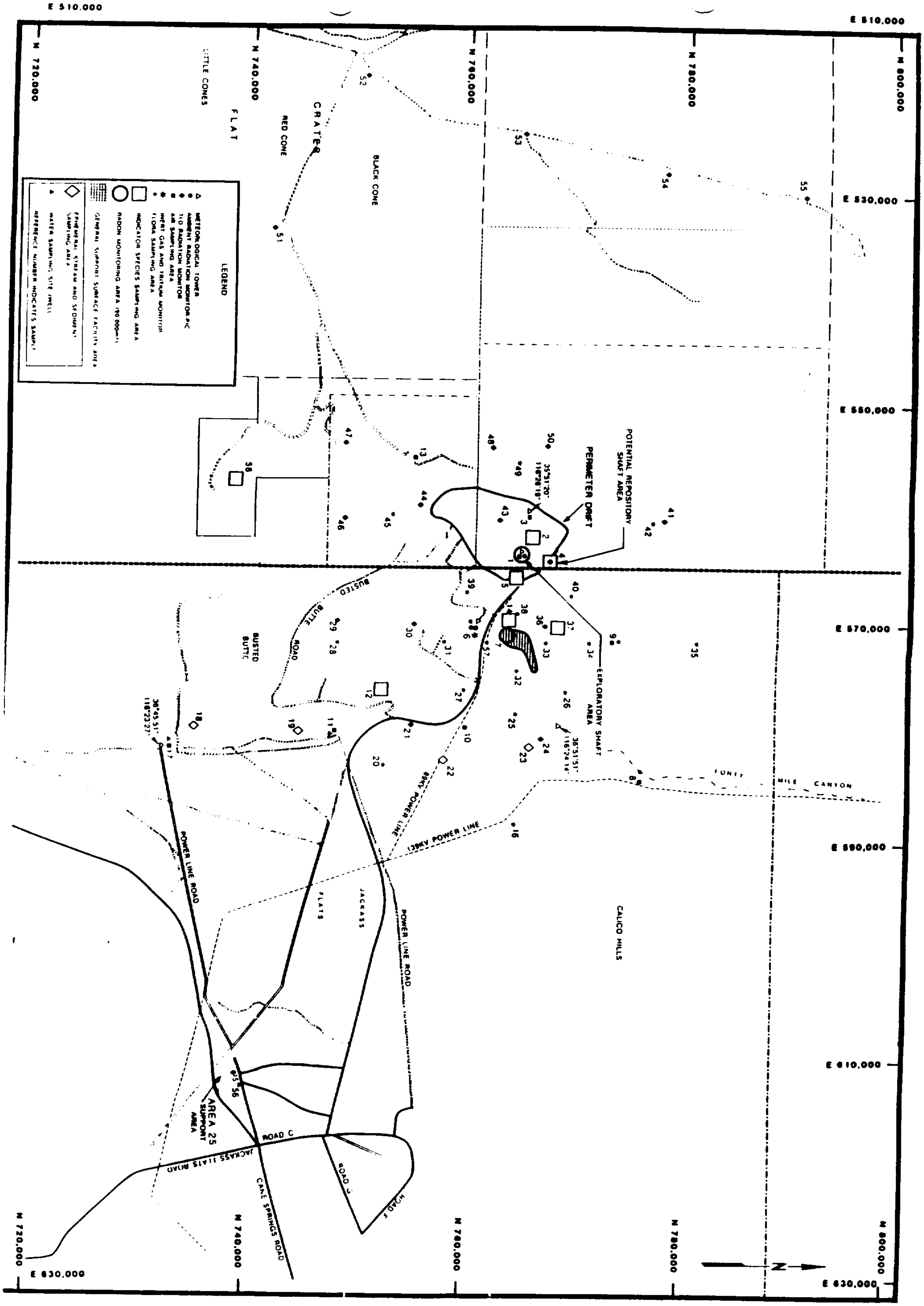


Figure 4-15 Near-field water sampling locations.

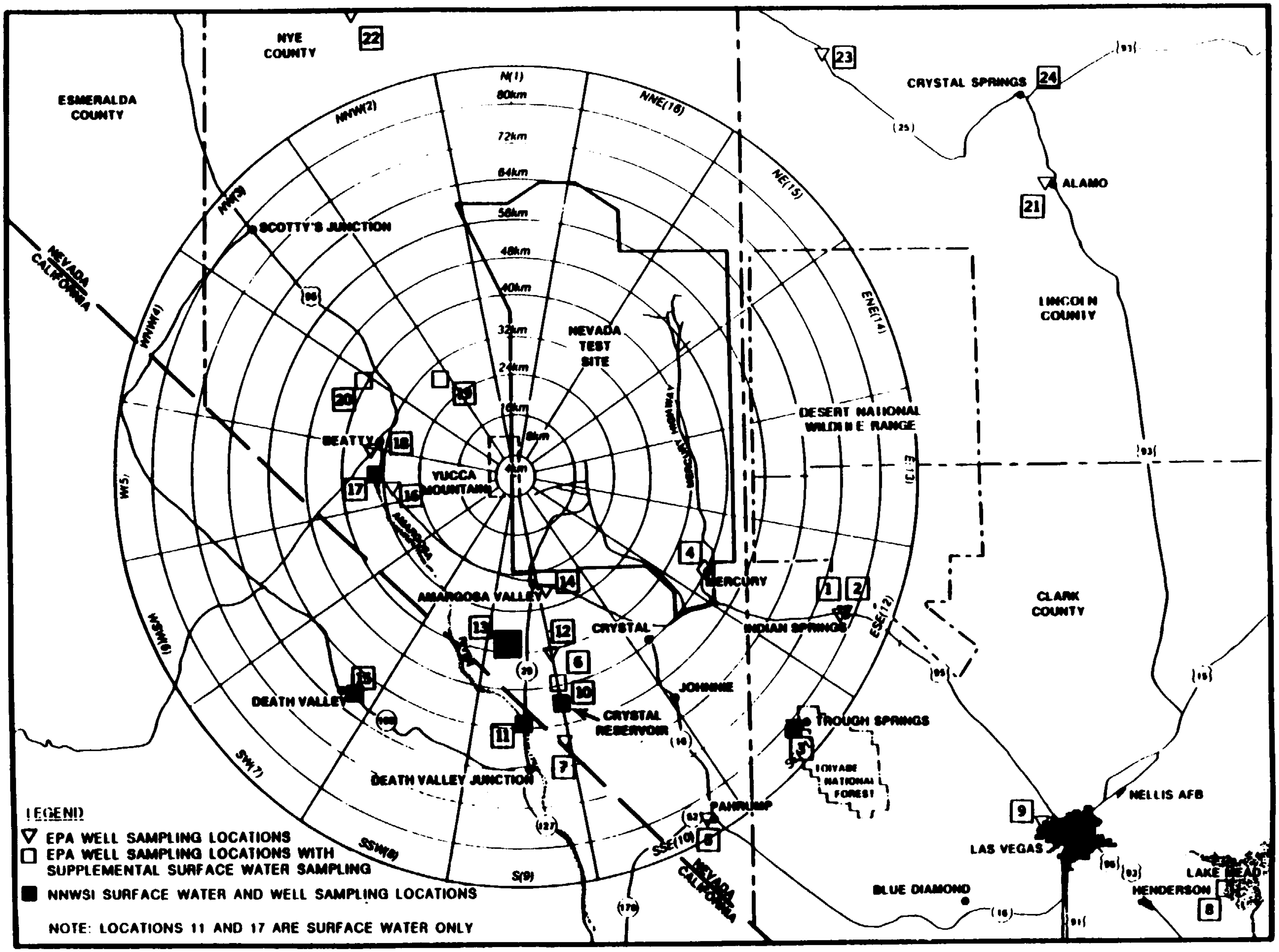


Figure 4-16. Far-field water sampling locations.

and stations 1, 2, 4, 5, 6, 8, 9, 12, 14, 15, 16, 18, 19, 20, 21, 23, and 24 (shown in Figures 4-16 and 4-17). EPA water sampling data is available for the other locations (unnumbered) listed in Figure 4-17.

4.3.5.1.3 Groundwater

It is unlikely that groundwater will accumulate radioactivity from the facility; however, a small potential exists for such an effect during the postclosure period. Soil and geologic media tend to act as filter and ion exchange media for most radionuclides that might be released during the postclosure period. However, tritium can migrate at the same rate as the groundwater. The halogens and certain chemical compounds of a few other common radionuclides also have a substantial potential for moving through the geologic media in the groundwater. Groundwater modeling, in addition to radionuclide analysis, will be a key factor in repository evaluations. The dose modeling techniques using simplified pathways analyses described in the Environmental Pathways Analysis Scoping Study for the Yucca Mountain Site (EPASS) provide specific guidance on radionuclide/exposure pathway combinations of potential significance to initially maintaining program activities. For the far-field water pathway, H-3, Tc-99, Zr-93, Pu-239, and Pu-240 are the radionuclides of principal concern. Specific sampling and radioanalytical processes, as a part of the radiological monitoring activities, will provide background data on these and other radionuclides of interest.

An extensive program for geohydrologic monitoring and water resource evaluation is described in the Site Characterization Plan (DOE, 1988b) and associated study plans (Appendix H), and in other NNWSI Project field study plans such as the Environmental Field Activity Plans (Appendix H). Monitoring of groundwater will be conducted near the proposed repository facility and in areas down-gradient from other facilities or activities. NTS operations and other potential contaminant sources will be addressed. Radionuclides are the contaminants of specific interest regardless of the source. To facilitate the assessment of potential sources of radionuclides and their impact on the Project, at least two wells will be selected for evaluation. The groundwater monitoring program during the site characterization phase will also determine the proper aquifers to sample to achieve an optimum assessment program. Where available, existing NNWSI Project and NTS wells and planned NNWSI Project wells (Appendix H) will be used for acquisition of these data. The need for other wells to monitor other locations in addition to existing and planned wells will be evaluated during the EIS scoping process.

The NNWSI Project far-field groundwater monitoring program includes the various wells noted in Figure 4-16. Supplementary data supplied by the EPA water sampling program are illustrated in Figure 4-17.

Near-field monitoring is still being evaluated based on access to existing wells and potential new wells. As U.S. Geological Survey (USGS) or other test wells in the area become available, water samples will be obtained, if possible. Most of these samples will be archived. A limited

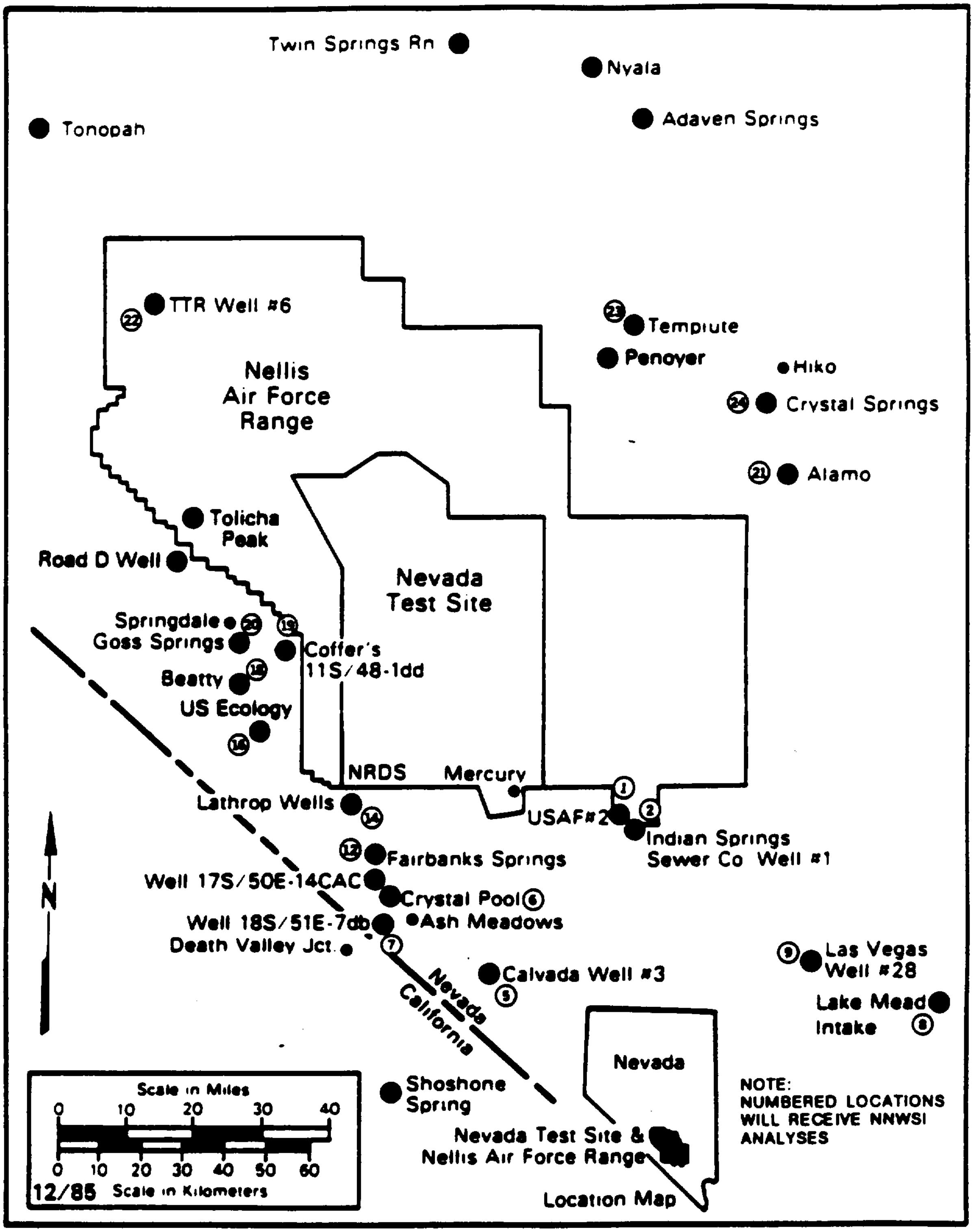


Figure 4-17. EPA drinking water sampling locations near the NTS (from wells and springs).

number (around 10 percent) will be analyzed to supplement the near-field (Figure 4-15) groundwater monitoring data. Additional information concerning the archiving of water samples is presented in Appendix F.

As this program matures, monitored wells will be located or established just outside the control area. These wells will be used to monitor compliance with EPA's groundwater monitoring requirements in 40 CFR 191.15 and 40 CFR 191.16.

4.3.5.2 Methods

The major concerns for water sampling are the collection of a representative sample and the preservation of radionuclides in their original concentrations before analysis. Most water measurements are made on samples taken in the environment and returned to the laboratory for analysis. The general problem of the measurement of radioactivity in environmental water samples has been discussed by Kahn (1972). Perkins and Rancitelli (Montgomery et al., 1974) have discussed techniques for determining radionuclides in natural waters. Standardized methodologies for collection and handling of water samples are also discussed in numerous documents, including APHA (1971), ASTM (1987a,b), Manual of Ground Water Sampling Procedures (NWWA/EPA, 1981), USGS (1977), and EPA (1977). All sampling activities will be consistent with Conti et al. (1978) and applicable NRC guidance.

4.3.5.2.1 Water sampling

Collection and preparation of representative environmental water samples for analysis present a number of unique problems for which clearly defined answers are not always available. In addition to the general problems of avoiding interferences (e.g., chemical content affecting radionuclide contents) and of finding sampling locations representative of the stream or body of water at points of interest, natural waters are frequently two-phase systems (i.e., solid materials are suspended in or floating on the water). Routine surface-water samples will be taken from beneath the water surface to avoid floating debris. Caution should be taken to avoid collection of sediments or benthic material in shallow waters.

The type of sampling system used for collection of groundwater samples is a function of the type and size of well construction, pumping level, pollutant or contaminant of interest, analytical procedures, and presence or absence of permanent pumping fixtures. Ideally, sample withdrawal mechanisms should be completely inert; easily cleaned, sterilized, and reused; easy to operate at remote sites; and capable of delivering continuous but variable flow rates for well flushing and sample collection. Additional information on groundwater sampling sections is provided in Appendix G.

The ephemeral streams will be sampled by installing a large-volume passive container in the stream bed. This container will collect water when sufficient precipitation in the area creates stream flows. An aliquot of sample will be collected from this embedded sample container. Use of a passive collection container is presently the safest and most economical method for sampling an ephemeral stream.

Ion exchange techniques are used to concentrate minute quantities of radionuclides from the water sampled. Tritium is an exception to this process, but it can be determined on a collected fraction of the water leaving the ion exchange column. Nearly all radionuclides may be removed from water by astute selection of ion exchange media (Montgomery et al., 1974). The efficiency of any system or combination of systems (equipment and analytical process) chosen must be tested under operating conditions to determine the effects of flow rate, volume, chemical form of the radionuclide, stable chemical elements, and other material in the water.

The size of a water sample to be collected will be determined by the analytical process, the derived minimum detectable concentration of the radionuclides(s) of concern, and the number of sample splits or aliquots needed for analysis and archiving purposes. Typically two 3.5-liter (1 gallon) samples are collected for routine analytical procedures. A separate set of two 0.5-liter samples is collected for tritium analysis. In special cases, a 10-liter sample may be necessary at selected locations to provide sufficient sample aliquots for analysis and special archiving (Appendix F). Typically only four 0.5-liter aliquots are archived. Sample collection volumes must also be increased to support splitting of a sample for quality control, and to replicate sample analyses.

The U.S. Public Health Service (Douglas, 1967) usually calls for filtering surface-water samples (unless it is drinking water, in which case the total activity is desired) to obtain the distribution of activity. Soluble/insoluble nuclide ratios may be useful in relating to effluent data, and should be measured. Well samples will be filtered since suspended material is usually an artifact of the sampling process (well-casing particles, dirt near water-soil interface) and may not be representative of the groundwater. The filtered material and the liquid will be analyzed separately for radionuclide content. Caution will be exercised to ensure that water samples are not cross-contaminated by reuse of sampling containers for collecting samples.

Continuing biological and chemical action in a sample during and after collection causes changes in chemical form, deposition on container walls, and removal of radioactivity from solution by biological growths. Known phenomena which may effect the representative status of the sample include:

1. Cations, at very low concentrations, being lost from solution (e.g., cesium exchanging with potassium in container media such as glass).

2. Radionuclides being absorbed by algae or slime growths in sample lines or on container walls, especially in sample containers which remain in the field for extended periods.

3. Hydrolysis and sorption on container walls or on particles in the water occurring at low acidities (typical of many natural waters).

4. Radiocolloidal phenomena resulting in large flocculant particle formation or additional plate-out on container walls.

5. Pretreatment inducing change in nuclide distribution (e.g., acidification leaching suspended particles in the original sample so that more radioactivity appears in solution).

6. Acids used as biocides oxidizing iodide to iodine, resulting in its volatilization.

7. Acids quenching standard liquid scintillation cocktails, invalidating tritium analysis results.

8. A change in counting geometry occurring for gamma-ray counting if finely-divided particulate activity settles out or if soluble species become fixed on the container walls during counting.

Current practice at most nuclear installations is to pretreat the sample container with an acid (typically 2 to 3 ml concentrated H_2SO_4 per liter of sample), which inhibits both biological growth and plate-out of dissolved ions on the container wall. This practice will be considered for this program.

The radioanalytical procedures to be used, the purpose of the specific measurement, and the chemical characteristics of the sample will govern which, if any, pretreatment is used. Radioiodine analyses especially will not be performed on acidified samples. Optimum preservation procedures will be determined by local testing.

4.3.5.2.2 Sediment sampling

Samples of deposited sediments from surface-water sampling locations will usually be collected by using hand-held equipment and by core sampler. The use of a dredge will be considered if water depth limits the use of other methods. Manual sampling methods are more useful than dredging because the location and depth of the sediment collected can be well-defined. The non-mechanical and dredge methods primarily provide surface sediment samples. Coring devices provide for collection of sediment at depth and sample separation with depth. Water depth and stream-flow data at the time of sampling may be useful. Other physical and chemical characteristics of the sample, such as particle size distribution, soil type, ion exchange capacity, and organic content, will be evaluated to allow for proper interpretation of the radionuclide analytical results.

All sediment samples will be oven-dried and the radioanalytical results reported on the basis of activity per gram (or kilogram) dry weight. Oven drying temperatures will be from 80° to 130°C. After samples have been dried, they should be reduced to a small particle size by grinding, and then homogenized by mixing. To prevent cross-contamination, the equipment will be thoroughly cleaned between samples. EMSL/HASL procedures (Harley, 1986) for preparing soil samples for analysis are equally applicable to sediment samples.

4.3.5.3 Sampling frequency and analysis

Based on the recommendation of the NRAD and the characteristics of the flow regime (regional hydrology) in the Yucca Mountain area, the water typically will be sampled annually. A gamma spectroscopy evaluation will be completed on each sample. Approximately 10 percent of the samples collected will be analyzed for the radionuclides discussed in Section 4.3.3, with four possible exceptions: Fe-55, Ni-59, Ni-63, and Sm-151. Only about 5 percent of the samples typically being subjected to the full suite of analysis will be analyzed for Fe-55, Ni-59, and Ni-63 (these concentrations are expected to remain constant and the analyses are extremely difficult). Since it is very difficult to test for Sm-151, and because the radionuclide will behave in the environment like europium, analysis for Sm-151 will only be conducted when europium is detected. Note: Europium's and samarium's concentration in the waste will be similar. Careful evaluation of preliminary results for these two nuclides will eventually determine the future frequency of analysis.

All samples will be analyzed using field gamma spectra analysis equipment. Samples receiving the full analytical treatment for specific radionuclide determination will be selected based on the following:

1. Results of gamma spectroscopy for all samples.

2. All drinking water supply samples.

3. Samples to support NNWSI Project groundwater flow path modeling.

4. Whether the sample was analyzed in previous years and the results of such analysis, if any.

Sediment samples will be taken annually. The sediment sample will be subjected to a screening process (similar to the one for water samples), to determine the procedures to be used. These analyses will consist of:

1. Field gross alpha/beta screening (for special handling requirements).

2. Gamma spectroscopy.

3. Alpha spectral analysis or other analytical technique for assessing the concentrations of Ra-226 and the transuranics (except Pu-241).

4. Analysis for the radionuclides Pu-241 and Sr-90.

5. Total uranium analysis.

Ephemeral stream-water sampling will be conducted each time a significant flow occurs in the stream being evaluated. Sediment samples will be collected following the first significant flow in the spring.

4.3.6 SOIL AND DRIFT SURFACE SAMPLING

The DOE (Corley et al., 1981; Walker, 1987) provides recommendations for soil sampling. The document indicates that soil provides an integrating medium that can account for contaminants released to the atmosphere (either directly in gaseous effluents or indirectly from resuspension of onsite contamination) or through liquid effluents released to a stream which is subsequently used for irrigation. Hence, soil sampling and analysis will be used to evaluate the long-term accumulation trends and to estimate environmental radionuclide inventories. In addition to radionuclides that are specific to a particular operation or facility, naturally occurring and fallout radionuclides can be expected in soil samples.

During underground mining and operation, driftwall sampling will be used to characterize the uranium and thorium sources which produce the radon/radon daughter product inventory emanating from the mine.

4.3.6.1 Location and frequency

Background determinations will be based on soil sampling and analysis at points corresponding to background (or control) air sampling locations. Primary soil sampling locations have been selected to coincide with air sampling stations since the comparability of data may be important in achieving the objectives of the overall environmental sampling program. Soil samples will be collected at all air sampling locations indicated in Figure 4-5 (or Figure 4-15).

A set of representative soil samples will also be taken in a manner similar to that described in Gilbert (1987) throughout the indicator species sampling area shown in Figure 4-5 (or Figure 4-15). This will allow characterization of the conditions to which the indicator species is exposed.

In addition, representative soil samples will be taken for archiving from all environmental sampling locations. A set of representative soil samples will be taken, following the methodology described in Gilbert (1987), from areas where major activities are planned (e.g., future facility location and the exploratory shaft area). These samples will also be archived for possible use in evaluating anomalous results from the environmental sampling program, evaluating the impacts of potential releases from the NTS or the Yucca Mountain facility, and supporting decontamination and decommissioning activities.

Except where the purpose of the soil sampling dictates otherwise, every effort will be made to avoid disturbed areas (i.e., tilled, plowed, etc.) or areas of unusual wind or precipitation influence when selecting soil sampling locations. An annual sampling frequency is planned to assess long-term trends.

4.3.6.2 Sampling methods

Several reports are available that should be used as guidance in sampling, preparing, and analyzing soil for plutonium (AECDR, 1974; Fowler et al., 1971; Sill and Williams, 1971), for radium (Fleischhauer, 1984; Meyer and Purvis, 1985; Myrick et al., 1983), and for other radionuclides (ASTM, 1986a; Mohrand and Franks, 1982). In addition, Healy (1984) has proposed a standard for comparing observed to allowable concentrations of plutonium. Note: Consideration will be given to cost effectiveness in analysis. A limited number of analyses will be completed with very high sensitivity, whereas most analyses will use standard analytical techniques.

Trends in local environmental radionuclide levels will be determined through routine soil sampling. In addition, the guidance in ASTM (1986b) and Harley (1986) will be used in developing these procedures.

Depth profiles need to be established. ASTM (1986a) recommends the collection of 30-centimeter depth profiles to measure the total amount of a radionuclide (1) deposited on the soil; (2) during preoperational assessment, periodically as needed; and (3) after a disturbance of the soil. These samples will typically be taken only at the air sampling locations and areas where the indicator species are being evaluated.

Useful information about soil contamination levels can also be obtained using in situ gamma-ray spectrometry. Estimates of individual radionuclide contributions in soil can be made from field spectra measurements such as those developed by Anspaugh et al. (1974), Beck et al. (1972), Beck and dePlanque (1966), and reported by Friesen (1982). In situ gamma-ray spectral data will be obtained for each area where soil samples were taken. It is expected that these data will be accumulated over several years. The soil concentration estimates from in situ spectra measurements depend on distribution of radionuclides with depth, soil density, soil moisture, and chemical composition.

4.3.6.3 Soil and drift surface sample analysis

The analysis for the soil samples will include the following:

1. Field gross alpha and beta counts (radioactive materials control provision).*
2. Gamma spectral analysis.
3. Specific analyses for the following radionuclides: Sr-90, Pu-238, Pu-239, Pu-241, Am-241, Ra-226, Np-237, Tc-99, I-129, and C-14.
4. In situ gamma-ray spectrometry (Section 4.3.8.1.4).

---

*Samples which may be classified as radioactive material will be identified by these counts.

These radionuclides were selected based on the recommendations of the DOE guidance and the specific concerns expressed in 40 CFR Part 191.

The analysis for the driftwall samples and some soil samples will consist of a gamma spectral analysis; total uranium; and detailed analyses for Th-232, Th-238, Th-230, Ra-228, Ra-224, Ra-226, U-238, U-235, U-234, and Po-210 to support radon analyses. Typically, soil sampling analyses are intended to assess deposition from site activities, whereas driftwall samples are directed towards characterizing natural radon emissions.

Further information on soil and driftwall sampling can be found in Appendix E.

4.3.7 BIOTA SAMPLING

The DOE (Corley et al., 1981; Walker, 1987) indicates that samples of milk, crops, and animal produce from livestock and game are of greatest importance in environmental surveillance because they provide the most direct basis for assessing the radiation dose to man from ingestion. The principal pathways for radionuclide contamination of food pathways to man are (1) atmospheric deposition onto crops and animal forage of crops from airborne releases, and (2) crop irrigation from water bodies receiving liquid effluents.

This section describes the methodology and rationale for the collection of food pathway samples based on DOE recommendations (Corley et al., 1981). Many details of the biota sampling program, however, cannot be presented until a detailed survey of the agricultural and cultural activities within the area is conducted. The preliminary data necessary will be collected over the next two years as indicated in Section 6.1 of Corley et al. (1981).

Presently, the biota samples collected under this monitoring plan will represent direct dosage pathways, indirect dosage pathways, and animal indicator species of local environmental contamination. Direct pathways are represented by food items and will include samples of milk, crops (intended for human consumption), beef, poultry, and eggs collected in the far-field area. Near-field samples of game birds may be collected if population densities increase sufficiently. Venison samples from local mule deer will not be collected due to low population density and movement pattern considerations discussed in Section 4.3.7.2.2. Indirect pathway samples will include cattle and deer forage species. Several indicator species indigenous to the facility area have been selected to assist in detecting inadvertent releases of radioactivity and to monitor any long-term radionuclide accumulation in the local environment. These species are identified and discussed in Section 4.3.7.3.

4.3.7.1 Direct pathways to man

Food items discussed in this section will include milk (cow and goat), as available; food crops (fruit and vegetable); domestic animals (meat and poultry); animal products (eggs and cheese); and game birds (dove, quail, and chukar). The EPASS recommends specific radionuclide/pathway combinations for monitoring these items. Table 4-7 identifies the radionuclides of interest.

4.3.7.1.1 Milk

Milk analyses for certain nuclides can be used for evaluation of short- or long-term trends as well as direct dose calculation. Milk is particularly important because it is one of the few foods commonly consumed soon after production. To a lesser degree, the same applies for some home-grown garden produce.

Since animal metabolism discriminates against many of the radionuclides from plant sources and from worldwide fallout, only a few radionuclides are expected to have significant dose impact via the milk pathway, notably Sr-89, Sr-90, Cs-137, and possibly Ba-La-140. If H-3 is the only nuclide released in quantity to a source of irrigation water, milk may be the critical pathway even though the dose is small.

Milk sampling of all dairy cattle herds (including single family cows) in this area is already monitored by the NRAD in support of the NTS. The existing EPA milk sampling locations are illustrated in Figure 4-18. The data from this program should be sufficient to support the NNWSI Project's activities.

To improve I-129 detection capabilities, cattle thyroids will be collected. Sample size is presently being evaluated. The thyroids concentrate the I-129 ingested by cattle (Smith, 1977) and they will be analyzed each fall as the grazing activities end. The samples will be held about 60 days to allow for the decay of short-lived radioiodines. This program will be initiated in 1988 to allow evaluation of the I-129 detection capabilities at the NRAD.

4.3.7.1.2 Crops

Crop samples will include those produced for human consumption as well as for feed for livestock. Crop selection will be based on the primary pathway being deposition of airborne activity on plants. A local land use study will be conducted to determine where crops (if any) important in the local diet are produced with regard to the site. Local land usage will be periodically reviewed as well as current farming and stock feeding practice at sampling locations based on technical, DOE, and NRC guidance on regulations. Crop samples are of interest not only for their contribution to the exposure pathway from ingestion, but also for monitoring long-term environmental contamination trends.

The choice of crops to be sampled will be guided by factors such as total production, crop availability, seasonal growth patterns, soil type, and farming practices. Analysis of a crop sample must consider the various pathways to man, such as surface deposition, root uptake, and translocation

Table 4-7. Recommended radionuclides to be monitored by identified significant pathways

Significant pathway media	Radionuclides
All samples/pathways	Gamma spectral analysis[a]
Range and leafy vegetation	Sr-90[a], C-14[a], Pu-239[a], Pu-241[a], Ni-63[a]
Milk[b]	Sr-90[a], I-129[c,a], H-3[a]
Beef, venison, and other meat animals	Sr-90[a], C-14[a], Pu-239[a], Pu-241[a]
Beef thyroid[d]	I-129
Groundwater	H-3[a], Tc-99[a], Zr-93[a], Pu-239[a], Pu-240[a], Ni-59[a]

[a]From the EPASS for the Yucca Mountain site (SAIC, to be issued).
[b]Goat milk and cow milk.
[c]Limiting Case Pathway (select samples from large herds).
[d]Sensitive detection methodology.

from other parts of the plant in determining (1) what part of the crop to analyze, and (2) the method of sampling. Fruit and vegetable samples will be collected near the point of maximum predicted annual ground contamination from airborne releases, and from areas which may be irrigated by potentially contaminated water.

About 0.5 kilograms of a crop sample may be needed, depending upon analytical sensitivities for the radionuclides of interest. Sample size and preparation of these crops should provide approximately 20 grams of ash from a representative sample of the edible portions (i.e., the part of the plant which is typically consumed). Twenty-kilogram samples generally fulfill this criterion and provide sufficient sample for most radionuclides of interest.

4.3.7.1.3 Meat, poultry, and eggs

For domestic animal produce, a local land use study will be conducted to determine where domestic animals and animal products important in the local

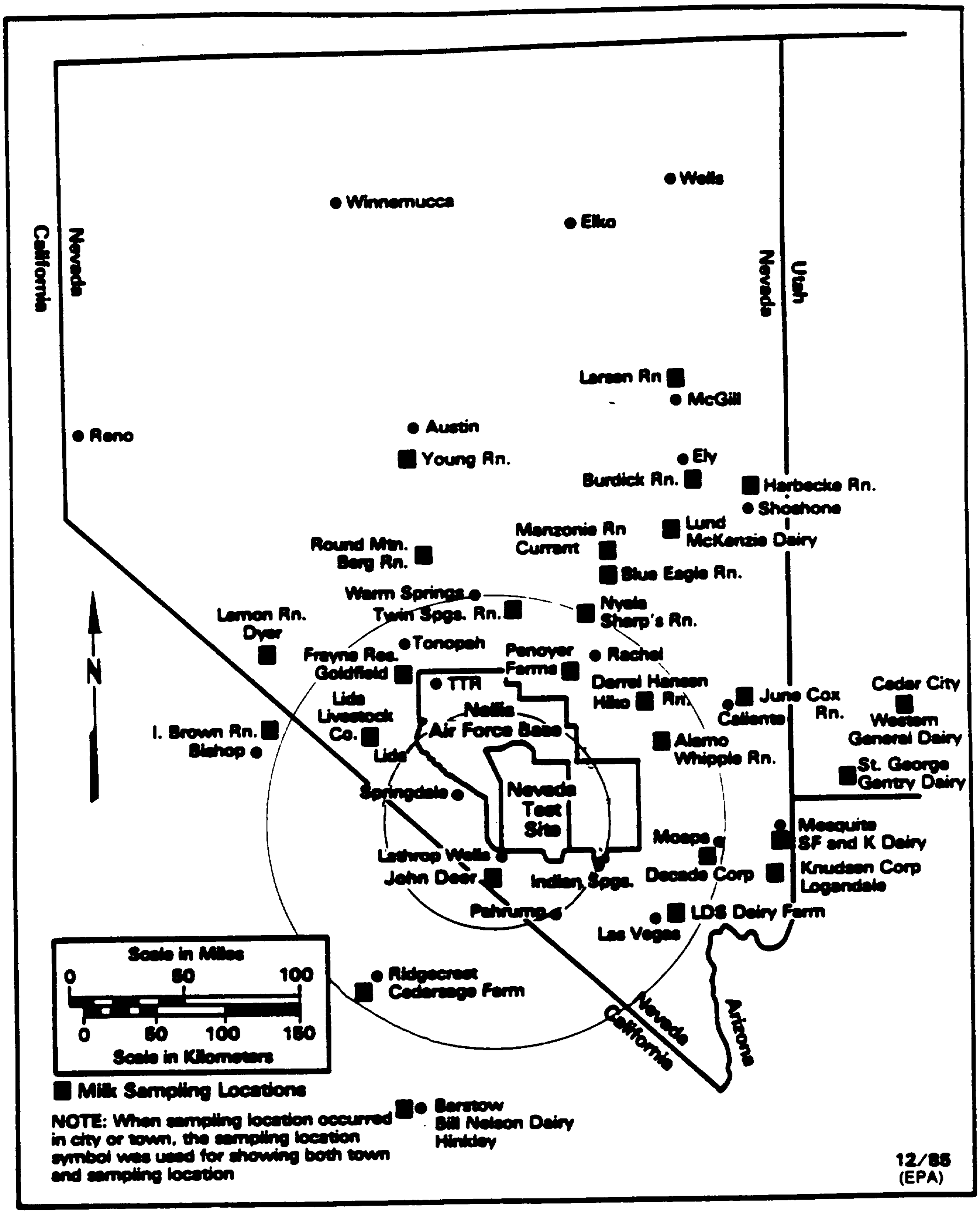


Figure 4-18. EPA milk sampling locations within 300 km of the Nevada Test Site.

diet are produced with regard to the site. Local land usage will be periodically reviewed as will current farming and stock-feeding practices at sampling locations.

Samples of meat, poultry, and eggs will be obtained from commercial producers and from local family farms. Meat samples may be collected at a slaughterhouse if the origin of the animals can be documented. It is anticipated that local health departments will be able to assist in collecting samples. Beef samples will be taken from animals, if any, fed on crops grown within 25 kilometers (15 miles) of the site in the prevailing downwind direction from the nearest source, as well as from the source with the highest predicted air far-field radionuclide concentration from the site. Samples from cattle which drink from surface-water sources or forage on crops irrigated from such surface-water or groundwater sources will also be included.

All animal produce samples will be placed in sealed plastic bags and appropriately labeled and preserved before delivery to the analytical laboratory as specified in appropriate technical procedures.

Domestic animal produce will be sampled annually, if appropriate; specifically at the time of slaughter or harvest, and quarterly for poultry and eggs. A survey of agricultural activity in the area of interest will be made (Section 6) and appropriate items will be sampled based on these data and the EPASS.

4.3.7.1.4 Game birds -- dove, quail, and chukar

Mourning doves are migratory game birds which have been observed infrequently on Yucca Mountain. However, one year out of three in which field investigation studies were conducted on Yucca Mountain, a spring immigration of mourning doves was observed in May, and the doves remained in the area to breed (O'Farrell and Collins, 1983). Surface facility related activities are likely to create a permanent water source on Yucca Mountain that will attract greater numbers of these migratory birds during their breeding season. Doves may consume seeds, grit, and insects exposed to radionuclides on the site before migrating offsite in the fall to areas where they may be hunted. Mourning doves are therefore considered a potential exposure pathway of radionuclides to man.

Available water may also increase local populations of the upland game species, Gambel's quail, and chukar on Yucca Mountain. Field observations of biologists working on Yucca Mountain over a three-year period suggest that population densities of these birds within the area are very low (Collins, 1987, personal communication). Only a limited number of quail were observed on the site during a wildlife survey, and no chukar were seen (O'Farrell and Collins, 1983).

As in the case of doves, quail and chukar may also consume food items contaminated by radionuclides. No hunting of game birds is permitted on NTS or Nellis Air Force Base lands, but public access by sportsmen to BLM-administered lands southwest of the surface facility is possible. If adequate numbers of quail and chukar are found to reside in the proximity of the surface facilities due to an increase in available water supplies, and are subject to hunting, they may be considered as possible exposure pathways to man, and limited samples may be collected for analysis.

Direct sampling of game bird species within an 8-kilometer (5 mile) radius of the proposed surface facilities area will not be initiated until field surveys indicate that population densities are sufficient to warrant collection and analysis. Field surveys will be conducted quarterly to determine the population density of mourning dove, Gambel's quail, and chukar in the near-field sampling area.

If game birds are collected for analysis, a composite sample of muscle tissue will be prepared from the twenty to thirty birds collected during the fall of the year. A composite sample will be necessary because of the small size of each bird with respect to the size of the tissue sample needed for the analytical laboratory.

Analyses of these various game bird tissues will provide relative information on radionuclide content of diet. Muscle tissue analysis can provide direct information of potential radionuclide transport to man through hunting and eating of these game birds.

4.3.7.2 Forage in pathways to man

4.3.7.2.1 Cattle forage

Cattle consume forage species which may either absorb radionuclides in soils through their roots, or entrap and retain airborne radionuclides on their foliage. Cattle grazing on rangelands within proximity of the Yucca Mountain surface facilities (far-field area, Figure 4-16) appear to be the critical pathway of radionuclide transport to man (EPASS). In addition to routine EPA sampling of beef and milk products from herds in the vicinity of the NTS, samples of native cattle forage species for radioanalysis will be taken.

Up to eight far-field sample areas for the collection of cattle forage species will be established on lands where cattle are grazed within an 84-kilometer radius of the proposed Yucca Mountain surface facilities. These sites will be located at various distances and compass directions from the proposed surface facilities, predominately to the northwest, west, south, and southwest. No grazing occurs on the NTS, Nellis Air Force Base Bombing and Gunnery Ranges, or the Desert Game Range which lie to the north and east of Yucca Mountain within the 84-kilometer sampling radius. All sampling locations will be permanently staked and flagged with surveyor's tape to ensure easy relocation in the field. Embossed metal identification tags will be affixed to each sampling location's center stake. A circular area of 30 meters in radius about the center stake will delineate each sampling location.

The following list of cattle forage species has been compiled based on knowledge of the vegetation associations present on Yucca Mountain and the surrounding lands, as well as published range management palatability evaluations of these plants in regard to livestock (O'Farrell and Collins, 1983, 1984; Collins and O'Farrell, 1985; USDA Forest Service, 1937; Stubbendieck et al., 1986).

Oryzopsis hymenoides	-	Indian ricegrass
Ceratoides lanata	-	Winterfat
Krameria parvifolia	-	Range ratany
Atriplex canescens	-	Fourwing saltbush
Atriplex confertifolia	-	Shadscale
Coleogyne ramosissima	-	Blackbrush
Grayia spinosa	-	Spiny hopsage
Hilaria jamesii	-	Galleta
Poa scrabela	-	Bluegrass
Ambrosia dumosa	-	White bursage

Based on the known distributions and densities of these species on and around Yucca Mountain, three species will be chosen for radiological monitoring. However, the list above contains primarily Mojave and Transition desert species common to sites west, south, and east of the surface facilities. If grazing lands north of the surface facility site are chosen for sampling, then Great Basin desert species will be sampled. Vegetation samples will be collected in the spring between March and May when the majority of the cattle forage species will have produced new growth.

Three replicate samples from each of three preferred cattle forage species of perennial bunch grasses and shrubs will be collected at each location. The eight locations will be sampled at a rate of four per year. For each of the three species, the succulent vegetative parts will be removed from as many individual plants as necessary to form composite samples. No significant intraspecies variation in radionuclide root uptake or adhesion and retention properties of vegetative surfaces is expected in plants collected at the same location. Over a two-year period, this represents a total of 72 samples. In the field, all samples will be sealed in labeled one-gallon metal-lid cans for shipment to the laboratory for analysis or archiving. The samples will not be washed before processing. Cattle forage sampling will not be initiated before 1989. If a specific representative species of forage can be identified, then only one species will be routinely sampled.

4.3.7.2.2 Deer forage

Mule deer is a game species which is known to be present on the NTS. Biological field surveys conducted on Yucca Mountain (O'Farrell and Collins, 1983, 1984; Collins and O'Farrell, 1985) indicated the presence of mule deer in low numbers. Occurrence of deer on Yucca Mountain is probably greatest during the winter months, when herds migrate from the northern mesas to winter ranges in the southern NTS (Giles and Cooper, 1985). Mule deer may also move off the NTS onto BLM lands to the west of Yucca Mountain, where they can be hunted by sportsmen. Since little is known about the movement patterns of deer on Yucca Mountain (they are likely to frequent other areas on the NTS during part of the year), direct sampling of deer tissues for radiological monitoring is considered unwarranted. Instead, indirect radiological monitoring of deer forage species located on and around the proposed surface facilities is suggested.

Eight transect lines will be established radiating from the proposed site of the Yucca Mountain surface facilities in the following directions: N, NE, E, SE, S, SW, W, and NW. Along each of the eight lines, deer forage species will be collected at distances of 2 kilometers and 5 kilometers from the center of the surface facilities (Figure 4-19). Within 500 meters of the facilities, only four sampling locations will be established along the north, south, east, and west transect lines (Figure 4-19). All 20 sampling sites will be permanently staked and flagged with surveyor's tape to ensure easy relocation in the field. Embossed metal identification tags will be affixed to each sampling location's center stake. A circular area of 30 meters in radius about the center stake will delineate each sampling location. On the two-kilometer circle, only the N, E, S, and W locations will be sampled the first year. For the five-kilometer circle, the NE, SE, SW, and NW locations will be sampled the first year. Then, each year, this scheme will be reversed.

The Mojave and Transition desert vegetation found on Yucca Mountain does not contain the species considered to be prime deer forage by range managers. Therefore it is difficult to predict accurately what the deer on Yucca Mountain are actually eating. To relieve this uncertainty, the food habits of mule deer will be studied by analyzing scat samples collected from Yucca Mountain. Samples collected from the vicinity of each vegetation monitoring location and from other locations known to contain ample deer sign will be sent to a food analysis laboratory. Results will be used to decide which plant species to collect for radioanalysis.

In the event that food habit studies are inconclusive or lack required specificity, three forage species will be chosen from the plant list in Section 4.3.7.2.1.

Vegetation samples will be collected once a year between November and April when deer, which have moved to lower elevations during the winter, are most likely to forage on Yucca Mountain. Radiotelemetry studies indicate that mule deer on the NTS return to their summer ranges by the middle of June (Giles and Cooper, 1985). Annual variations in seasonal rainfall and temperature patterns, and therefore vegetative growth, will be considered in deciding exactly when samples will be collected each winter.

Three replicate samples of each of three deer forage species will be collected at the designated sampling locations. Not all sampling locations will be sampled annually. However, all 20 sampling locations will be sampled at least twice during the site characterization phase. An attempt will be

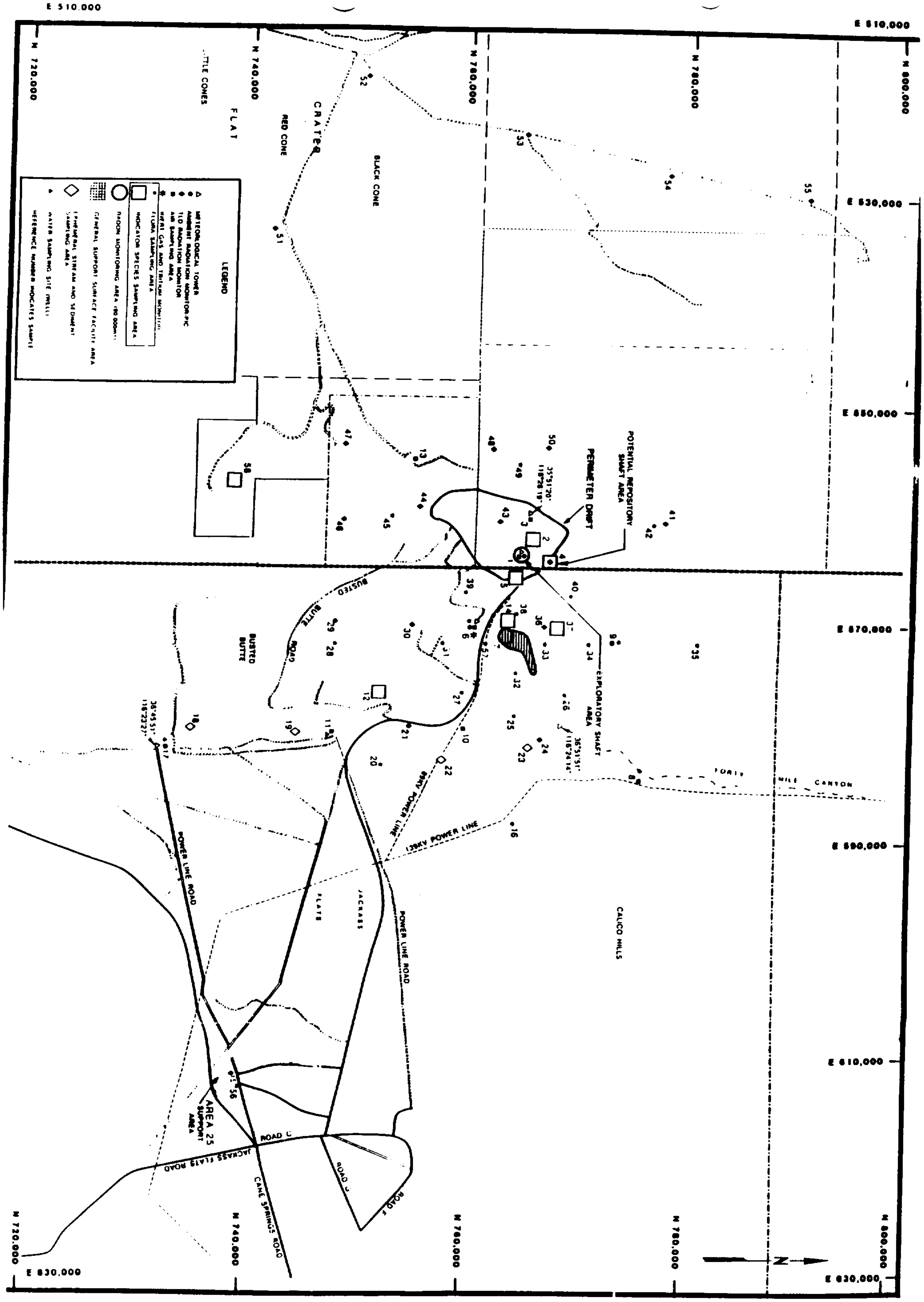


Figure 4-19. Near-field biota sampling locations

made to sample the same three shrub or grass species from each site. For each of the three species, the succulent twigs and leaves will be removed from as many individual shrubs as necessary to form three replicate composite samples. The weight of each sample will be 0.4 to 0.6 kg of plain material to provide 40 grams of ashed sample. No significant intra-species variation in radionuclide root uptake or adhesion and retention properties of vegetative surfaces is expected in plants collected at the same location. In the field, samples will be sealed in labeled one-gallon metal lid cans for shipment to the laboratory. The samples will not be washed before analysis or processing for archiving and future analysis.

4.3.7.3 Indicator species

4.3.7.3.1 Small mammals

Small mammal species will be involved in the radiological monitoring program as indicators of radionuclide concentrations in the biosphere.

Indigenous small mammals inhabiting areas contaminated with radionuclides have proven to be valuable biological test models for estimating the potential effects of these substances on domestic animals and man. They can provide information on (1) concentrations of plutonium and other radionuclides within vertebrate, especially mammalian species inhabiting contaminated areas; (2) tissue distribution; and (3) transfer coefficients between ecosystem components.

There are several advantages of using small mammals (i.e., mice and rats) rather than larger mammalian species such as rabbits, deer, or canid predators as indicator species. First, small mammals have discrete home ranges of limited size, thus providing information on activity in limited areas. These species quickly come into equilibrium with local environmental contaminants because they live and respire in close proximity to surface and subsurface soils and obtain all their food from local plants and animals. Because small mammals are abundant in Yucca Mountain ecosystems, adequate numbers can be collected to provide quantitative information. Several species are commonly found throughout Yucca Mountain, which facilitates comparisons between the various sampling locations.

Previous studies have described the species composition, relative abundance, and seasonal abundance of small mammals in various vegetation and elevations on Yucca Mountain (O'Farrell and Collins, 1983, 1984; Collins and O'Farrell, 1985). This information was used to determine the appropriate species to sample, months to collect samples, and amount of trap effort required to obtain an adequate sample.

Eight small mammal monitoring locations will be established in the vicinity of Yucca Mountain (Figure 4-19). At each location, sampling sites consisting of lines of Sherman live traps will be established. Monitoring locations and sampling sites will be distributed as follows:

1. Two sampling sites in the vicinity of the repository surface facilities (location 14).

2. One site up-canyon and one site down-canyon from the exploratory shaft (locations 2 and 5).

3. One site below the projected repository muck storage pile (location 37).

4. One site at a location east of VABM Fran (location 12).

5. One site in the vicinity of a third proposed shaft (location 4).

6. A control area on the west side of Yucca Mountain (location 58).

Merriam's kangaroo rat (Dipodomys merriami) and the long-tailed pocket mouse (Perognathus formosus) will be the designated indicator species for this program because they are typically the two most abundant and ubiquitous small mammal species on Yucca Mountain. Although both species should be trappable at each sampling location, it is likely that only one will be found in sufficient number at a given location to obtain an optimal sample. Merriam's kangaroo rat should be most abundant at all locations except near the exploratory shaft.

It is anticipated that 120 stations of two traps will be placed in parallel lines of 20 stations each for a total of 240 traps at each location. The trap stations in each line will be separated by 15 meters, the lines by 30 meters. Traps will be placed under metal tents and filled with dacron batting and seeds to protect captured animals from climatic extremes. Captured animals, of all species, will be marked with unique ear-tag or toe-clip numbers and each animal's weight, sex, reproductive condition, age class, pelage, and location of capture will be recorded. Trapping will continue intermittently through a three- to five-day period until an adequate sample of animals (sufficient to produce 20 grams of ashed sample) is collected. Animals will be euthanized in the field with chloroform, kept cool, and deep frozen upon return to the laboratory.

Trap lines will be operated four times a year: in January, April, July, and October. Samples for radioanalysis will be collected twice a year, in April and October, to coincide with peaks in the activity and abundance of the indicator species. In the nonsampling months of January and July, animals will be marked only.

Approximately 0.4 kg of tissue may be required for each sample to run a full suite of radionuclide analyses. This will necessitate pooling individuals into composite samples. Adult Merriam kangaroo rats weigh about 35 g; therefore at least 12 animals will need to be collected for each composite sample when all analyses are to be performed. Adult long-tailed pocket mice weigh approximately 20 g; thus fifty will be needed for each composite.

An important consideration of the sampling design is how to obtain and maintain an adequate sample of individuals within a discrete area. To avoid seriously depleting the population, no pregnant or lactating females will be taken. Population densities are likely to recover quickly as resident juveniles and, to a lesser extent, adults from surrounding areas fill vacated territories.

Trapping information gathered between sampling periods will be used to assess the degree of reproduction and recruitment which has occurred. Although trap-success (affected by changes in both abundance and activity of animals) normally varies dramatically with season, the between-sampling trapping information should indicate any significant decrease in population densities. Such information will allow investigators to compensate in the subsequent sampling session by increasing or decreasing the number of trapping days or the number of traps operated.

Residency of sampled individuals is another important consideration in the sampling design. Establishing individual home-ranges and residency patterns is a labor and time intensive task and considered unnecessarily beyond the scope of this program. Individuals will be marked four times a year and recaptured animals (which will have known residency of at least three months) will be sampled preferentially. Unmarked animals would be either residents which were untrapped in previous sessions, sub-adults recruited into the population since the previous trap session, or individuals which have moved from adjacent areas. Non-resident individuals which have moved in from other areas potentially do not represent the sampling location. However, given that trap-lines occupy only a small portion of the 500 square meter sampling area, it is unlikely that an individual would have moved from outside the sampling location.

4.3.7.3.2 Lagomorphs

Lagomorphs are typically the most abundant large herbivorous mammal in desert ecosystems. Because of their size and herbivorous nature, they are considered excellent substitutes for livestock and have consequently been used extensively, where abundant, for radiological monitoring programs. On Yucca Mountain, black-tailed jackrabbits (Lepus californicus) and desert cottontails (Sylvilagus audubonii) have been observed only in low numbers (O'Farrell and Collins, 1983). Because of their relative rarity on Yucca Mountain, lagomorphs were not included as an integral part of the RMP design. However, lagomorphs are noted for their ability to vary tremendously in density through time, and it is possible that lagomorph abundance on Yucca Mountain will increase in later years, especially as water is introduced into the ecosystem. Tissue samples from these species may be very valuable, even if available only sporadically. Given the potential value of lagomorphs to the radiological monitoring program, it would be prudent to collect information on their relative abundance and spatial and seasonal distribution on the site. This information would enable investigators to determine when densities were sufficient to permit sampling.

Density estimates of the lagomorph population will be achieved by conducting systematic transect surveys. One-mile-long transects will be randomly distributed throughout the Yucca Mountain study area in both ridge and bajada habitats. On bajadas, transects will be square-shaped with each side 0.25 miles long. Ridge surveys will be linear. Transects will be spaced far enough apart to prevent any overlap in the individuals sampled. One corner of each square-shape transect will be permanently marked with a metal stake; the remaining corners will be marked with flagging. The beginning and ends of each linear transect will be permanently marked.

Transects will be walked twice per year: in late February to early March to determine the density of the adult population before recruitment of any young of the year, and in September after reproduction and recruitment is complete. Transects will be walked between 0900 and 1600 hours when lagomorphs are most likely to be sedentary. Transect paths will be maintained with a handheld compass. When a lagomorph is observed, the perpendicular distance from the transect line to the flush point will be determined by pacing. Observers will also record the behavior of the animal when sighted (flushed, sitting, moving), and the direction the animal moved. Transects will not be walked during periods of rain or snow, or when wind speed exceeds 15-20 mph.

Data will be analyzed using the TRANSECT computer program (Laake et al., 1979; Burnham et al., 1980).

4.3.7.3.3 Predators

Large carnivorous predators, because they are relatively long-lived and positioned at the top of the food chain, can provide valuable information on the bioaccumulation and concentration of radionuclides in ecosystems. Moreover, because predator home ranges are large relative to those of the prey, predator body burdens tend to reflect the overall contamination level of an area. This information is valuable in monitoring overall trends in ecosystem levels of radioactivity. However, unless the home range of sampled individuals is known, the source of radionuclides cannot be pinpointed.

To evaluate the feasibility of incorporating predators into the radiological monitoring program, it is first necessary to collect more information concerning their abundance and distribution on the site. Evidence (i.e., sightings, dens, scats) collected during previous field studies (O'Farrell and Collins, 1983, 1984; Collins and O'Farrell, 1985) indicates that coyotes (Canis latrans), bobcats (Lynx rufus), badgers (Taxidea taxus), and kit foxes (Vulpes macrotis) are present on the site. No information on the densities, distribution, and movements of these species was collected, however.

Scent-station surveys will be performed to assess the presence, relative abundance, and general distribution of predators. The scent-station survey technique consists of sets of regularly spaced stations, three feet in diameter, placed along unimproved roads or trails. Stations are cleared of all vegetation and debris, smoothed, and covered with a thin layer of dust to enable ready identification of animal tracks (Harris, 1987). A fatty acid scent is placed in the center of the station as an attractant.

Stations are prepared in the evening and checked for tracks the following morning when the air is calm; surveys are not conducted in rainy or windy weather. Track identifications will be based on experience and upon information in field guides to animal tracks. Scent-stations will be operated four times per year: in February, May, August, and November.

Scent-station visitation rates will be used as an index of abundance for peach species. Indices of visitation are obtained by totaling the number of scent stations visited by each species and dividing by the total number of operable station-nights. (Nights when stations are inoperable due to weather, human interferences, or other disturbances are removed from the calculation.)

If the information obtained from these surveys indicates that any other predator species is present in sufficient number over a wide range of habitats, then this species will be added to the sampling program. Subsequent studies to determine the home range and movement patterns of the selected species may also be necessary. The need for such studies will be evaluated when the species is selected.

4.3.8 AMBIENT (BACKGROUND) RADIATION MONITORING

The exposure of environmental population groups (general public) to external radiation from nuclear facility operations includes that from cloud passage of airborne effluents, as well as that from previous radionuclide deposition patterns on soil, vegetation, sediments or structures. External exposure from radionuclides in water should be insignificant during normal operations at a site such as the Yucca Mountain facility, although unique situations may still arise where recreational, commercial, or industrial use of a receiving body of water may incur some direct exposure.

4.3.8.1 Methods

The feasibility of distinguishing an annual incremental exposure even as low as 5 mR at a given location with the best of available dosimetry is difficult in view of the variability of background radiation. The methods discussed in the balance of this section describe the range of available techniques and including those selected for use at Yucca Mountain.

4.3.8.1.1 Thermoluminescent dosimeters (TLDs)

Integrating dosimeters include such commonly used devices as TLDs, and ionization chambers. Records of environmental exposure rates for the early years at the NTS were largely based on ionization chamber readings, and are generally not well-suited for comparison at low exposures (in terms of accuracy) with more recent results using TLDs. TLDs are the dosimeters of choice based on demonstrated sensitivity, reproducibility, reliability, and long-term stability. The individual dosimeter is relatively inexpensive, although a complete dosimeter/reader system can involve a large initial cost.

4.3.8.1.1.1 TLD characteristics

A number of thermoluminescent (TL) materials are commercially available: lithium borate ($Li_2B_4O_7$), calcium sulfate ($CaSO_4$), lithium fluoride (LiF), and calcium fluoride (CaF_2), with various commonly available activators. Various forms and packaging configurations are available, including loose powder, powder deposited on metal backing and sealed in a glass envelope, pressed or extruded rods, and ribbons and disks of either pure TL material which is either pure or compounded with Teflon™ . The Teflon™-compounded disks tend to have less sensitivity and poorer reproducibility but are more economical.

In an unshielded configuration, some TL materials, particularly the calcium compounds, show excessive energy dependence. Dosimeter packaging is added to compensate for this, and must be carefully designed keeping in mind the characteristics of the radiation to be measured. If penetrating whole-body exposure is the parameter of interest, a lower energy cut-off of about 60 keV for photon radiation is satisfactory; however, such a packaging material will exclude most beta radiation. With astute selection of shielding materials, correction for energy dependence to within ± 30 percent is readily achievable across the range of 50 keV to 10 MeV, without limiting the desired sensitivity.

The list of literature references on TLDs is extensive and still increasing; specifically noted here is the literature on materials used for environmental measurements. Some of the available TLD information is given in Table 4-8. Additional data on commercially available TLDs and dose readout systems is given in Environmental Instrumentation Group (1972). Also, ANSI standard N545-1975 prescribes performance, testing, and procedural specifications for TLDs in environmental use, as well as suggested techniques for making corrections. This is implemented by Anspaugh (1974).

With careful handling and annealing procedures, the precision of measurement of a presorted batch of dosimeters should fall within ± 5 percent (corrected for energy dependence) at the 95 percent confidence level in the range of 1 to 100 mR (Hendee, 1967). Under less carefully controlled annealing, calibration, readout, storage, and exposure periods, accuracy of the measurements, especially with those materials most subject to fading, is less certain (Hoy, 1971, specifies ±30 percent). Accuracy should be verified by independent measurement. Exchange and readout of at least some dosimeters on a monthly schedule is suggested as a partial answer to long-term fading. Irradiation of calibration dosimeters at the beginning or early during the period of field measurements also helps to minimize fading errors. Post-exposure annealing is especially helpful in dealing with long-term fading, although some sensitivity is sacrificed for the sake of accuracy.

Ideally, calibration procedures for both dosimeters and exposure-rate instruments should be based on the nuclide mixture to be measured. In the case of environmental measurements, however, there will generally be a mixture of unknown nuclides (including those from natural radioactivity), and no ideal source is available. An aged radium source will be used since it gives a spectrum of gamma energies and National Bureau of Standards (NBS) standardization is readily available.

Table 4-8. Comparison of TLDs[a] for environmental radiation measurement (page 1 of 2)

TLD Phosphor	Form	Package	Exposure range	Minimum[b] photon energies	Energy[b] dependence to 1 MeV	Comments
LiF	Extruded	None	5 mR to 10^5 R	15 keV	(±)25%	High triboluminescence; requires careful annealing; may be neutron sensitive. Relatively energy-independent. Neutron sensitive in natural form; depleted form available.
CaF_2:Mn	Powdered on wire, extruded	Glass capsule, metal case and shield	1 mR to 10^4 R	25 keV	(±)25%	Less stringent annealing requirements; capsule may cause self-dosing; some energy dependence; some room temperature fading.
CaF_2:Dy	Extruded	Tantalum and lead shield	0.5 mR to 10^4 R	50 keV	(±)20%	Low triboluminescence; high initial fading; careful shielding and annealing required.
$CaSO_4$:Tm $CaSO_4$:Dy	Extruded Powder	Capsule and metal shield	0.1 mR to 20 R	10 keV	(±)40%	High sensitivity; low fading; high energy dependence.
$CaSO_4$:Mn	Powder	Capsule and metal shield	0.1 mR to 20 R	30 keV	(±)40%	High sensitivity; rapid fading; high energy dependence.

Table 4-8. Comparison of TLDs[a] for environmental radiation measurement (page 2 of 2)

TLD Phosphor	Form	Package	Exposure range	Mininum[b] photon energies	Energy[b] dependence to 1 MeV	Comments
BeO	--	Capsule	2 mR to 200 mR	15 keV	(±)25%	Some fading.
$Li_2B_4O_7$:Cu	Extruded	Plastic	2.5 mr to 6000 R	10 keV	(±)20%	Tissue equivalent dosimeter some fading (10% per month)

[a]TLD = Thermoluminescent dosimeter.
[b]For packaging indicated; may be altered by additional shielding.

The NRAD is currently using $CaSO_4$:Tm and $Li_2B_4O_7$:Cu dosimeters (Table 4-9) with a Panasonic Model 4D710A readout system. This equipment is currently planned for use in this RMP monitoring activity.

4.3.8.1.1.2 <u>TLD locations and frequency</u>

As with air sampling, a sufficient number of dosimeter locations must be established to provide reliable estimates of external doses to key population groups, as well as the 84-kilometer population dose. For convenience, therefore, integrating dosimeters (TLDs) will be placed at all environmental sampling stations, including control or background locations.

Where integrating dosimeters (TLDs) are used, at least three dosimeters (in the same package, if possible) will be provided at each location to permit averaging and allow for the detection of faulty dosimeters. Quarterly exchange periods are planned.

The recommended height for placement of dosimeters is about one meter above the surface to approximate the lowest significantly affected level of the human body and to minimize surface effect scatter. If another height is used, the relationship to the one-meter height should be established for the site. Special care must be used in mounting dosimeters to avoid partial shielding by buildings, trees, or posts. Suspension from a fence wire or from a thin metal post, a minimum of 50 meters from the nearest building, is recommended. Some compromise may be necessary for protection of the dosimeters because of the susceptibility of dosimeter packages to pilferage and vandalism. In addition to locating dosimeters at all environmental sampling locations, other TLD locations have been added to provide an accurate representation of current site conditions. These near-field locations are shown in Figure 4-20. Existing EPA TLD stations are shown in Figure 4-21. Finally, TLDs will be added to monitor the far-field area at locations 27 to 31 in Figure 4-22 and every five miles along U.S. Highway 95 from Las Vegas to Beatty as depicted in this same figure. U.S. Highway 95 is either the location of, or the boundary between, the major population in the area and the Yucca Mountain area. Thus these dosimeters monitor the impact of the boundary between the Yucca Mountain area and the public.

4.3.8.1.2 Exposure rate

Various instruments are available for continuous monitoring of the exposure rate as a function of time. For the monitoring of intermittent or unplanned releases, characterization of diurnal variations, and better identification of source terms, exposure rate instrumentation should be available. Several types of instruments suitable for measurement of environmental exposure rates are commercially available, as shown in Table 4-10.

Table 4-9. NRAD environmental dosimeter

Phosphor	Shielding	Number of dosimeters per package
$Li_2B_4O_7:C_u$	14 mg/cm^2 of plastic	1
$CaSO_4:Tm$	1,000 mg/cm^2 plastic and lead	3

Low-level portable exposure rate instruments, using either GM tubes or scintillator materials, are capable of exposure rate measurements down to 5 μR/hr, and are relatively inexpensive compared to the Pressurized Ion Chamber (PIC). However, stability and reproducibility of measurements are much less satisfactory due to problems associated with geometry, thermal sensitivity, and energy response. These instruments also lack the sensitivity and accuracy needed for this program.

The argon-filled pressurized ionization chamber (PIC) listed is capable of continuous unattended operation and exposure rate measurement down to 1 μR/hr, and has excellent energy response characteristics. In addition to a chart recorder, the PIC has an optional tape cassette readout which can provide computer-compatible data for detailed analysis. This type of unit has been selected for the program based on its superior characteristics and its consistency with the monitors used in the current NTS program. Because of its cost, however, only a limited number will be used.

The deployment of at least one continuously-recording exposure rate instrument (PIC), preferably near the site boundary, is recommended by Corley et al. (1981). This instrument will be used to verify dispersion calculations, and provide detection and approximate magnitude of sudden changes in airborne natural radioactivity, fresh fallout, or other sources. Currently, the EPA is recording these data at Beatty, NV; Amargosa Valley, NV; Indian Springs, NV; Pahrump, NV; Furnace Creek, CA; and Shoshone, CA. The radiological monitoring program will add stations to collect exposure rate data at Scotty's Junction, the Amargosa Farm area (exact location to be determined), and at the near-field locations indicated in Figure 4-21. One portable PIC will also be obtained for monitoring various temporary locations, such as Death Valley Junction, and for interim replacement of a failed unit at a permanent station location.

4.3.8.1.3 Aerial surveys

Aerial surveys consist of overflights of the near-field area by an aircraft-borne radiation measurement and recording system. A satisfactory

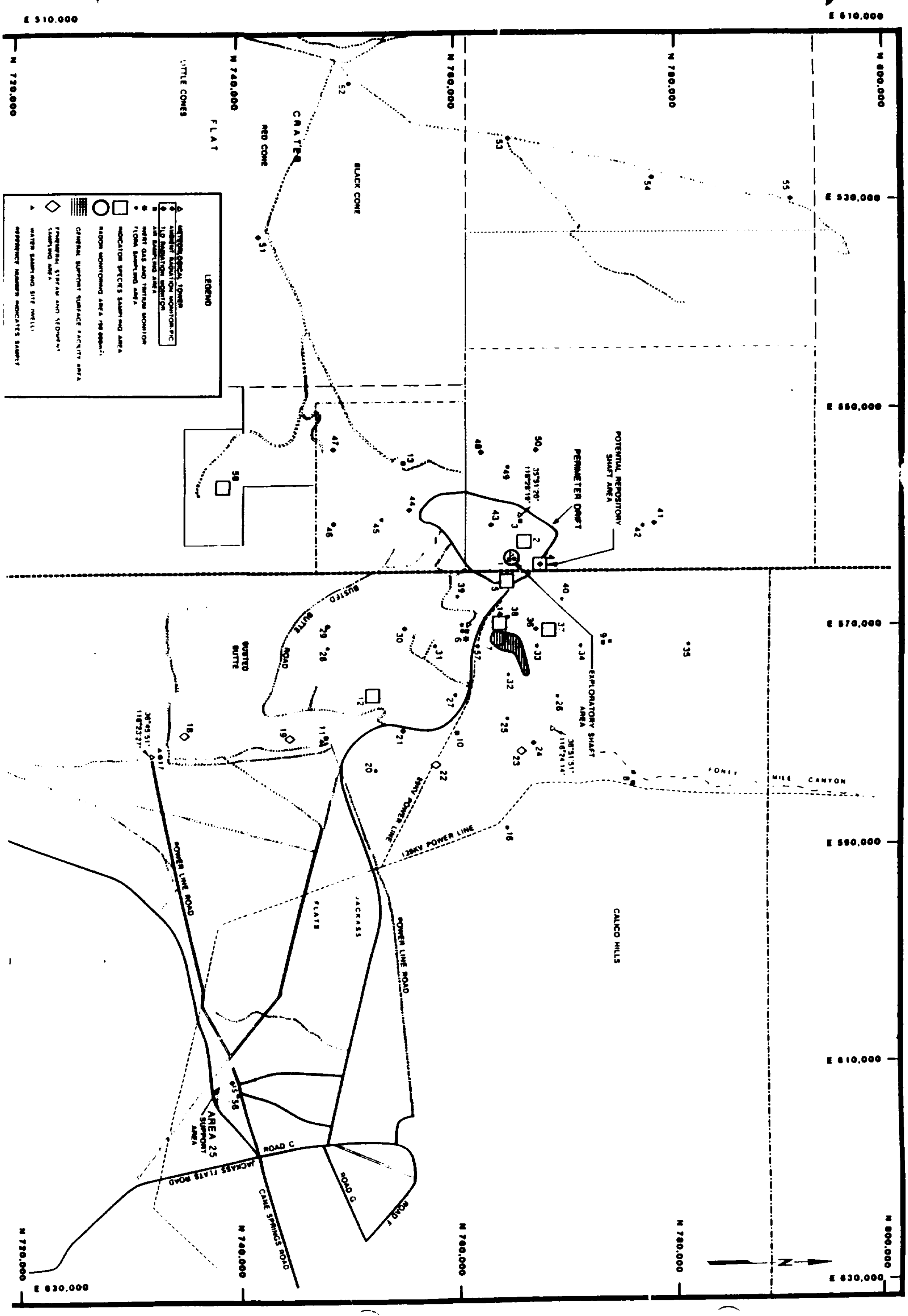


Figure 4 Near-field ambient sampling locations

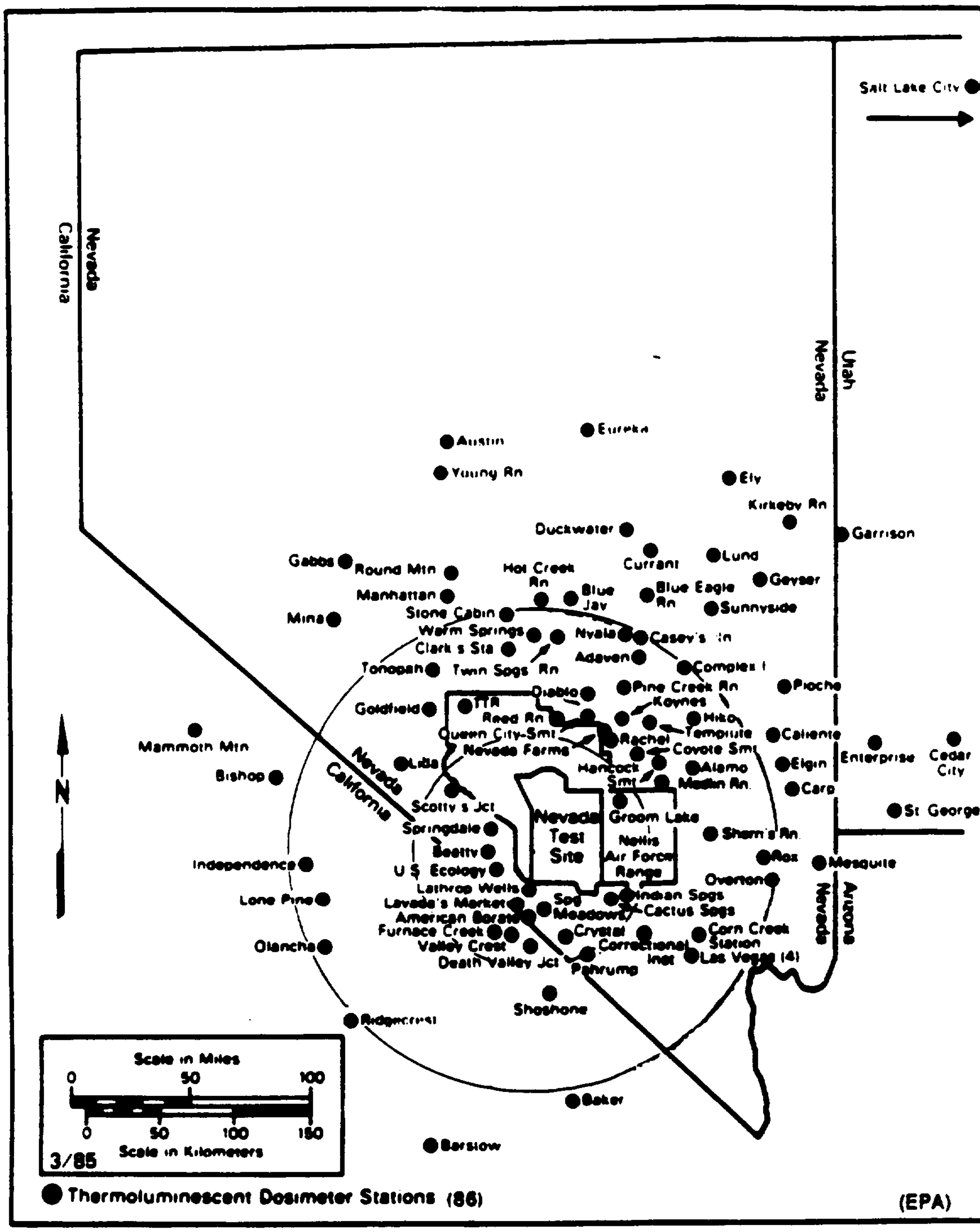


Figure 4-21. EPA TLD monitoring stations.

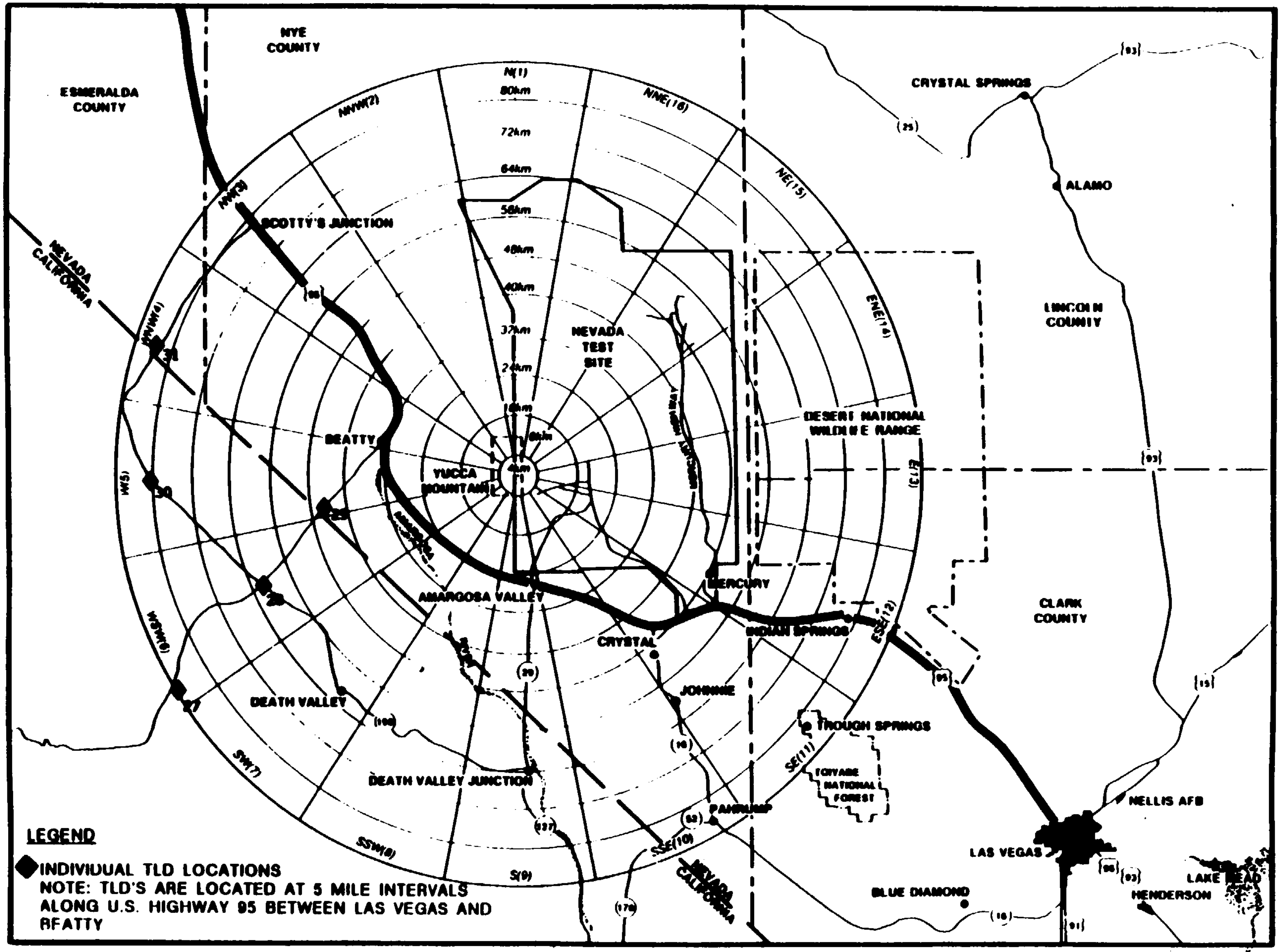


Figure 4-22. NNWSI Project supplemental TLD monitoring locations.

Table 4-10. Exposure rate monitors

Type	Detector	Radiation	Exposure rate range	Energy range	Accuracy	Graph readout	Power	Operation period	Relative cost
Movable	Pressurized ion chamber	γ	1 μR/hr to 150 μR/hr	50 keV to 5 MeV	($\pm$)5%	Option	Line or battery	Continuous (200 hr on battery)	High
Station-ary	G.M.	γ or β, γ	10 μR/hr to 100 mR/hr	100 keV to 2.4 MeV	($\pm$)20%	Option	Line	Continuous	Moderate
Portable	Scintillator	γ	5 μR/hr to 50 mR/hr	--[a]	--	Option	Battery	100-300 hr	Moderate
Portable	Air Ioniza-tion	β, γ	10 μR/hr to 1000 mR/hr	40 keV to 1.3 MeV	($\pm$)20%	--	Battery	100 hr	Moderate
Portable	G.M.	β, γ	5 μR/hr[b] to 2 R/hr	45 keV to 3 MeV	($\pm$)20%	--	Battery	4 hr cont. 50 hr int.	Low

[a]-- indicates data not available.
[b]Selected ranges available within these limits.

system for relatively coarse discrimination of ground-level sources may be assembled by using a large NaI scintillator (at least 10 cm x 10 cm), a high voltage supply, amplifier, ratemeter, graph recorder, and portable power supply (batteries).

The Aerial Measurements System (AMS) (Doyle, 1974; and Deal and Doyle, 1975) operated for the DOE by EG&G Inc. is of more sophisticated design. It provides detailed data analysis from aerial surveys of gamma radiation levels in and around nuclear facilities. Although developed primarily to provide improved radiation accident response capability, results from AMS helicopter surveys of major DOE sites (Burson and Boyns, 1975) have provided an overview of the location, relative intensity, and identification of gamma-emitting radioactive contaminants. Particularly valuable is the definition of radioactivity levels in areas difficult to measure by ground survey techniques.

Calibrations for surface contamination levels (in $\mu Ci/m^2$) and for exposure rates at one-meter height are currently available with this system for several nuclides, including Co-60 and Cs-137. Others may be developed upon declared need. For the AMS survey over the Oak Ridge site, the level of detectability for unshielded point sources on the ground surface was about 2 mCi of Co-60 or 6 mCi of Cs-137. For equivalent one-meter exposure rates (averaged over the detector field of view, about 400-meters in diameter) resulting from only man-made radioactive sources, the level of detectability was about 0.8 $\mu R/hr$.

The AMS surveys are usually funded by the DOE Operational and Environmental Safety Division. Arrangements are currently being made to have an AMS survey conducted for the Yucca Mountain area (Figure 4-21).

4.3.8.1.4 In situ gamma spectroscopy

In situ gamma spectroscopy will be used to characterize the ambient environment at each soil sampling location (Section 4.3.6). The data collection (site-specific spectral data) will initially occur at each soil sampling location, and will normally be repeated only if there is an indication that the radiological conditions have changed. A limited number of locations will be selected for quarterly reevaluation to provide some idea of the variability of these spectra over time.

4.3.8.1.4.1 <u>Technical basis for in situ gamma spectroscopy</u>

The primary driving force for in situ spectroscopy, as for the radiological monitoring program, are the requirements and recommendations in the current draft of Corley et al. (1987) which is an attachment to DOE (1987c). This DOE document specifies in:

1. Section 5.4.2 (pg 5.12) that "[b]efore final placement of any environmental radiation measurement station (background or control and indicator locations), an initial on-the-spot survey should be performed and documented to determine the absence of possible

naturally occurring anomalies that could affect interpretation of later measurements . . . . An in situ gamma-ray spectrometer . . . can be used . . . ."

2. Section 5.4.2 (pg 5.14) that "in situ gamma spectroscopy should be used as a method of documenting environmental mixtures of radionuclides. . ."

3. Section 5.7.3 (pg 5.36) that "[u]seful information about soil contamination levels can also be obtained using in situ gamma-ray spectroscopy."

The recommendations of the DOE/HQ consultants during a review of the status meeting on the RMP on May 13 and 14, 1987 was that in situ gamma spectral analyses should be included as part of the radiological monitoring program.

In addition to the DOE requirements, NCRP (1976) indicates that "[i]n situ measurements are valuable for the rapid assessment of radiation exposure, identification of radionuclides, and detection of trends in environment radioactivity due to man's activities."

IAEA (1975) indicates that in situ measurements are extremely useful in evaluating the impacts of unplanned releases. However, this evaluation is only feasible if baseline in situ data have been collected before the release.

The DOE indicates in the EML-HASL/300 (Procedure C-02-01) that "[f]ield spectrometric techniques permit the rapid identification of particular radionuclides in the environment...." Furthermore, DOE Environmental Monitoring Laboratory personnel indicated at the IEEE Nuclear Science Symposium (San Francisco, CA, October 21-24, 1981) that "in situ gamma spectroscopy results may be obtained more rapidly than laboratory counting a grab sample, and will generally be more representative of the area."

Thus, the technical requirements and guidance indicate that in situ gamma spectroscopy is appropriate. The question addressed in the next section is how these data might be used at Yucca Mountain.

4.3.8.1.4.2 <u>Projected use of in situ gamma spectral data</u>

The following discussion of in situ gamma spectroscopy use relates primarily to the spectral data collected during in situ gamma spectroscopy for radionuclide identification. However, the count rate data can also be used to provide limited data on relative abundance of radionuclides and the potential ambient radiation field. Examples of in situ gamma spectroscopy use:

1. The results of the in situ measurements for an area will be used to screen (select) soil samples to determine analytical requirements.

2. The in situ data, coupled with the soil sampling data, will allow assessment of how representative of the area the soil sample is and whether further sampling and analysis is required.

3. If any unplanned release of radioactivity were to occur from some source during site characterization, or later during the life of the Project, a second set of in situ measurements could be made at selected locations to determine if resampling of the areas was needed and, if so, what the scope of the sampling activity might be.

4. The in situ data can be used to verify the identity of samples and analytical results by establishing relative radionuclide ratio by an independent field method.

5. The in situ data will facilitate identification of ambient radiation sources.

6. The in situ data may allow evaluation of the vertical distribution of radionuclides in the soil.

The technical data this technique provides will be very useful additions to the radiological monitoring program.

4.3.8.1.4.3 <u>In situ gamma spectroscopy system</u>

The radiological monitoring program is currently considering a system for in situ gamma spectroscopy consisting of a Nuclear Data ND990 Multichannel Analyzer System with associated electronics and an intrinsic germanium "N" type detector with 30 percent efficiency (2.0 keV resolution) with a mechanical cooling device.

4.3.8.1.5 Public monitoring

Based on the precedent established by the existing NTS environmental monitoring program, this RMP activity may also support the public monitoring activity associated with the NTS. A limited number of individuals in the public (1) are monitored with a personal dosimeter, (2) receive routine bioassay, and (3) receive routine in vivo counting in the NTS program.

If it is determined that additional monitoring is appropriate, a limited number of individuals may be selected from the area located in the SE to W section of the grid in Figure 4-1. This portion of the program is still under evaluation. However, the current data from the NTS program will be available to support this activity.

4.4 IMPLEMENTATION OF THE RADIOLOGICAL MONITORING PROGRAM

The radiological monitoring program will consist of six major tasks:

1. Program development and planning.
2. Specific program implementation (operation).
3. Data and sample archiving.
4. Quality control activities.

5. Analysis of data and reporting.
6. Program revision.

Under Task 1, there are several subtasks. These subtasks include the preparation of required documents (in accordance with T&MSS administrative and technical procedures) and completion of the following activities:

1a. Technical plan(s).

1b. Hazard review/safety plan.

1c. Training program.

1d. Procedures.

1e. Identification of required equipment and services.

1f. Procurement specification after identification of the required equipment and services.

1g. Quality assurance/quality control implementation plans/procedures.

1h. Checklist for assessing an activity's operational readiness.

1i. Budget and staffing requirements.

1j. Planning and scheduling of expected activities.

1k. Waste Management Project Office (WMPO) authorization to initiate the expected activities.

Task 2 can also be broken into various subtasks:

2a. Procurement of required equipment.
2b. Procurement of outside services.
2c. Personnel training (procedures and equipment operation).
2d. Field data collection.
2e. Laboratory analyses.
2f. Field instrument calibration/accuracy checking.
2g. Preparation of quality control samples.

The balance of the tasks are essentially self-explanatory, with the exception of Task 6, which is discussed in Section 8.2.

4.4.1 PARTICIPANTS

During site characterization, the primary participants in this program will be the DOE/NV-WMPO, the T&MSS Contractor (SAIC), and the EPA/NRAD in Las Vegas, Nevada. Other groups that will be participants or provide needed support include the DOE/NV Health Physics and Environmental Division (HPED), EG&G/EM (Santa Barbara Operations), the EPA Office of Radiation Programs (ORP) (Las Vegas, NV), REECo (the prime contractor at the Nevada Test Site), DOE Nevada Operations Office, and the State of Nevada.

4.4.1.1 DOE/NV Waste Management Project Office (WMPO)

The WMPO, particularly the Regulatory and Site Evaluations Branch, has primary management responsibility for the entire radiological monitoring program. The program, future revisions to the program, the budget and schedule for implementation of the program, and the report issued by the program will have to be approved by the WMPO.

4.4.1.2 Technical and Management Support Services (T&MSS) Contractor

The T&MSS Contractor has primary responsibility for implementation of the radiological monitoring program as indicated in the tasks in Section 4.4. The T&MSS Contractor is completing Task 1 with support from the NRAD, EG&G, DOE/NV-HPED, and the WMPO. The T&MSS Contractor will also participate in Task 2, with primary responsibility for Subtasks 2a and 2b, and significant involvement in the other subtasks with the exception of Subtask 2e. Note: The T&MSS Contractor has primary responsibility for the radon monitoring program, and will have primary responsibility for the other major tasks (with significant support from the NRAD and EG&G).

4.4.1.3 EPA/LV Nuclear Radiation Assessment Division (NRAD)

The NRAD will provide technical support to the T&MSS Contractor to complete the first task. It will also review the product of this task. The T&MSS Contractor will support the NRAD in preparation of required documentation. The NRAD will perform most of the laboratory analyses (Subtask 2e). The analyses not performed by the NRAD are likely to fall under Subtask 2b and are analyses (primarily related to radon and the AM survey) performed by outside laboratories. The NRAD will also complete a majority of Subtask 2d within the limits of manpower and convenience. The T&MSS Contractor will support the NRAD in completion of these and other subtasks, including providing needed personnel. The NRAD will provide the primary technical support and technical review for the balance of Task 2 and the remaining tasks, and will provide its internal documentation under Subtasks 1c, 1d, 1e, 1f, 1g, 1h, 1i, 1j, 2c, 2g, 3, and 4 with support from the T&MSS Contractor.

4.4.1.4 DOE/NV Health Physics and Environmental Division (HPED)

The HPED has primary responsibility for implementing radiation safety requirements for the worker, the public, and the environment at the NTS. The HPED will review the RMP, all technical procedures, and all reports associated with the program to ensure RMP activities comply with the standards, requirements, and guidance established by the HPED, and to ensure minimal impact of the program on other DOE programs. In addition, the participants in the radiological monitoring program will comply with all applicable HPED standards and requirements.

4.4.1.5 EG&G/Energy Measurements (Santa Barbara Operations)

EG&G/Energy Measurements, as the NNWSI Project's and the Nevada Test Site Operations Office (NTSO's) technical expert in the biological sciences, will be a participant in Task 1, Subtasks 2a, 2b, 2d, 2g, and Tasks 4, 5, and 6 (Section 4.4). The area of participation is associated with the collection and evaluation of biota samples from the environment.

4.4.1.6 EPA/LV Office of Radiation Programs (ORP)

The ORP has agreed to assist the T&MSS/NRAD team in the preparation of Quality Control control samples and the calibration of equipment for radon monitoring. This activity is consistent with their basic function within the EPA.

4.4.1.7 Reynolds Electrical and Engineering Company (REECo)

REECo is the prime contractor for the Nevada Test Site (NTS). As such, REECo provides the general support services at the NTS. REECo will provide the support services to these radiological monitoring activities, including radioactive material control (RAMATROL), general health physics control, emergency support, maintenance, and other services. In addition, REECo may participate in the collection of some samples and may provide the analytical support for NTS/DOE related requirements.

4.4.1.8 DOE Nevada Operations Office (DOE/NV)

The DOE/NV is the organization responsible for NTS operations. The radiological monitoring program will comply with all applicable DOE/NV requirements and standards. The radiological monitoring program will, through the WMPO, request the DOE/NV to obtain required NTS support services and approvals for the RMP field activities.

4.4.1.9 State of Nevada

It is hoped that the State of Nevada will be a participant in this program. Details of this participation have not yet been established. When such details are available, this section will be revised to describe the State's participation.

4.4.2 DOE PROCEDURAL REQUIREMENTS AND OPERATIONS

All activities in the radiological monitoring program must be approved by the WMPO and the implementation must have the concurrence of the DOE/NV. The program will follow all applicable DOE requirements and standards. The program and its major participants have their own radiological and nonradiological safety requirements, which will also be followed. The radiological monitoring program will also comply with the REECo Safety Manual and the REECo Environmental Sciences Division (ESD) Standard Procedures.

4.4.3 NNWSI PROJECT INTERFACES

Activities in the RMP that overlap with activities of other NNWSI Project participants or T&MSS organizations will be planned to prevent duplication of effort. Two basic procedures will be followed: one for other NNWSI Project participants and one for other T&MSS organizations. In both cases, the technical individuals (principal investigators) will meet and establish a mechanism for sharing information. For activities involving other T&MSS organizations, the appropriate department managers will approve the decision. However, for other NNWSI Project participants (with the exception of the NRAD/EPA*), a WMPO representative may be involved in the technical discussion. Concurrence of the affected Technical Project Officers is required in the decision. Areas where this overlap appears to exist include:

1. The Sandia National Laboratories radiological assessment activities.
2. Water sampling for radionuclide constituents.
3. Air quality monitoring (particle size analysis).
4. Fauna and flora sampling for radionuclide analysis.

4.4.4 EQUIPMENT AND SERVICES

The equipment and service needs to implement the radiological monitoring program are summarized in Table 4-11 (for equipment) and Table 4-12 (for services and expendable equipment). These tables do not address services from the NNWSI Project or NTS contractors, which will be discussed in Section 8.3. This section only addresses equipment for implementation of the program during the site characterization phase. These data will require updating as the RMP is revised.

---

*The NRAD/EPA will resolve overlaps within the technical context of the development and revision of this program in which they are a participant.

Table 4-11. Equipment requirements (page 1 of 3)

Item	Function	Number	Cost/per item	Total cost	Status
Continuous Radon Monitor (high sensitivity).	Continuous radon monitoring	3	8K	24K	1 procured no action on the balance
Limited sensitivity radon detector	Radon monitoring (short timeframe)	1	1K	1K	Procured[a]
Working level detector for radon monitor	Working level measurement	1	1K	1K	Procured
Continuous air sampling station	Particulate and iodine sampling	25	1.7K	43K	Procured
Low energy photon detector with shielding and electronics	I-129 and Tc-99 measurements	1	50K	50K	In procurement for non-capital equipment, no action on capital equipment
Glasswire for C-14 analysis (specified system)	C-14 measurements	N/A	5K	5K	Early procurement required, no action
Radioactive standards to support analysis activities	All measurements	N/A	5K	5K	In procurement
Alpha Spectrometer		6	3K		

Table 4-11. Equipment requirements (page 2 of 3)

Item	Function	Number	Cost/per item	Total cost (per year for services)	Status
High pressure ion chamber	Environmental exposure rate measurements	6	10K	60K	In procurement
Tritium monitor	Monitor Tritium	3	3K	9K	No action
In situ Gamma Spectral Analysis Equipment	In situ Gamma Spectral Analysis	1	75K	75K	Proposed for inclusion
Noble gas monitors	Monitor noble gases	3	7K	2K	No action
TLD/holder for environmental measurement	Ambient radiation monitor	120	160	19K	In procurement
Particulate AED samplers and support equipment	Measurement of AED	2	8K	16K	Procured
Soil/water/sediment sampling equipment (sample splitters, screens, shakes, collect equipment, coring tools, drums, etc.)	Collection of soil samples	1 set	12K	12K	Various
Analytical balance	Measurement of AED and various samples	1	5K	5K	Procured

Table 4-11. Equipment requirements (page 3 of 3)

Item	Function	Number	Cost/per item	Total cost	Status
Biota sampling equipment (traps, etc.)	Sampling biota	TBD[b]	10K	10K	No action
Radon monitoring station equipment	Radon monitoring	2	300	6.6K	In procurement
ADP analysis support equipment	Data collection and analysis	2	9K	18K	No action

[a]One already procured
[b]To be determined

Table 4-12. Services and expendable equipment (page 1 of 2)

Item	Function	Stations a,b	Units per station per year	Unit cost	Yearly costs[a]	Set up charge (one time)	Loss or repair estimate
Terradex radon monitors	Radon monitoring	22	12	$75	$20K	2K	1K
Rad services radon monitors	Radon daughters product monitoring	22	12	80	21K	5K	
Air sampler filtration media	Particulate air sampling	25	104	.3	1K		
Charcoal cartridges for air samplers	Iodine air sampling	25	52		2	3K	
Calibration of radon monitoring equipment	Radon monitoring	3	1		3K	9K	2K
Air sampler calibration and repair	Air sampling	2[c]	2	600K	12K		6K
TLD replacements	Ambient radiation monitors	TBD	20	160K	3K		2K
Soil/water/sediment sample bottles	Sample storage	TBD	TBD	1K			
Core sample containers	Sample storage	TBD	TBD	1K			
Particle AED filters and support materials	AED measurement	TBD	TBD	2K			

Table 4-12. Services and expendable equipment (page 2 of 2)

Item	Function	Stations[a,b]	Units per station per year	Unit cost	Yearly costs[a]	Set up charge (one time)	Loss or repair estimate
Ion chamber calibration	Environmental exposure for monitoring		3	1K	3K		1K
Miscellaneous outside analyses	N/A			TBD	2K		
Noble gas/tritium sampler maintenance	Noble gas/tritium measurements			TBD	3K		3K
ADP Maintenance and supplies	Data analysis and collection .	-	-	TBD	2K		2K

[a]Number in parentheses for first year only.
[b]Include QA samples.
[c]Number of calibrators.

5.0 METHODS FOR RADIOLOGICAL ASSESSMENT

In addition to the activities detailed in Section 4.0, various computational/analytical methodologies are required to support the radiological monitoring program and various other NNWSI Project site characterization radiological assessment activities. These methodologies can be relatively uncomplicated calculation models or more comprehensive computer programs with varying degrees of complexity.

The analytical methods required to implement the RMP's radiological assessment element are partly determined by the reporting and analytical needs of the Project during site characterization. Most of the methodologies will be directed towards the estimation of potential radiation doses to the worker and the public, or the dispersion of activity into the environment from existing or planned activities. A limited number of computational methodologies are needed to support (1) resolution of other radiological issues, such as shielding design verification and impact analysis; (2) review of safety analysis, etc.; and (3) other assessment activities. The methodologies presently identified are briefly discussed in this section. The criteria for selecting methodologies for use in NNWSI Project radiological impact assessments are also addressed. In addition, the probabilistic risk assessment methodology (PRAM) working group is considering many of these same analytical methods for use in repository design and licensing. Every effort will be made to ensure consistency of this activity with the PRAM activities.

5.1 REQUIREMENTS FOR THE METHODS

All radiological assessment methodologies require various types of input data. In many cases, the development of input data itself may require various levels of analytical effort. The following sections briefly describe the basic analytical methodologies, the various inputs, or the assessment techniques necessary to support the required analysis.

5.1.1 SOURCE TERM ASSESSMENT

An input for the dose assessment methodologies discussed in the next two sections are the results of a source term analysis. Types of data required to estimate the source term and release mechanism include:

1. The amount of radioactive material in spent fuel as a function of reactor type, burnup, and decay period.

2. The mix of waste received by the facility (waste inventory).

3. The time-phased projection of specific radionuclide activity, corrected for decay and ingrowth.

4. A method to model the resuspension and deposition of radioactivity.

5. A method to model atmospheric dispersion in some cases.

These are areas of current interest for evaluation of RMP data or other related analyses currently planned. Other areas of source term estimation may be important elsewhere in the NNWSI program.

5.1.2 PUBLIC RADIATION DOSE ASSESSMENT

This section will discuss the various methodological requirements for calculating radiation dose to the public as a result of NNWSI Project activities. Only those methodologies presently anticipated for use in support of the Project are considered. Some assessment methodologies will be initiated through other NNWSI Project participants, other Office of Civilian Radioactive Waste Management (OCRWM) participants, or through contracts with other organizations. Efforts will be made to ensure consistency between methodologies used by all participants and methodologies proposed by the PRAM working group.

One of the primary requirements of the NNWSI Project is the calculation of the radiation dose to the public from NNWSI Project activities. The assessment methodology used for population dose estimation will need to consider the inhalation, immersion, direct radiation, and ingestion exposure pathways. A model for dispersion through the liquid effluent surface-water pathway is not required due to specific characteristics of the site (lack of a significant surface-water pathway), but impacts of ephemeral streams will be considered. The estimation of radiation dose to the public using these methods will provide the means for assessing compliance with the requirements detailed in Sections 3.3.1.1.2.1, 3.3.1.1.3.2, 3.3.1.2, 3.3.1.3, and 3.3.1.4.

The codified version of AIRDOS-EPA will be used to calculate the exposure to the public for compliance with the Clean Air Act as required by the EPA and DOE Orders.

5.1.3 WORKER RADIATION DOSE ASSESSMENT

Methodologies are also needed to assess compliance with applicable worker radiation dose limits and guidance. Typically only the inhalation, direct radiation, injection (through a break in the skin), and immersion doses are considered in occupational dose assessments. As with the doses to the public, the expected occupational doses are compared to the appropriate criteria detailed in Sections 3.3.1.1.2.1, 3.3.1.1.3.2, 3.3.1.2, 3.3.1.3, and 3.3.1.4.

Working level months (WLM) of worker exposure to radon/radon daughter products must also be evaluated. The WLM results must be compared against the criteria discussed in Sections 3.3.1.1.3.3 and 3.3.1.1.2.2. These exposures will be added to other occupational exposures using the data available from the ICRP (ICRP, 1959; 1977; 1979; 1981; and 1985) and compared to applicable standards in addition to meeting the standard specifically addressing radon.

5.1.4 RISK ASSESSMENT

In addition to the doses calculated for determining compliance with prescribed limits, the dose estimate information will be reported in terms of health risk for preclosure activities to allow a clear interpretation of the results by the public. Risk assessment methodologies include the consideration of the probability of an initiating event occurring and the consequence of such an event. The codified version of RADRISK will be used to calculate the health risk of the potential dose. RADRISK is required by the EPA and DOE, unless an acceptable alternative is approved by the EPA.

5.1.5 RADON SOURCE TERMS

A special program for determining preclosure radon/radon daughter product source terms is also needed. The methodology for assessing a source term is different from the source term assessment discussed in Section 5.1.1. The method will provide an estimate of the quantity of radon released based on uranium and thorium concentration in site-specific material (naturally occurring geologic media). This methodology will reflect the need to differentiate the infinite source (the existing environment) and the discrete source (created by man). This analysis will be used to estimate radon concentrations in the underground drift areas and the area surrounding the repository facility. Radon gas potentially dispersing offsite and reaching the public will also be evaluated. The radon release assessment will be used to review compliance with the criteria and guidance discussed in Section 3.3.1.1.2.1. Useful information is also provided by these data to support the facility design and its compliance with occupational limits for radon/radon daughter exposure.

5.2 SELECTION AND VERIFICATION, VALIDATION, OR DOCUMENTATION OF METHODS

All assessment methodologies/programs used in this task will be evaluated against a set of defined considerations. The Technical and Management Support Services (T&MSS) Contractor will evaluate these methodological programs for use in assessing compliance during the site characterization and construction phases (and others as needed). These evaluations will be submitted to the Waste Management Project Office (WMPO) for approval when completed. These considerations include, but are not necessarily limited to, the following questions:

1. To what extent does the methodology/program provide the required data from available input?

2. How feasible is it to modify the methodology/program to provide the required data from available input?

3. Are there alternate methodologies/programs that can provide the required data from available input?

4. Has the methodology/program been accepted in NRC licensing proceedings?

5. Has or will the methodology/program be accepted by the EPA, OCRWM, or other DOE organizations?

6. Is adequate documentation available for use of the methodology/program?

7. Has the methodology/program been verified?

8. Has the methodology/program been validated?

9. If the answer to Item 7 or 8 is no, can verification and validation be accomplished?

10. Can site-specific data be used in these methodologies/programs?

11. Does the methodology/program produce answers within an acceptable level of uncertainty?

12. Is the methodology/program consistent with statutory requirements, regulatory criteria, and technical guidance?

13. Is the methodology/program consistent with the PRAM and other OCRWM programs, and is it consistent with state-of-the-art technology?

Evaluations of the various methodologies/programs within these constraints and considerations will rely on completion of the following activities:

1. Obtaining and reviewing a copy of documentation for the methodology of interest.

2. Performing a test case implementation of the methodology.

3. Documenting the selection process for a methodology. (Software documentation is discussed in AP 1.24, AP 5.5, and SOP-02-03.)

4. Verification and validation, as appropriate.

5. Implementing configuration management controls as described in the Systems Engineering Management Plan (SEMP) and associated documents.

After completion of the evaluation activities, the methodology is approved for use. The evaluation process may be terminated at any step if it is determined that no significant benefit to the Project will result from completion of the process.

5.3 SUMMARY OF PROJECT ASSESSMENT METHODOLOGIES

The application of specific methodologies has not yet been established. The determination of appropriate programs and methodologies is presently being evaluated. Some of the methodologies noted below are listed to indicate the source of the data need discussed in Section 6. Methodologies, which are expected to be available, may be needed to supplement analyses at some future date. Currently identified models or programs for consideration include:

1. AIRDOSE-EPA/RADRISK (Moore, 1979; Dunning, 1980) for estimation of doses and risk from particulates and gaseous routine releases (noncodified and codified versions).

2. CRRIS (Begovich, 1986) for estimation of offsite doses and risks from particulates and gaseous releases.

3. MILDOS (Gnugnuli, 1980) for the estimation of offsite doses from radon releases.

4. RAECOM (Rogers, 1984) for the estimation of radon emissions from materials.

5. PATHWAY (Whicker, 1986) for estimates of the impacts from the ingestion pathway of short-term releases.

6. DACRIN (Houston, 1976) for estimates of the impacts from inhalation of short-term radioactive releases.

7. GASPAR (Eckerman, 1977) for the estimation of annual dose due to routine releases of radioactivity.

8. RADTRAN III (or IV?) (Taylor, 1977) for the estimation of the radiological impacts of the transportation of radioactive materials. (Use is not expected during site characterization. It is noted for the purpose of completeness. It is similar in nature to the other programs and is being implemented at SAIC relative to other activities.)

9. XOQDOQ (Sagendorf, 1977) to calculate plume dispersion and deposition.

10. Various EPA-approved meteorological dispersion programs selected and run by the Environmental Field Programs Branch at T&MSS.

11. ORIGEN 2 (Croff, 1980) for projection of spent fuel source terms corrected for decay and ingrowth.

12. ACT (Woolfolk, 1985) for projection of radioactive ingrowth without the use of the more complicated computer program ORIGEN.

13. Various PRAMs currently being considered by the PRAM Working Group.

14. ISOSHIELD (Engel, 1966), DOT (Rhoades, 1982), and KENO IV (Radiation Shielding Information Center, 1975) for calculation of shielding characteristics. (Use is not expected during site characterization. They are noted for the purpose of completeness.)

15. Resuspension models such as those discussed in Hall et al. (1977) and NVO-178, which will be selected and used to model the resuspension of radioactive aerosols at the site.

16. Hydrological models, which will be developed by NNWSI Project staff members and the results of their modeling reflected in future data reports.

17. Models incorporated into ARAC (Atmospheric Release Advisory Capability) may be used for calculation of site dose where appropriate. (Use is not expected during site characterization. They are noted for the purpose of completeness.)

Note: ARAC is a real-time emergency response system designed to assess the potential environmental consequences of radiological accidents. It responds to a wide variety of atmospheric release scenarios associated with transportation accidents or facility accidents. It consists of communications and computer systems, data bases, verified atmospheric dispersion models, and an assessment staff. ARAC is located at Lawrence Livermore National Laboratory and is presently providing support to 50 U.S. Department of Defense (DOD) and DOE facilities, as well as to NRC licensed nuclear power plants.

6.0 RADIOLOGICAL DATA COLLECTION FOR DESIGN SUPPORT, REGULATORY COMPLIANCE, SAFETY ANALYSIS REPORT (SAR), AND OTHER ACTIVITIES

This section discusses collection of data required to support radiological analyses. It does not include collection of the radiological monitoring data previously addressed in Section 4.

The primary data needed to support the radiological safety analysis are those data necessary for implementation of computer programs (Section 5.3). The primary area of emphasis is the calculation of radiation doses to the public using programs such as AIRDOS-EPA. These data will include radiological, meteorological, agricultural, cultural, and general biota data; characteristics of radioactive aerosols; and population demographics. Also required are

1. Resuspension and deposition data for radioactive particulates.
2. Solubility/leachability of radioactive materials.
3. Chemical form of radionuclides.
4. Radon emanation rate for various materials (or characteristics to assess this value).
5. Effects on radon emanation rates of meteorological conditions and expected site activities.
6. Characteristics of off-normal and accident scenarios for the activities (present and future).
7. Ventilation flow characteristics.
8. Environmental sensitivity to the impact of radionuclide uptake.

6.1 DATA REQUIREMENTS OF CALCULATION MODELS FOR USE IN THE ENVIRONMENTAL IMPACT STATEMENT (EIS), SAFETY ANALYSIS REPORT (SAR), AND OTHER ACTIVITIES

The data required in developing the EIS and SAR are essentially identical to those data required in assessing regulatory compliance and environmental monitoring commitments. The following sections address collection of these data based on the potential data source. This set of data may require changes following the EIS Scoping Hearings.

6.1.1 RADIOLOGICAL DATA

The primary radiological data needed to support the RMP and related activities are

1. Physical and chemical decay characteristics of radionuclides.

2. Shielding characteristics of the radioactive material present and the shielding material (e.g. soil).

3. Estimates of external dose from immersion and surface contamination.

4. Estimate of internal dose from inhalation, ingestion, and injection (through an opening in the skin).

5. Assessment of risk as a function of absorbed dose.

6. Existing environmental radiological background levels.

7. Applicable regulatory criteria (specifications of dose limits).

These data will be used to calculate the radiation dose to workers and the public to ensure compliance with applicable regulations (Section 3.3) and to ensure that the health and safety of the public and workers is protected. These data will also be applied in the effort to minimize the impact-versus-benefit ratio for NNWSI Project activities. This relates particularly to implementation of the Environmental Monitoring and Mitigation Plan (DOE, 1988c). Because radiological health risk, rather than dose, is a much more effective way of presenting these impacts to the public, all impacts will be presented in terms of radiological health risk.

Many of the radiological data needed are available in the technical literature and require only identification and evaluation for applicability. Many of the data related to Item 7, however, require collection at the site. These data are addressed specifically in Section 4.

6.1.2 CHARACTERISTICS OF RADIOACTIVE AEROSOLS

The characteristics of radioactive aerosols involve primarily their aerodynamic equivalent diameter (AED) distribution and their resuspension and deposition. Data on resuspension and deposition are available in the technical literature. The AED distribution will come primarily from the monitoring activity discussed in Section 4.3.4.4.1. Confirmatory data will be available in the technical literature.

These data will be used in the calculation of the doses mentioned in Section 6.1.1. They are also needed to assess the environmental impact mentioned in Section 6.1.1.

The data on resuspension and deposition, which are related to the AED distribution, are used to establish potential source terms as a function of meteorological conditions and work activity. Thus, these data provide an assessment of the changes in source term as the material disperses. In addition, these data are used as input to programs and models projecting ingestion and immersion pathway doses and the external exposure from deposited material. Resuspension and deposition data, when coupled with meteorological conditions and work activity data, also provide information on the movement of radioactive material throughout the environment. The AED distribution, coupled with the chemical characteristics of the material, is used to assess the behavior of radionuclides entering the body along the inhalation pathway.

The amount of time required for this data collection is not definite; data gathering is performed until variation in the data (at 95 percent confidence level) is within an established acceptable range (typically ±20 percent) or until sufficient data are collected to indicate the range is not an achievable goal, and a new goal is established.

6.1.3 METEOROLOGICAL DATA

Required meteorological data will typically be in two forms: basic data (discussed later in this section) and derived dispersion factor (χ/Q) estimates.

A χ/Q estimate based on appropriate site meteorological data and models must be derived for the centerpoint of each section in the Figure 4-1 grid. Data sufficient to reasonably extrapolate χ/Q values for any point along each of the 16 major points of the compass rose must also be provided. Furthermore, the χ/Q values will be needed for Las Vegas. It is presently anticipated that two χ/Q sets will be required: one centered on the proposed surface facility and one centered on the major exploratory shaft facility (ESF) shaft. The χ/Qs should consider ground-level, 10-foot, and 100-foot release heights. Values should also be given for both annual averages and "unfavorable dispersion conditions." The unfavorable dispersion values for χ/Q are those that are exceeded by 0.5 percent of the total number of hourly χ/Qs in the data set. (Refer to Regulatory Guide 1.145 or Elder et al., 1966.)

Based on the input requirements for the particular program and the models for the calculation of radiation doses discussed in Section 6.0, some parameters typically required (e.g., AIRDOS-EPA, CCC-357) are

1. Average annual atmospheric lid (or ceiling) height.

2. Average annual and monthly rainfall/snowfall/other.

3. Average annual and monthly temperature.

4. Vertical temperature gradient for Pasquill categories E, F, and G.*

5. Annual wind direction frequency (16 compass points).

6. Annual reciprocal-average windspeed as a function of the 7 Pasquill categories* and 16 wind directions.

*Currently only six categories (A through F) are being reported. However, data exist to generate all seven categories.

7. Average windspeed as specified for Item 6 above.

8. Annual frequencies of the 7 Pasquill stability categories* as a function of the 16 wind directions.

These data will be used in the dose calculations mentioned in Section 6.0. Also, hourly data on barometric pressure and humidity will be required to estimate radon emissions (Rogers et al., 1984). The DOE and NRC prefer at least two years of data to establish a basis for these calculations (Elder et al., 1966; Regulatory Guides 4.2 and 1.111).

6.1.4 AGRICULTURAL DATA

The agricultural data required typically consist of distribution data (related to Figure 4-1) and general data:

1. Type and number of meat animals.

2. Type and number of animals producing dairy products (e.g., cattle, goats, chickens).

3. Acres of pasture land.

4. Acres of feed crops.

5. Acres of vegetable and produce crops.

6. Acres of grain.

7. Other agricultural activities in the area.

8. Fraction of locally produced agricultural products sold locally (minimum and maximum):

   a. Vegetables.
   b. Produce.
   c. Meat.
   d. Milk.
   e. Eggs.
   f. Fodder.

9. Milk production rate per cow or goat.

10. Pounds of meat per type of meat animal.

---

*Currently only six categories (A through F) are being reported. However, data exist to generate all seven categories.

11. Fraction of meat animal herd slaughtered yearly and typical age of the animal at time of slaughter.

12. The typical amount of time that meat and dairy animals are on pasture per year.

13. The typical fraction pasture represents of the total feed consumed when meat and dairy animals are pastured.

14. Typical fodder/pasture daily consumption rate by meat and dairy animals.

15. Typical time delays after slaughter before meat is consumed.

16. Time delay after production before milk (or other dairy products) is consumed.

17. Growth time (before harvest) for produce, vegetable, and feed crops.

18. Time delay after harvest before consumption of produce, vegetables, and fodder.

19. The depth to which land is typically plowed.

20. Fractions of pasture and other crops which are irrigated.

These agricultural data are required as input to the AIRDOS-EPA (AIRDOS-EPA, CCC-357). This program's input requirements are believed to be representative of programs used to calculate the doses for the ingestion pathway discussed in Section 6.1.1. These data will initially be collected from August 1987 to September 1989, and subsequently updated from September 1991 to January 1993.

6.1.5 CULTURAL DATA

The cultural data needed normally include:

1. Sources of water used for human consumption, including locations.

2. Location of surface-water bodies used for swimming relative to the grid in Figure 4-1.

3. Amount of fishing (for consumption) in local surface water (expected to be very small).

4. Dietary data (typical fraction of daily intake):

    a. Vegetables/fruits.
    b. Grains.
    c. Dairy products.
    d. Beef.
    e. Chicken.

   f. Pork.
   g. Mutton.
   h. Wild game and plants (types).
   i. Other meat products.

5. Fraction of vegetable and produce from local gardens.

6. Typical total daily food intake, if it deviates significantly from the dietary norm (Regulatory Guide 1.109).

7. Typical family, if it deviates significantly from the U.S. dietary norm (Regulatory Guide 1.109).

The requirements and uses of these data are the same as those for the data discussed in Section 6.1.4.

6.1.6 POPULATION DEMOGRAPHICS

For the area around the Yucca Mountain site, the population size in each section of the Figure 4-1 grid is needed, as well as any significant time-related variation in these data. Data on the age distribution in the population is also needed. In addition, to comply with the dose limits for the nearest highly populated area (10 CFR 960.5-2-1(a)), it is necessary to verify that Las Vegas conforms to the criteria for highly populated areas specified in 10 CFR Part 960. These data are based on the same requirements and uses of the data discussed in Section 6.1.4.

6.1.7 GENERAL BIOTA DATA

Data similar to that required for agricultural animals (Section 6.1.4) will be required for deer, chukar, and doves since they are part of the projected ingestion pathway.

6.2 DATA AVAILABLE IN THE TECHNICAL LITERATURE

A significant amount of the data discussed in Section 6.1 is available in the technical literature. A major source of this technical guidance is Regulatory Guide 1.109 (applicable to nuclear reactors) (Till and Meyers, 1983; Elder et al., 1986); however, this guidance recommends the use of local data rather than generic data. Because of the Yucca Mountain area's arid characteristics, site-specific data are very important, since most generic data (e.g., Regulatory Guide 1.109) were developed for non-arid environments. If site-specific data cannot be obtained, the data from Regulatory Guide 1.109 or other sources in the technical literature will be used.

Should any plant or animal species having a high bioaccumulation factor (relative to assumptions in the Environmental Pathways Analysis Scoping Study

(EPASS) (SAIC, to be issued)) or a high biological susceptibility to radiation be identified within the area, special monitoring will be added to that described in Section 4.0. The cited reference documents are intended as examples and should not be interpreted as prescriptive.

6.2.1 RADIOLOGICAL DATA

These data, with the exception of the existent environmental radiological background, will be obtained from the technical literature.

The physical characteristics of radioactive decay will be based on Evans (1972), ICRP (1983), Bureau of Radiological Health (1970), Fitzgerald et al. (1967), the computer programs ORIGEN-2 and ACT, and Kocher (1981).

Other available technical references may be used to supplement the radiological data. Shielding characteristics will be based not only on the preceding references, but also on Rockwell (1956), Jaeger et al. (1975), and the results from various shielding programs, such as ISOSHIELD (Engel et al., 1966) and DOT IV (Rhoades and Childs, 1982).

External radiation dose estimates, including doses from immersion and surface contamination, will be based on the preceding references and "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," to be issued by the DOE Office of Environmental Guidance attached to DOE (1987c); ICRP (1977); ICRP (1979); ICRP (1959), if required for evaluation of regulatory compliance; and any other applicable ICRP and NCRP documents.

Estimates for internal dose from inhalation, ingestion, and injection will be based on data from the preceding documents, as well as "Internal Dose Conversion Factors for Calculation of Dose to the Public," to be issued by the DOE Assistant Secretary for Environment, Safety, and Health as an attachment to DOE (1987c); Dunning (no date), for first and worst-year annual dose commitments; and the system of computer programs AIRDOS-EPA/RADRISK or CRRIS.

The foregoing references supply part of the information required to assess risk as a function of absorbed dose. Data and recommendations will also be used from the National Academy of Sciences (1980), National Institute of Health (1985), and any other documents determined to have applicablity.

The existent environmental radiological background will be determined by the data collected in Section 4.3. However, EPA and REECo documents detailing environmental conditions at the NTS will also be used (Table 6-1).

6.2.2 CHARACTERISTICS OF RADIOACTIVE AEROSOLS

Current data on the characteristics of aerosols at the NTS and other areas are available from references such as those listed in Table 6-1. The table also summarizes whether these data relate to the AED, deposition rate,

Table 6-1. Characteristics of radioactive aerosols

Reference	Resuspension		Deposition	Particle size distribution	Location
	Normal	Enhanced			
NVO-18, "Transuranics in Natural Environments" (pp. 171-302)	x	x	x	x	NTS, Kansas, Colorado, Texas, Rocky Flats
NVO-224, "The Radioecology of Transuranics and Other Radionuclides in Desert Ecosystems" (pp. 119-136)				x	NTS
PB 83-177659, "Methods for Assessing Exposure to Windblown Particulates" (pp. 13-27)	x			x	General
BNWL-B-303, "Potential Airborne Releases of Surface Contamination During A Range Fire in the B-C Controlled area"	x	x			Hanford
RFP-3914, "Dust Transport - Wind Blown and Mechanical Resuspension July 1983 to December 1984"	x				Rocky Flats
BNWL-1996, "An Assessment of the Risk of Transporting Plutonium Dioxide and Liquid Plutonium Nitrate by Train" (pp. 10.5-10.9)	x				General
NUREG/CR-2651, "Accident-generated Particulate Materials and their Characteristics -- a Review of Background Information"	x	x		x	General

or resuspension rate. General information on the behavior of radioactive aerosols already identified as useful in either developing this program or analyzing the collected data can be found in Hidy (1984) and Lioy et al. (1983).

Using these and other relevant published references (e.g., Hall et al., 1977; and NVO-178), as well as the data described in Section 4.3.4.4.1, specific models will be developed to reflect the resuspension, deposition, and disposition of radioactive aerosols around Yucca Mountain.

6.2.3 METEOROLOGICAL DATA

Meteorological data for the area surrounding Yucca Mountain (84-kilometer radius circle, Figure 4-1) and for the Las Vegas area discussed in Section 6.1.3 (except for χ/Q values) are available from National Oceanic and Atmospheric Administration Environmental Data Services STAR Program reports, the DOE Defense Programs Office for the meteorological towers operated by the DOE at the NTS, meteorological reports for the NNWSI Project meteorological monitoring program discussed briefly in Section 6.3.3, and National Weather Service data and reports. The meteorological program's use of these data is discussed further in Section 6.3.1.2.

6.2.4 AGRICULTURAL DATA

Some of the agricultural data required in the radiological monitoring program have been and will be obtained from agricultural statistics (Table 6-2) published by the U.S. Department of Agriculture, the Nevada Department of Agriculture, and the California Department of Food and Agriculture. Data collected by the NRAD for the areas surrounding the NTS will also be available to support this program. Furthermore, agricultural data are available from many references such as those specified in the EPASS.

6.2.5 CULTURAL DATA

Site-specific cultural data available for the areas of interest are very limited. Some of the specific data may be available from the NRAD, the agriculture departments previously mentioned in Section 6.2.4, and the local Fish and Game Department. Default data can be found in references such as those specified in the EPASS.

6.2.6 POPULATION DEMOGRAPHICS

The current data available on population demographics for the area of interest (Figure 4-1) are from the U.S. Census Bureau and NRAD published reports (e.g., Smith and Coogan, 1984). The population data used in the EA are documented in a memo from R.I. Brasier, SNL/LATA, to Jean Younker,

Table 6-2. Examples of published agricultural data

1985 -- 1986 Nevada Agricultural Statistics.

U.S. Department of Commerce, 1982. "1982 Census of Agriculture, Part 28, Nevada State and County Data."

Shaw, R. W., et al., xxxx. "Agricultural Production in the United States by County: A Compilation of Information from the 1974 Census of Agriculture for Use in Terrestrial Food-Chain Transport and Assessment Models," ORNL-5768.

Brown, Dorothy, 1974. "Methods of Surveying and Measuring Vegetables," Bulletin 42, Commonwealth Bureau of Pastures and Field Corps.

State of California Department of Food and Agriculture, 1984. "California Agriculture, 1984."

Science Applications International Corporation, dated May 8, 1985 (File No. 3.5.4.1); Clark County Department of Comprehensive Planning (1983); McBrien and Jones (1984); Ryan (1984); State of Nevada, Department of Transportation (ca. 1984); and State of Nevada, OCS (1984). Other Project population demographics data used in the EA (transportation sections) are documented in SAIC (1987b). The sources used to collect the population data needed as part of this program will be selected and documented by the T&MSS Socioeconomics Branch.

6.2.7 GENERAL BIOTA DATA

Data on the uptake of radionuclides by plants and animals, and the deposition/retention characteristics of plants in the general environment, are documented in the existing literature. Examples of these data are used in the EPASS. Plants and animals in the Yucca Mountain area which may be part of the human food chain are identified in literature from the Nevada State Department of Fish and Game, by the agricultural data discussed in Section 6.2.4, and in technical literature on animal ingestion pathways for these animals in man's food chain. Detailed data are still being collected, primarily by EG&G Energy Measurements (Santa Barbara Operations), which has also provided recommendations on an indicator species based on their pathway research in the area. The current data are discussed in Section 4.3.7.3.

6.3 PROCEDURE FOR ACQUIRING DATA NOT AVAILABLE IN THE TECHNICAL LITERATURE

Technical data not addressed in Section 6.2 of this document are of two types. The first type are site-specific data which need to be collected in the Yucca Mountain area (Figure 4-5). The second type are general technical data which are needed to support these processes and are not currently available. The two types will be discussed separately.

6.3.1 SITE-SPECIFIC DATA

Site-specific data include the characteristics of radioactive aerosols at the site, the meteorology of the site, the agricultural and cultural data for the Yucca Mountain area (Figure 4-5), the population demographics, and the general biota data for the site.

6.3.1.1 Characteristics of radioactive aerosols at the site

These data will be collected as described in Section 4.3. They will then be used to (1) assess the resuspension and deposition of radioactive aerosols at the Yucca Mountain site, and (2) determine the typical particulate size distribution for use in assessing dispersion and deposition of any potential radioactive aerosols and the resultant dose to man.

6.3.1.2 Meteorology of the site

The meteorological data collection needs are addressed in the existing NNWSI Project Meteorological Monitoring Plan and the NNWSI Project Environmental Field Activity Plan for Air Quality Monitoring. Collection and reporting of data discussed in Section 6.1.3 are essential to the successful completion of this activity.

6.3.1.3 The agricultural and cultural data for the Yucca Mountain site

The site-specific agricultural and cultural data (Sections 6.2.4 and 6.2.5) for the Yucca Mountain site that are unavailable in the technical literature will be needed between 1988 and 1989. After a review of the technical data currently available, supplemental data will be developed by the T&MSS Socioeconomics Branch. When an initial data set is developed, it will require routine updating approximately every five years and just before preparation of the Draft Environmental Impact Statement (DEIS). The agricultural and cultural data collection activities will be separate activities and may also be reported separately.

6.3.1.4 The population demographics for the site and nearest highly populated area

The required demographic data discussed in Section 6.1.6 will be developed by the T&MSS Socioeconomic Branch in cooperation with the NRAD and other organizations. These data will reflect currently available data (Section 6.2.6) and new data collected by the NRAD or other organizations in support of general NTS activities. The initial data will be needed between 1988 and 1989. To collect changes that occur with time, these data should be updated at least every five years and just before preparation of the DEIS . Also, projections of population changes throughout the licensing and operation phases will be needed.

6.3.1.5 General biota data for the site

The biota data collection supporting the radiological analyses for the site is primarily addressed by those activities described in Section 4.3.7. Ongoing NTS biota monitoring activities and the NNWSI Project Environmental Field Activity Plan For Terrestrial Ecosystems Monitoring (to be issued) will provide supporting data.

6.3.2 AREAS REQUIRING FURTHER RESEARCH

Presently the only area requiring further research, aside from the collection of site-specific data, is routine environmental sample analysis methods for Tc-99, C-14, and I-129. These isotopes are specified in 40 CFR Part 191, but have not (to date) been included in the routine analysis programs for the NTS. The development of sampling techniques for these isotopes is underway at the NRAD with NNWSI Project support. It is expected to be completed in late FY 88 or early FY 89. The analytical technique for I-129 will involve gamma and beta anti-coincidence counting. The radionuclide analyses for Tc-99 and C-14 will use various wet chemical concentration techniques and existing counting/analysis methodologies.

7.0 QUALITY ASSURANCE

The RMP activities will be conducted in full compliance with regulatory requirements, guidelines, and applicable sections of the Waste Management Project Office (WMPO) Quality Assurance Program Plan (QAPP), which implements 10 CFR 50 Appendix A. The plan's primary specified activities are designated QA Level I activities as delineated in the Quality Assurance Level Assignment Sheets (QALAS) attached to the Scientific Investigation Plan for WBS 1.2.3.6.1.2.T (SAIC, 1986).* These activities are to be implemented in accordance with the WMPO QAPP and supporting procedures as indicated in the QALAS for WBS 1.2.3.6.1.2.T* for Environmental-Radiological activities. The WMPO QAPP and supporting procedures will be supplemented by Environmental-Radiological Branch Technical Procedures and a comprehensive quality control program implemented by the Environmental Radiological Monitoring Team as shown in Figure 7-1. The signature and initials of persons authenticating records for this activity will be documented in the Environmental Radiological Monitoring Technical Procedures Manual or the equivalent Nuclear Radiation Assessment Division (NRAD) documentation.

All procurement shall be made in a manner consistent with the WMPO QAPP and applicable supporting documents. Receipt, inspection, and acceptance testing procedures will be based on the procurement specifications.

The accuracy of monitoring instrumentation will be routinely confirmed using standard accuracy verifications or approved calibration procedures. Accuracy verification is similar to calibration except that it uses comparison to a traceable single point rather than the minimum three points required for a calibration. All accuracy verification and calibration, test, inspection, surveillance, and audit activities will be fully documented. Analyses of results will be performed on a regular basis by the Senior Health Physicist and specially trained professionals or technicians.

WMPO Quality Assurance ensures through audit, surveillance, and monitoring activities that applicable functions are performed in accordance with the WMPO QAPP, supporting procedures, and supplementary procedures. Activities of the Preliminary Site Characterization Radiological Monitoring Plan (PSCRMP) are also subject to WMPO QA audit and surveillance.

7.1 FIELD QUALITY CONTROL ACTIVITIES

The field activities organization is illustrated in Figure 7-1. The Radiological Field Program Branch (RFPB) Manager provides administrative control for all activities. The Senior Health Physicist provides technical direction to the Environmental Radiological (ER) Team and the NRAD Team, which complete these activities. Specially trained WMPO QA personnel verify

---

*WBS 1.2.3.6.1.2.T is the work breakdown structure (WBS) number for the Environmental Monitoring-Radiological Task (NNWSI Project, Controlled Document).

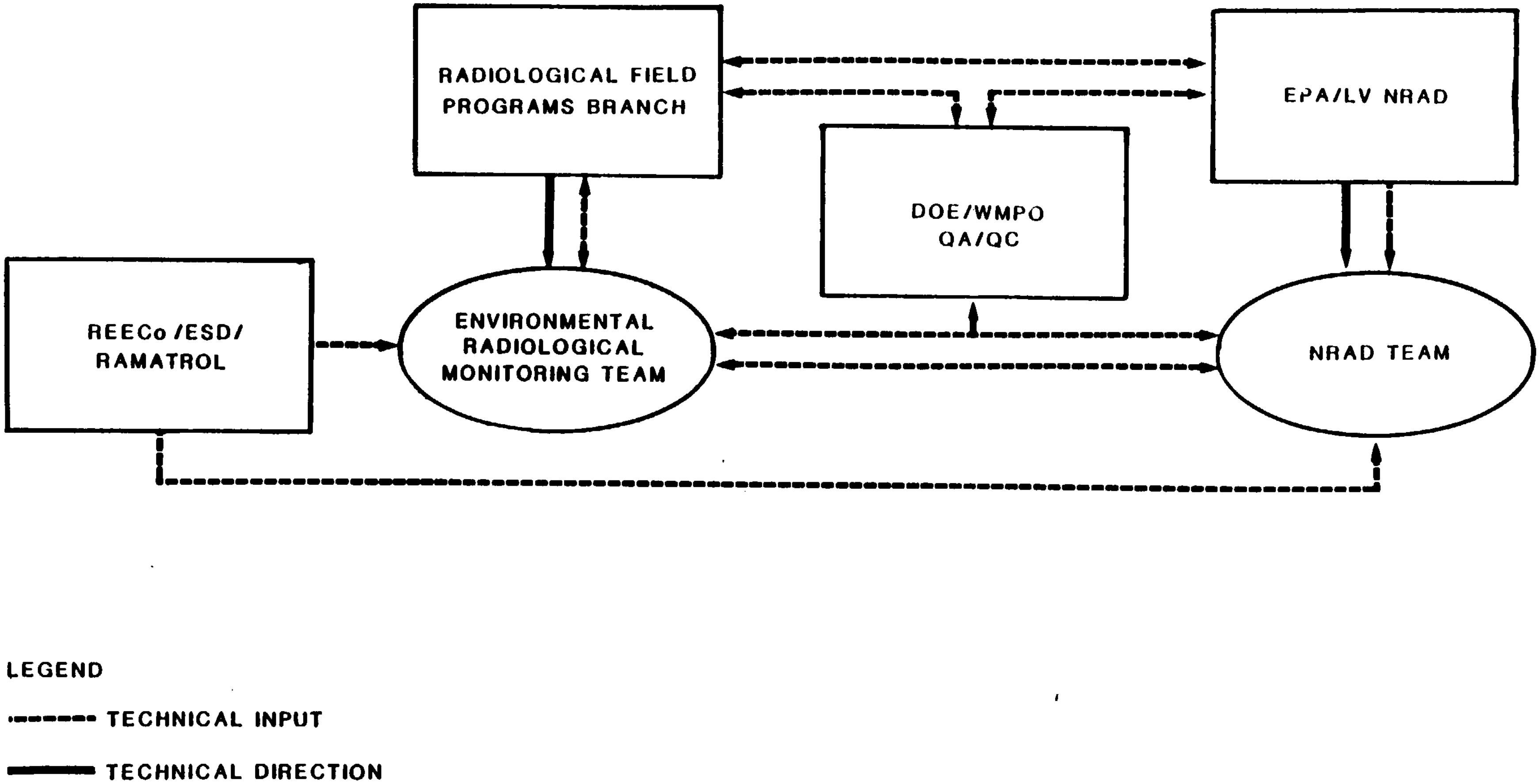


Figure 7-1. Field operations organization.

and document the completion of hold points as specified in the Environmental Radiological Monitoring Technical Procedures and applicable NRAD procedures. RAMATROL (REECo) provides control of all radioactive material used on the Nevada Test Site (NTS), control of the radiological release of any property removed from the NTS, and storage and management of radioactive sources used in calibration.

7.1.1 RECEIPT, INSPECTION, ACCEPTANCE TESTING, AND INSTALLATION OF EQUIPMENT

Program samplers and monitors will be received and handled as indicated in the Environmental Radiological Monitoring Technical Procedures. Receipt of all equipment will be documented on data sheets. The initial quality control tasks will involve inventory and thorough inspection of equipment upon receipt, and acceptance testing of all equipment before installation.

Equipment inspection will be performed by a trained and qualified technician or health physics professional according to Environmental Radiological Monitoring Technical Procedures. Acceptance testing will be conducted by qualified personnel following approved procedures. Any non-conforming condition will be documented in accordance with the WMPO QAPP.

Installation of each piece of monitoring equipment will be performed after the equipment is inventoried, inspected, and acceptance tested. Installation, onsite tests, and related activities will be performed following approved procedures. These activities will be thoroughly documented in the appropriate logs, and on other required forms as specified in the Environmental Radiological Monitoring Technical Procedures. Distribution of the maintenance of related records is addressed in the applicable procedures.

7.1.2 CALIBRATIONS AND PRECISION ASSESSMENT

All instrumentation calibrations must be traceable to the National Bureau of Standards (NBS) or some other acceptable standard. The standards actually used in this calibration will be primary or secondary standards. If the instrumentation requires adjustment during calibration, both pre- and postcalibration data will be documented. The Senior Health Physicist will evaluate and document the effects out-of-calibration equipment had in regard to the validity of previous results and data. If the calibration occurs at other than the installed location, the accuracy of the equipment will be verified following its installation.

Verification of equipment performance using traceable accuracy verification or calibration will be completed at least at the frequency specified by the manufacturer: twice yearly if the equipment is used to make measurements and the calibration can be reasonably altered without destroying the instrument. When accuracy verification is used instead of calibration, calibration is required at least once every two years by an independent agency. All measurement/monitoring equipment will be calibrated at least once a year. All accuracy verification and calibration will be traceable to the NBS or appropriate established standards. All program activities will be designed to ensure overall data accuracy, accountability, traceability, and repeatability.

Laboratories performing analyses will use appropriate standards and procedures to ensure the quality of their analysis and its traceability to NBS or other appropriate established standards. Laboratories must participate in intercomparison studies directed by the EPA, NRC, or DOE. The Senior Health Physicist will submit, where possible, blind, blank, or spiked samples to laboratories for analysis with the actual samples. If blank or spiked samples are not feasible, but duplicate samples can be obtained, they should be used to replace the blanks or spikes. The blanks and spikes will be used to assess the accuracy of the results in conjunction with the data reported by the laboratory. Precision will be assessed from duplicate sampling or duplicate analysis.

7.1.3 MAINTENANCE AND SPARE PARTS

To provide continued proper operation of the monitoring systems, the Senior Health Physicist will implement a scheduled maintenance program utilizing written, approved operating procedures. The activities performed in this maintenance program include, but are not limited to:

1. Weekly cleaning of the magnetic tape recording heads, if any.
2. Semiannual lubrication or replacement of moving parts as per applicable procedures.
3. Weekly checking of all sensor cables, tie-downs, power cords, etc.
4. Weekly inspection of all sensors for proper operation.
5. Weekly inspection of all digital and strip chart recorders for data reasonableness and proper timekeeping.

In addition to the Project maintenance schedule, maintenance instructions and schedules in manufacturers' manuals will be followed for each instrument. The recommended maintenance schedules may be modified based on the operational experience gained in the initial period of monitoring.

7.2 DATA HANDLING ACTIVITIES

7.2.1 DATA TRANSMITTAL AND SCREENING

To ensure maximum data recovery, the technician or health physics professional will deliver on a weekly basis (±3 days) all data collected onsite to the Senior Health Physicist or his designee located at the WMPO facilities in Las Vegas, Nevada. Upon receipt, the data will be inspected by the health physics staff for errors or suspected errors in transmittal, recording, or documentation. Any errors noted will be brought to the immediate attention of the Senior Health Physicist who will, in turn, notify the individuals involved to correct the errors and document the problem as specified in approved procedures. The digital data tapes and other portable digital storage devices, if any, will be transcribed onto a permanent file in the computer (VAX) system within one week of collection. The digital data file will then be subjected to a screening process that identifies anomalies, and such data will be investigated and anomalies resolved, per approved procedures. Nonconformances and corrective actions will be documented and resolved in accordance with the WMPO QAPP and applicable supporting procedures.

7.2.2 LABORATORY REPORTS

Data reported by the laboratories will be transmitted to the Senior Health Physicist. Upon receipt of such reports, the Senior Health Physicist will

1. Transmit copies of the data to the Project files, WMPO Quality Assurance, the Correspondence Control Facility (CCF), the Technical Records Center (TRC), and the RFPB Manager.

2. Review the data for completeness and reasonableness (this includes documentation of any findings and their resolution).

3. Compare the reported data to activity information present on the spiked or blank sample analyzed at the same time.

4. Take appropriate action and document the steps followed to resolve any unacceptable variations in accuracy, if necessary (all results are reported as a mean value plus or minus the statistical uncertainty at the 95 percent confidence level).

The Senior Health Physicist will ensure initiation of appropriate nonconformance or deficiency reports, as specified in the WMPO QAPP and applicable supporting procedures.

7.2.3 INTERNALLY GENERATED DATA

Continuous radon monitor data and air sampler flow-rate data are examples of internally generated data. Internally generated data will be reviewed by the Senior Health Physicist for reasonableness, completeness, and accuracy. Resolution of any questions will be documented and attached with the data, per approved procedures. The Senior Health Physicist will then transmit copies of the data to the Project files, WMPO QA, the CCF, the TRC, and the RFPB Manager, as well as initiate any nonconformance reports if required by the WMPO QAPP and applicable supporting procedures.

Data described in Section 4.3 will be reviewed according to the following criteria:

1. Uncertainty (95 percent confidence level) in the value.

2. Consistency with meteorological parameters.

3. Consistency/variation with previous results.

4. Consistency with practical range of variation based on past data and existing National Council on Radiation Protection and measurements (NCRP) documents on environmental radiation.

5. Instrument problem or calibration data.

6. Quality control samples analyzed at the same time.

After data quality has been evaluated, the data will be placed in the Project technical data base for use.

7.3 INDEPENDENT SYSTEM AND PERFORMANCE AUDITS

As required by the EPA, specific auditing activities (i.e., independent system and performance audits) are conducted in accordance with established procedures and are performed in addition to the quality audits delineated in the WMPO QAPP. System audits encompass all aspects of the monitoring program, i.e., sampler siting, data handling activities, calibration techniques, and schedules (maintenance schedules, etc.). Performance audits involve verifying the accuracy of monitoring equipment.

Within 60 days after monitoring stations become operational (or at the time that the station becomes operational, if required by applicable procedures) and on an annual basis thereafter, a system audit of the monitoring, installation (for portable equipment installation in the equipment's initial use for data collection), and operational activities will be conducted, in addition to the verification required in specific procedures. The system audit will include a critical review of the monitoring stations to determine compliance applicable to specific procedures and the RMP. The review will also include an investigation of the onsite data handling and transmittal activities, the schedule of calibration activities, and other functions in accordance with the WMPO QAPP and supporting procedures. All deficiencies identified in a system audit will be recorded in an audit report and the deficient activity corrected.

At least yearly, a performance audit to verify the accuracy of the monitoring equipment will be performed and documented. All deficiencies identified by this audit will be documented in the audit report, and deficient activity corrected.

An audit plan that outlines the schedules for system and performance audits, as well as the procedures to be used during these audits, will be developed as soon as this proposed monitoring program has been approved.

WMPO QA staff will monitor the internal data handling and analysis activities and ensure that nonconformances and deficiencies are identified and resolved in accordance with applicable procedures. As required by the EPA regulations (EPA, 1980), WMPO personnel will participate in the EPA national performance audit program.

7.4 QA RECORDS

All data sheets, hard copy instrument readouts, logbooks, data reports from analysis, and any other documentation delineated in the applicable Environmental Radiological Monitoring Branch Technical Procedures are considered QA records. Copies of the QA records, with the exception of logbooks and hard copy instrument readouts, will be sent to WMPO QA, the RFPB Manager, and the Senior Health Physicist within seven days of completion. Originals of all QA records will be sent to the TRC upon completion, with the exception of logbooks, which will be sent to the TRC within 120 days.

8.0 SCHEDULE AND REVISIONS

This section provides the needed administrative data to support implementation of the radiological monitoring program. These administrative data emphasize the future planning for the program.

8.1 SCHEDULE (MILESTONES)

The basic schedule for RMP activities is summarized in Figure 1-1. A detailed network of the total plan activities is given in Figure 8-1. The network reflects RMP implementation, issuance of annual data reports each May, preparation of a summary data report in 1993, revision of the RMP to reflect major changes in Project activities, and preparation of other relevant reports.

Supplementing the basic schedule, Table 8-1 provides a summary of the detailed initial RMP implementation. The schedule described in Table 8-1 is based on expected procurement time, funding, land access, site activities, and perceived need. Most of the expected scheduling relates to potential procurement delays and to uncertainty in the scheduling of other Project activities.

8.2 REVISIONS

Planned revisions of the RMP are shown in Figure 1-1 and Figure 8-1. These revisions relate to presently identified changes in Project activities. If future Project activities or the data collection results indicate a need for additional revisions, the revisions will be initiated by the Radiological Field Programs Branch (RFPB) Manager or any individual in the reporting structure (Technical Direction) shown in Figure 1-2. In addition to the planned and other revisions to the RMP, modifications to the field activities may also occur. These changes will be documented by letters to the WMPO Project Manager, Quality Assurance, and RMP participants. These letters will be added to Appendix K of the RMP controlled copies as they are issued. This will allow the program to respond to needed changes in a timely and fully documented manner.

The planned revisions are expected to be primarily changes in scale of the activities. The first revision following the Environmental Impact Statement (EIS) scoping hearings will reflect both recommendations from these hearings and results of the human food chain study discussed in Section 4.3.7.2.

The revision at the time of EIS preparation (October 1993) will reflect a reduction in the program and represent completion of major data collection. The program will be used to maintain data continuity and to monitor any changes in site conditions. This revision will also affect the current facility design.

TOTAL ACTIVITY PLAN

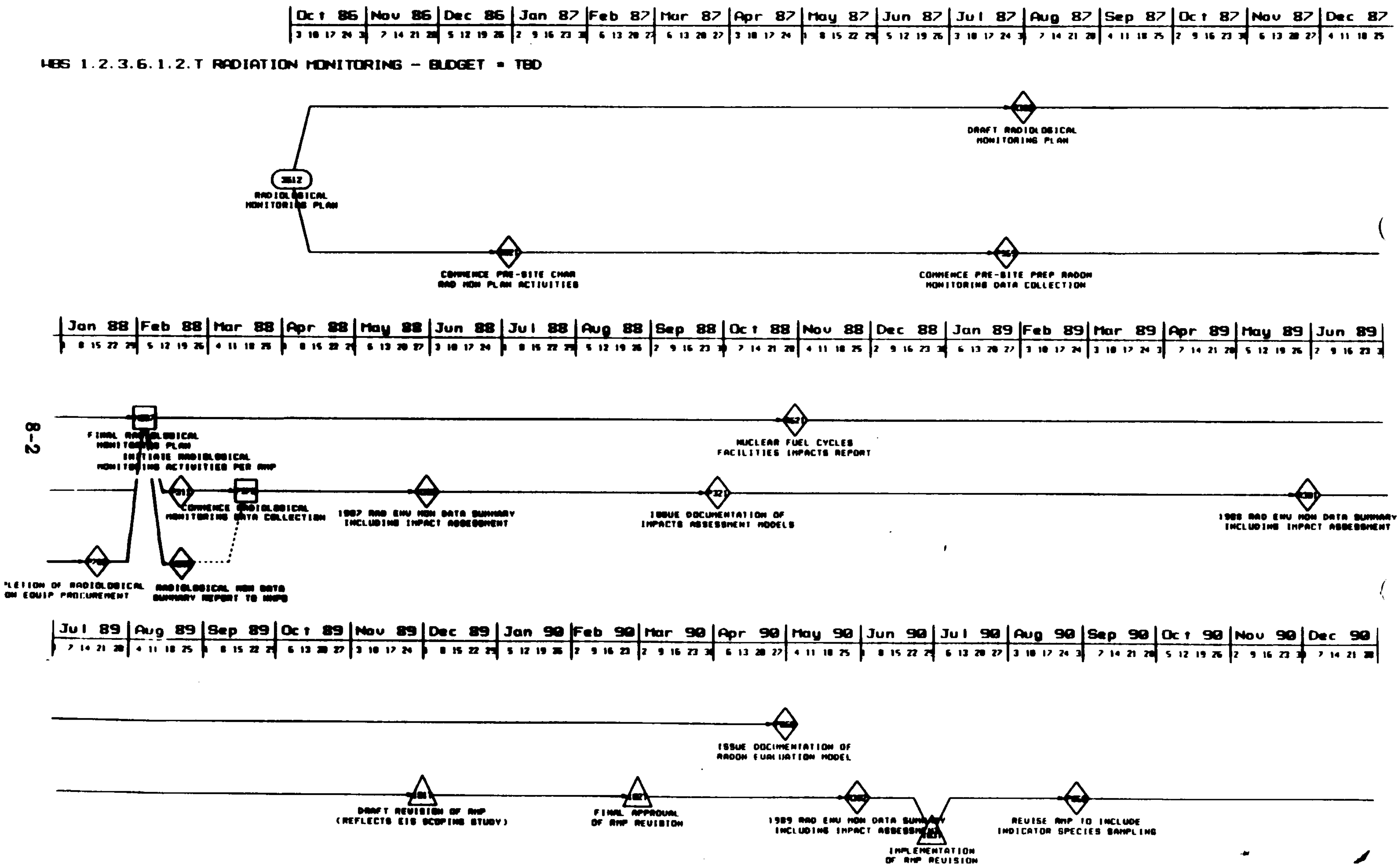


Figure 8-1. Total activity plan.

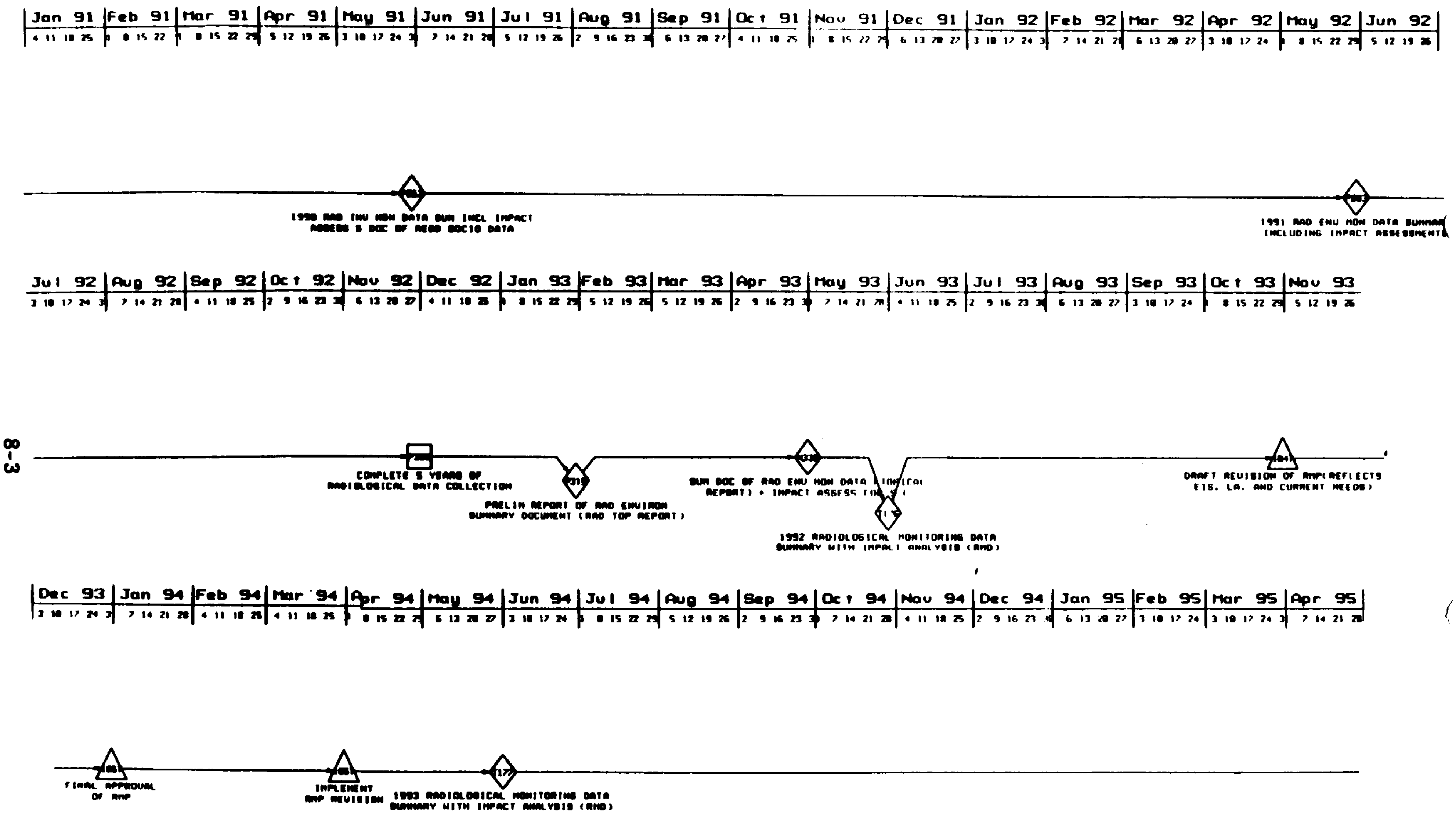


Figure 8-1. Total activity plan.

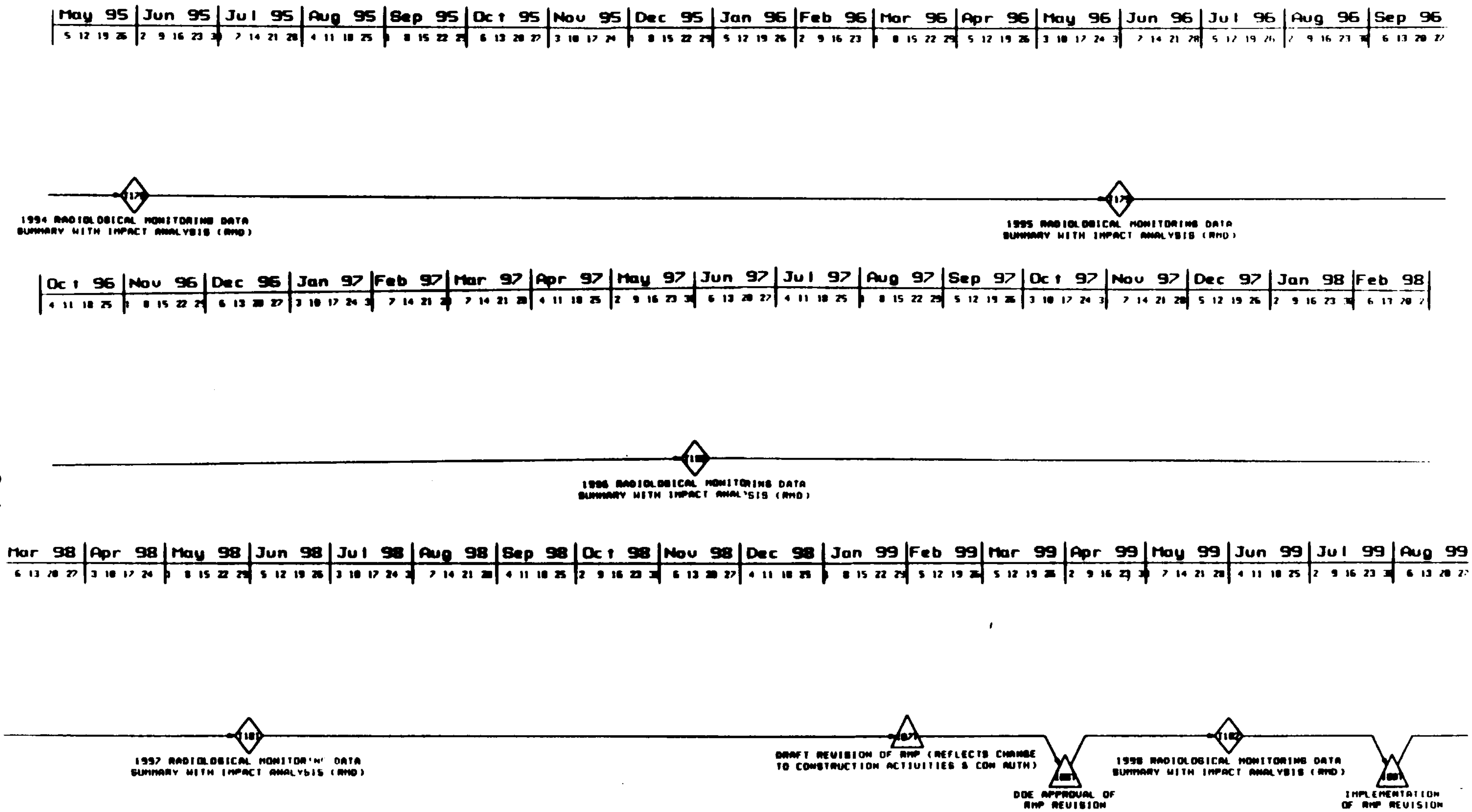


Figure 8-1. Total activity plan.

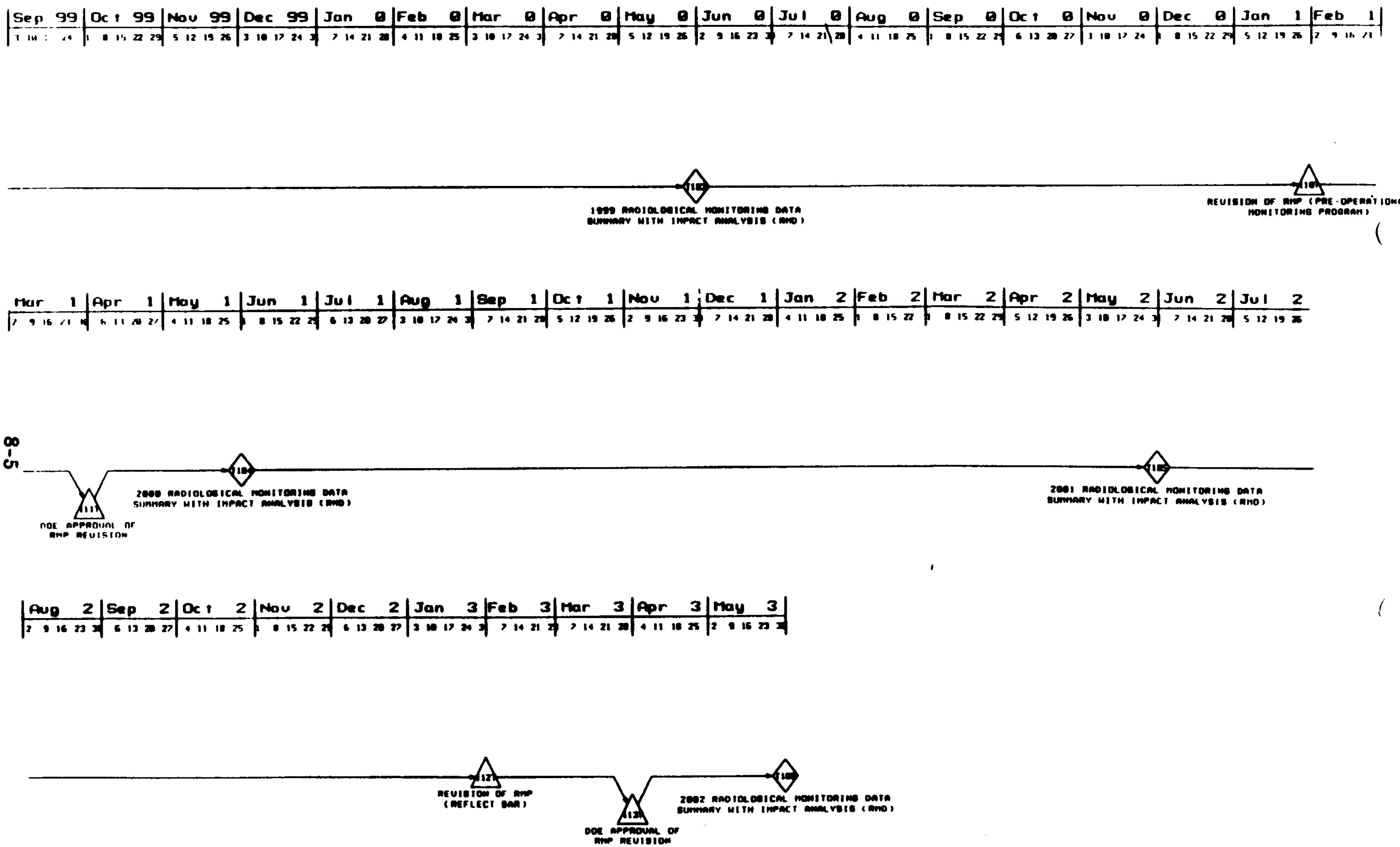


Figure 8-1. Total activity plan.

Table 8-1. Implementation plan for RMP activities

Activity	Initiation	Completed[a]
Air sampling (60-meter tower/ particulate iodine only)	9/87	--
Air sampling/near field	6/88 to 7/88	--
Air sampling/far field	6/88 to 7/88	--
Water sampling (general)	4/88 to 7/88	--
Catch basin survey	7/88	1/89
Water sampling (catch basins)	10/88 to 11/88	--
Inert gas and tritium sampling	7/88 to 9/88	--
Radon integrating samplers	9/87	--
Radon continuous monitoring	3/88	--
Initiate analysis capability development for Tc-99, C-14, and I-129	4/88	8/89
Soil/sediment sampling	5/88 to 8/88	--
In situ gamma spectral analysis	6/88 to 11/88	--
Milk sampling	Ongoing[b]	--
Near-field biota sampling	5/88 to 2/89	--
Survey of far-field biota in human food chain	6/88	6/89
Preliminary assessment of sampling needs in the biota (human food chain)	9/88	2/89
TLD monitoring implemented	4/88 to 8/88	--
High pressure ion chamber monitoring	7/88 to 11/88	--
ARM survey	--	4/88 to 1/91
Public personnel monitoring	Ongoing[b]	--

[a]"--" indicates that this activity will continue throughout the program.
[b]This is simply an ongoing Nevada Test Site activity from which data will be obtained.

The next potential revision is expected to occur with construction authorization. This revision would reflect any changes made in the program as a consequence of the construction activities and the detailed knowledge of the facility's design at this stage. This revision is not indicated in Figure 1-1 since it is expected to be a relatively minor variation in planned activities.

In the year 2001, the preoperational monitoring activities will be initiated as required by NRC and DOE regulations (Section 3.3.1.2.2). This program will take the final baseline data before first receipt of waste. This data collection activity will be similar in scale to the activity which occurred during the initial implementation of the RMP. However, the scale and content will reflect the previous collected data.

The program will be revised again in 2003 to reflect the routine monitoring program approved by the DOE and NRC for this facility. Typically, this is reduced in scale from the preoperational phase and relies to some extent on site effluent data.

The program will again be revised in about 2028 to reflect implementation of decommissioning activities (Section 3.3.1.4). This change will reflect both the change in activities and the need for confirming data following completion of decommissioning activities.

When decommissioning has been completed, including a limited period of confirmatory monitoring, the program will be reduced to a long-term monitoring program as required by law (Section 3.3.1.5). That program is not yet well-defined.

8.3 COSTS

The costs associated with the radiological monitoring program consist of direct and indirect personnel costs for SAIC and NRAD personnel (Table 8-2). There will also be costs associated with the equipment and services for implementation of the radiological monitoring activities, which are addressed in detail in Tables 4-11 and 4-12, as well as costs associated with the training of personnel, provision of required references, document publication, and other miscellaneous needs. Finally, there are costs associated with other activities which support radiological monitoring activities. These activities are not directly controlled or funded by the radiological monitoring program and include (1) the meteorological monitoring activities; (2) the collection of population, agricultural, and cultural data; and (3) the collection of biota samples. These activities typically have multiple uses and are the responsibility of the NNWSI Project meteorological activity, socioeconomic activity, and EG&G (Santa Barbara), respectively.

Table 8-3 provides a summary of the expected costs. The first-year implementation costs and subsequent general yearly costs are both shown, since first-year costs reflect initial equipment and supply procurement. The anticipated PSCRMP costs are also included. These costs only address the site characterization phase, and do not reflect the results of EIS scoping.

Table 8-2. Program personnel costs

Item		SAIC[a]		NRAD		EG&G	
		FY 87	FY 88	FY 87	FY 88	FY 87	FY 88
PSCRMP	Preparation	$10K	$	$	$	$	$
PSCRMP	Procedures and associated document preparation	8K					
PSCRMP	Procurement	2K					
PSCRMP	Sample Collection	8K	25K				
PSCRMP	Sample Analysis (NRAD)			20K	5K		
PSCRMP	Data Analysis	5K	10K		2K		
PSCRMP	Data Reporting	1K	5K		3K		
RMP	Preparation	77K	20K	65K	10K		
Analytical	Methodology development for Tc-99, I-129, and C-14		95K		20K		
RMP	Procedures and associated document preparation	10K	50K		10K		
RMP	QA Activities	5K					
RMP	Procurement	16K	20K		5K		
RMP	Sample Collection	2K	115K		60K		
RMP	Sample Analysis (NRAD)	1K	70K		75K		97
RMP	Data Analysis	2K	50K				20
RMP	Data Reporting	1K	40K				10

[a]The SAIC manpower consists of: 40% Junior level technical staff, 35% Senior level technical staff, 12% Technician level staff, and 12% Secretarial level technical staff, plus 2 radiochemists and two technicians to provide support unavailable from EPA due to their manpower limitations (Note: One radiochemist will only be required during analytical program development [circa/year].)

Table 8-3. Program costs

Item	PSCRMP SAIC	PSCRMP NRAD	PSCRMP CAPITAL	FY 1988 SAIC	FY 1988 NRAD	FY 1988 EG&G	FY 1988 CAPITAL	Yearly SAIC	Yearly NRAD	Yearly EG&G	Yearly CAPITAL
Program personnel	111K	85K	--	500K	190K	127K	--	550K	269K	120K	--
Air sampling operator contracts	--	--	--	--	7K	--	--	--	14K	--	--
Support personnel (QA, Procurement, etc.)	20K	--	--	45K	--	--	--	40K	--	--	--
Material and supplies Equipment (Table 4.4.3-1) Services (Table 4.4.3-2)	30K	--	--	260K	20K	12K	203K[b]	100K	35K	10K	150K
Associated Cost (Training, Travel, References, and Documents Publishing)	--	--	--	40K	25K	--	--	80K	47K	--	--
Meteorological Program[a]	320K	--	--	320K	--	--	--	320K	--	--	--
Socioeconomic[a] Data Collection											

[a]Cost not directly charged to this task, and having multiple uses.
[b]Includes 21K for vehicle procurement for EG&G.

Additional costs due to changes based on the EIS scoping hearings are not expected to be significant. The costs associated with later phases will be developed as more definite data are available on the programs.

9.0 OPERATIONS AND SAFETY

As indicated, the radiological monitoring program will be conducted in a manner consistent with specific SAIC or NRAD technical procedures, administrative procedures, and other applicable requirements. SAIC requirements are documented in the Environmental Radiological Monitoring Technical Procedures Manual. Before initiating an activity, an internal hazards analysis and operational readiness review evaluation will be conducted and documented. Personnel will receive appropriate and verified training for those activities. The safety training portion will address the information in the hazards analysis and will be mandatory for all SAIC personnel involved in the program. Activities will be completed by personnel based at the T&MSS (SAIC) Las Vegas office and the NRAD Las Vegas office. An onsite field support office located in the NNWSI Project health physics trailer in Area 25's support services area (specifically, 1st and C streets) will also be used.