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RADIOLOGICAL MONITORING PLAN
FOR THE NNWSI PROJECT

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1.0 INTRODUCTION AND PLAN SUMMARY

1.1 INTRODUCTION

The U.S. Department of Energy (DOE) plans to begin operating the first geologic repository for the permanent disposal of commercial spent nuclear fuel and high-level radioactive waste near the end of this century. Public Law 97-425, the Nuclear Waste Policy Act of 1982 (the NWPA), specifies the process for selecting a repository site and constructing, operating, closing, and decommissioning a repository.

In February 1983, the DOE identified the Yucca Mountain site in Nevada as one of nine potentially acceptable sites for the geologic disposal of radioactive waste. Yucca Mountain is in the Great Basin, which is one of five distinct geohydrologic settings considered for the first repository. The site is located on and adjacent to the southwest side of the Nevada Test Site (NTS), approximately 26 kilometers (16 miles) north of the junction between U.S. Highway 95 and Nevada State Route 73. To determine suitability, the nine sites were evaluated in accordance with the DOE General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories (10 CFR Part 960). These evaluations were reported in the draft and final Environmental Assessments (EAs), which were issued for public review and comment. On the basis of the evaluations, the DOE found that the Yucca Mountain site was suitable for site characterization.

On May 28, 1986, the President approved the Yucca Mountain site, Nevada; Hanford site, Washington; and Deaf Smith County site, Texas, for site characterization. During site characterization of these three sites, the DOE will construct exploratory shafts for underground testing to determine whether geologic conditions will allow the construction of a repository that will safely isolate radioactive waste. The NWPA requires the DOE to prepare site characterization plans for review by the Nuclear Regulatory Commission (NRC), affected States, affected Indian Tribes, and the public. After site characterization and with completion of an Environmental Impact Statement (EIS), the DOE will recommend one of the characterized sites for development as the first repository. The DOE will then proceed to obtain a license for the repository from the NRC.

If Yucca Mountain is selected as the repository site, then the Nevada Nuclear Waste Storage Investigations (NNWSI) Project will oversee the conduct of eight phases for the Yucca Mountain site. The eight phases 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).

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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/Operate.

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. Note the site phase numbers specified in Figure 1-1 refer to the site phases above and that the major activities presented in the RMP occur during site characterization. It should not be assumed that this document indicates the final outcome of the repository selection process. If the Yucca Mountain site is not selected as the site of the repository, Phases

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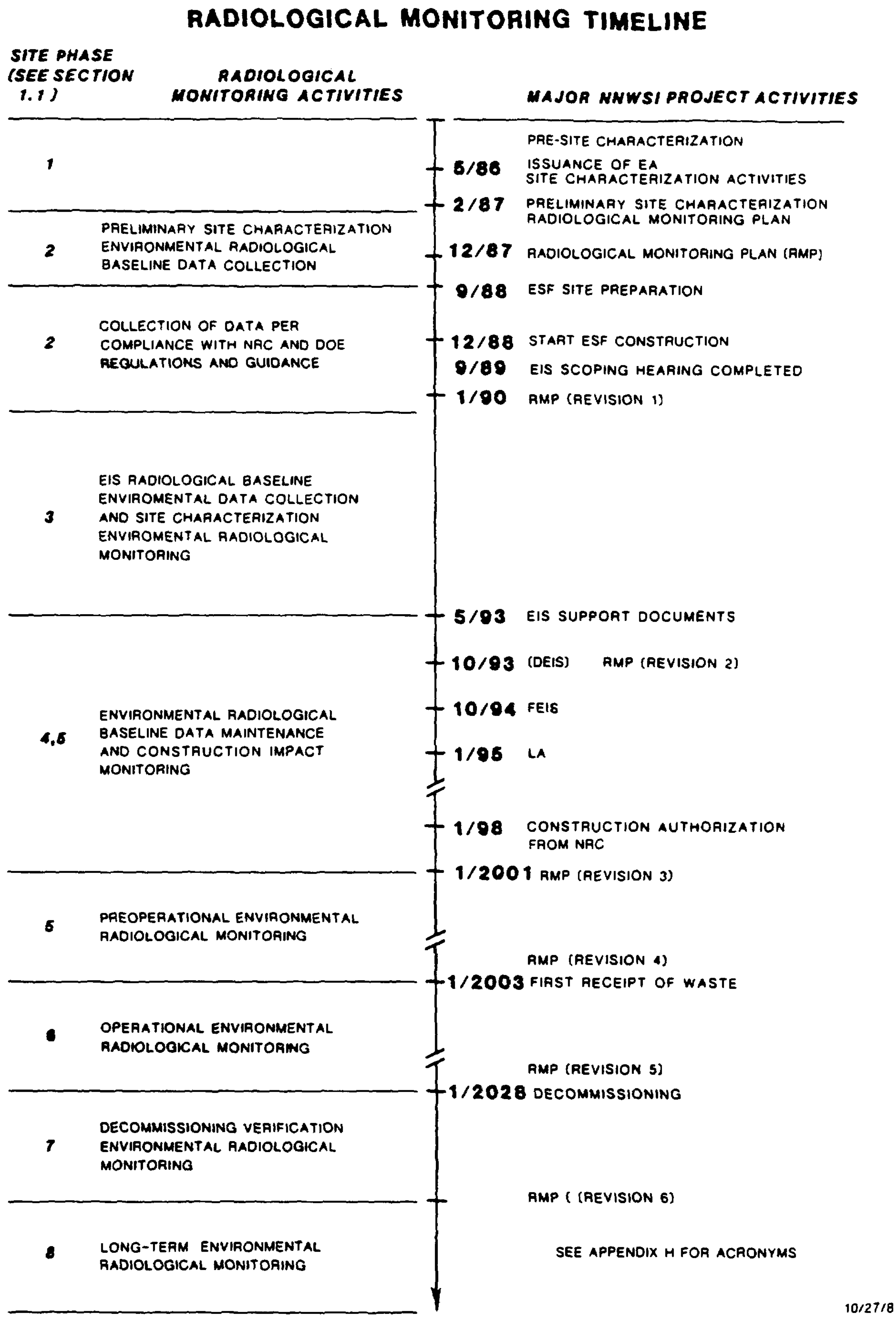

Figure 1-1. Radiological monitoring timeline.

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5, 6, and 8 will be eliminated (since they will not occur) and the schedule shortened.

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), 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 (including the Scientific Investigation Plan for this activity (SAIC, 1986)), 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 technical procedures as part of the controlled procedure manual, which is maintained in an updated, audited form by each user.

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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 Environmental Protection Agency (EPA) in Las Vegas under an interagency agreement with the NNWSI Project through the Nevada Operations Office of 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 Characterization Plan (SCP) 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

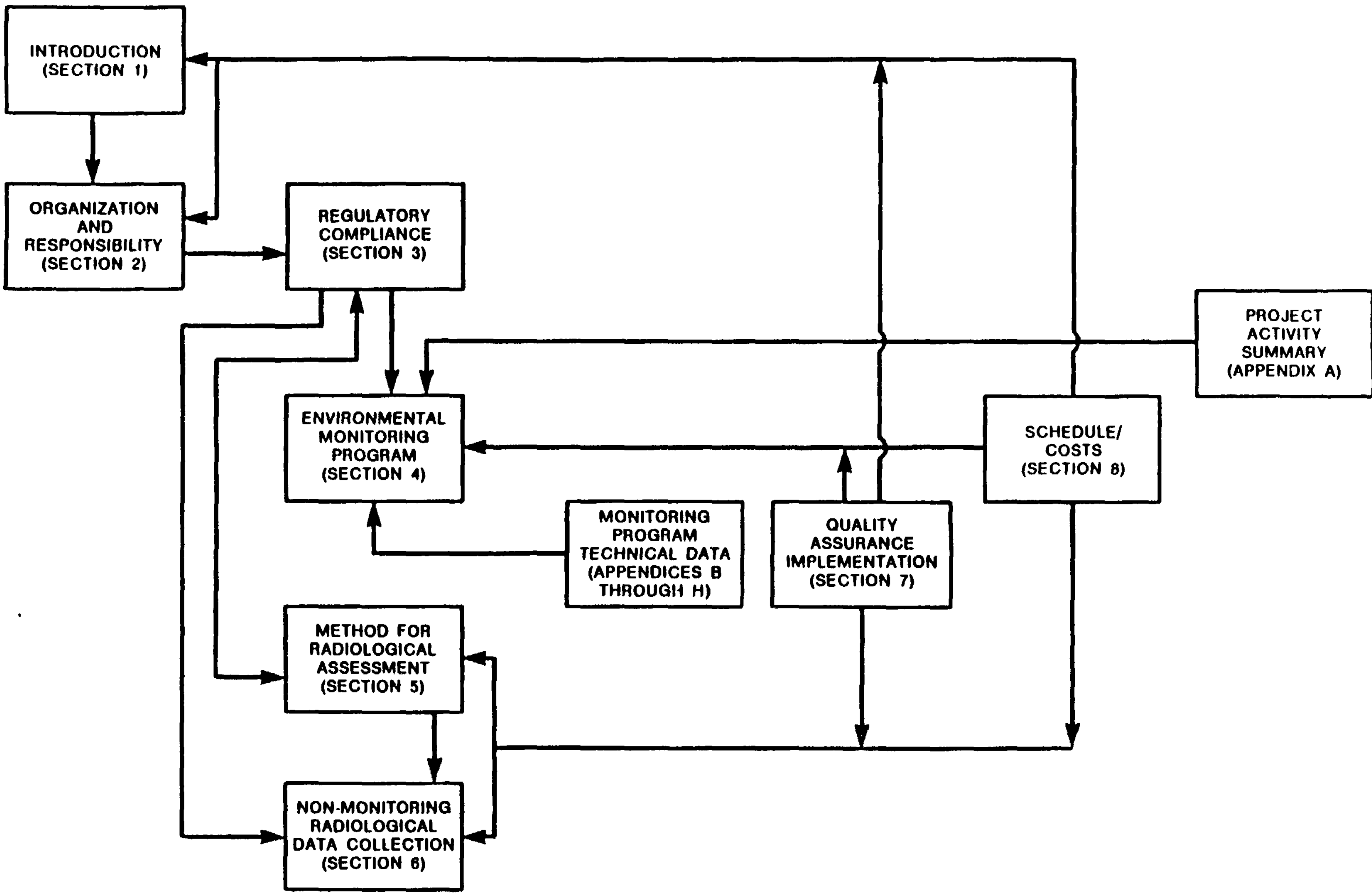

Figure 1-2. Information flow between sections of the RMP.

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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, and Appendix J contains a glossary for the text. As stated earlier, the RMP acts as the controlling document for the radiological monitoring activities in support of the NNWSI Project.

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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 for high-level radioactive waste, (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

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

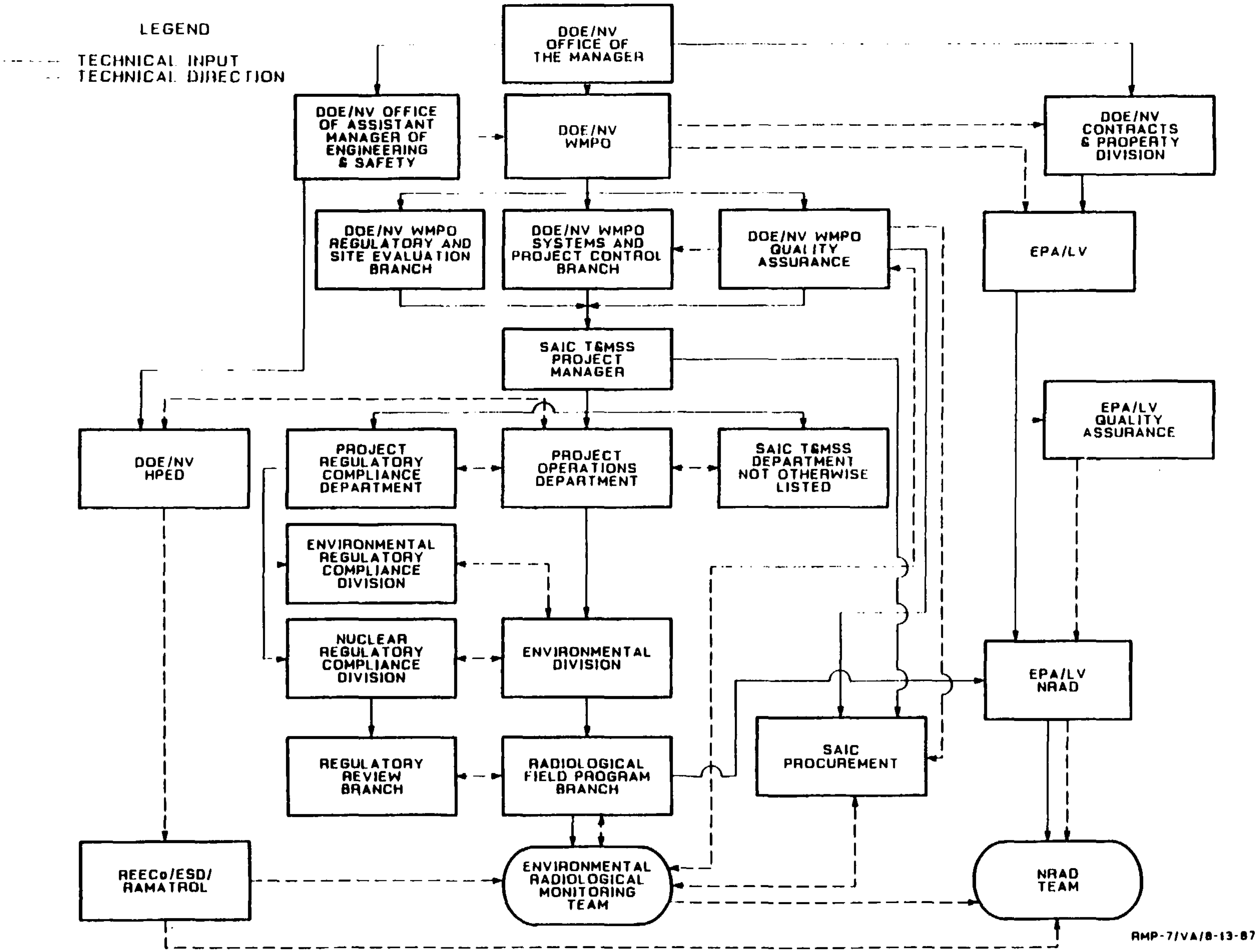

Figure 2-1. Environmental radiological monitoring activities organization chart.

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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.

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3.0 RADIOLOGICAL COMPLIANCE

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.

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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 exist 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 (if the site is selected).

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

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Under the requirements of the Nuclear Waste Policy Act of 1982 (NWPA) and Presidential decisions, the DOE is required to site, construct, operate, and decommission a geologic disposal facility for 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 the DOE Orders. The States 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.

3.1 REGULATORY APPLICABILITY

3.1.1 SITING

The activities associated with siting occur in the period preceding the license application:

1. Data are collected to monitor the impacts of site characterization (Environmental Monitoring and Mitigation Plan for Site Characterization).

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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 site characterization activities are exempted from formalized National Environmental Policy Act of 1969 (Public Law 91-190) documentation requirements by the NWPA. 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.

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3.1.1.1 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 required data will be gathered using methods consistent with Corley and Corbit (1982) as specified in DOE Order 5480.4. DOE Order 5480.4 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 regulation cites 30 CFR 57.5-37 for radon monitoring. Thus 30 CFR 57.5-37 is the applicable mine safety requirement for protection of the workers from radon.

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

In addition to this DOE guidance that affects the data above, 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 public and worker health and safety and environmental protection requirements

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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 when implementing DOE Orders.

3.1.1.2 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 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 1.21, 1.109, 1.110, 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, 1.111, 1.112, 1.113, and 1.23 are an integral part of the technical requirements implemented by the RMP. The program described in this document will consider any other applicable branch or NRC 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 revised as needed.

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3.1.1.3 State regulations and state flow down/EPA regulations

State flow down/EPA regulations refer to Federal regulations which the EPA has authorized states to enforce through their own regulations. The only such regulation which is of concern at this time to the radiological monitoring program is the Clean Air Act.

The activities conducted during the siting will comply with the limits established in the Clean Air Act, specifically Subpart H of 40 CFR Part 61, and therefore will be consistent with Nevada Revised Statute 445.6605 and related statutes. This regulation 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 version of AIRDOSE-EPA and RADRISK computerized risk assessment models 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, which in turn reports these results directly to the EPA.

10 CFR 30.12 and the State of Nevada Regulations for Radiation Control 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 authorizaton of T&MSS to "receive, own, possess, or use byproduct (radioactive) materials..." (Fitzsimmons, 1987).

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3.1.2 CONSTRUCTION

If Yucca Mountain is selected and before construction can commence, a license application must be submitted to and construction authorization received from the NRC. The NRC will become the regulatory authority for facility construction activities only through the construction authorization (although it can extend its authority by placing constraints in the construction authorization). However, 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.

3.1.3 OPERATION

If Yucca Mountain is selected as the repository site, 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 (Section 3.1.1.3) and may require reporting to the State, the NRC, and directly to the EPA depending on the statutory requirements in existence at the time.

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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 Yucca Mountain is selected as the repository site, then the post-closure 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, States 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 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) is required for the site characterization and construction phase, aside from that addressed in the Environmental Monitoring and Mitigation Plan (EMMP). 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.

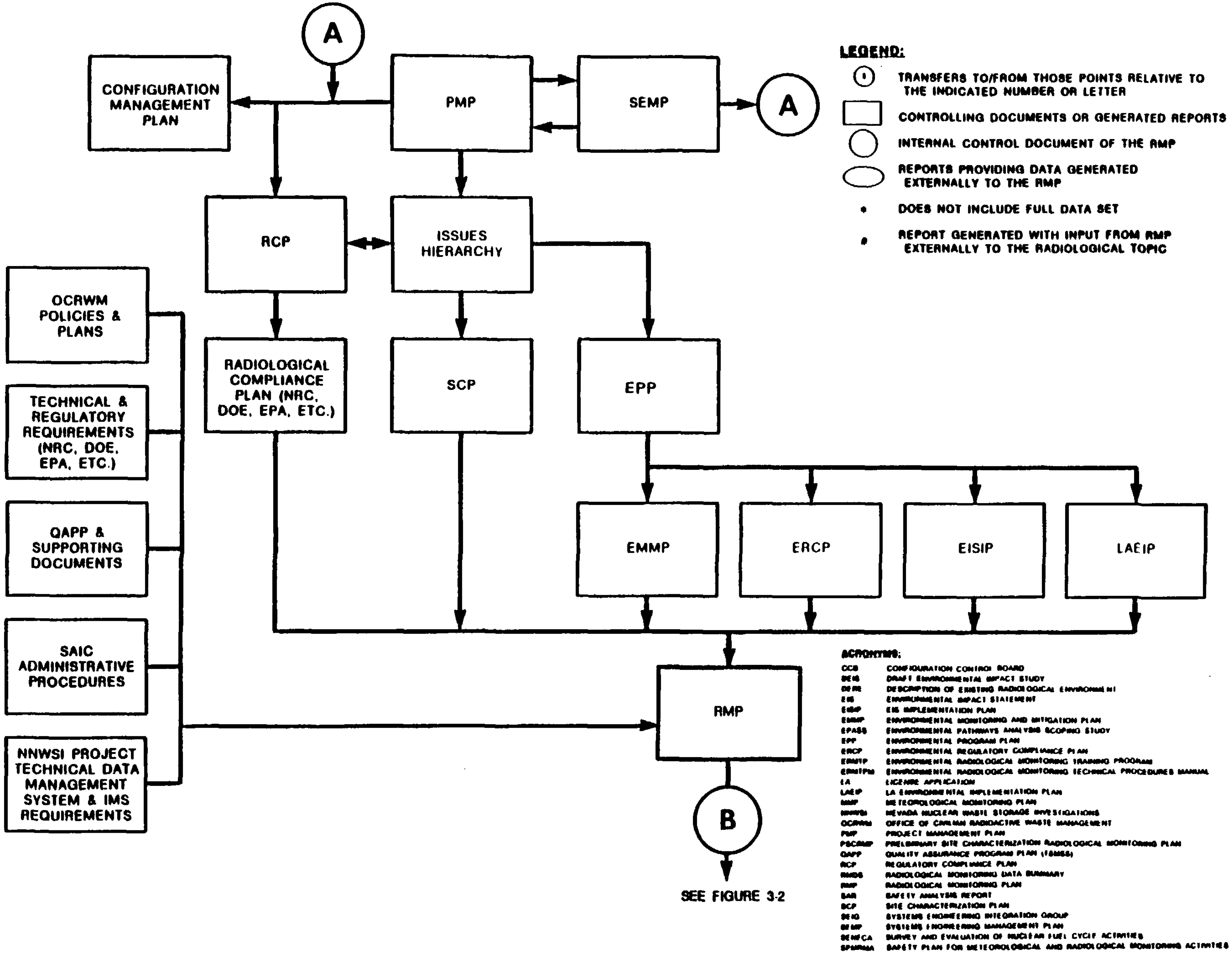

Figure 3-1. Site characterization document hierarchy.

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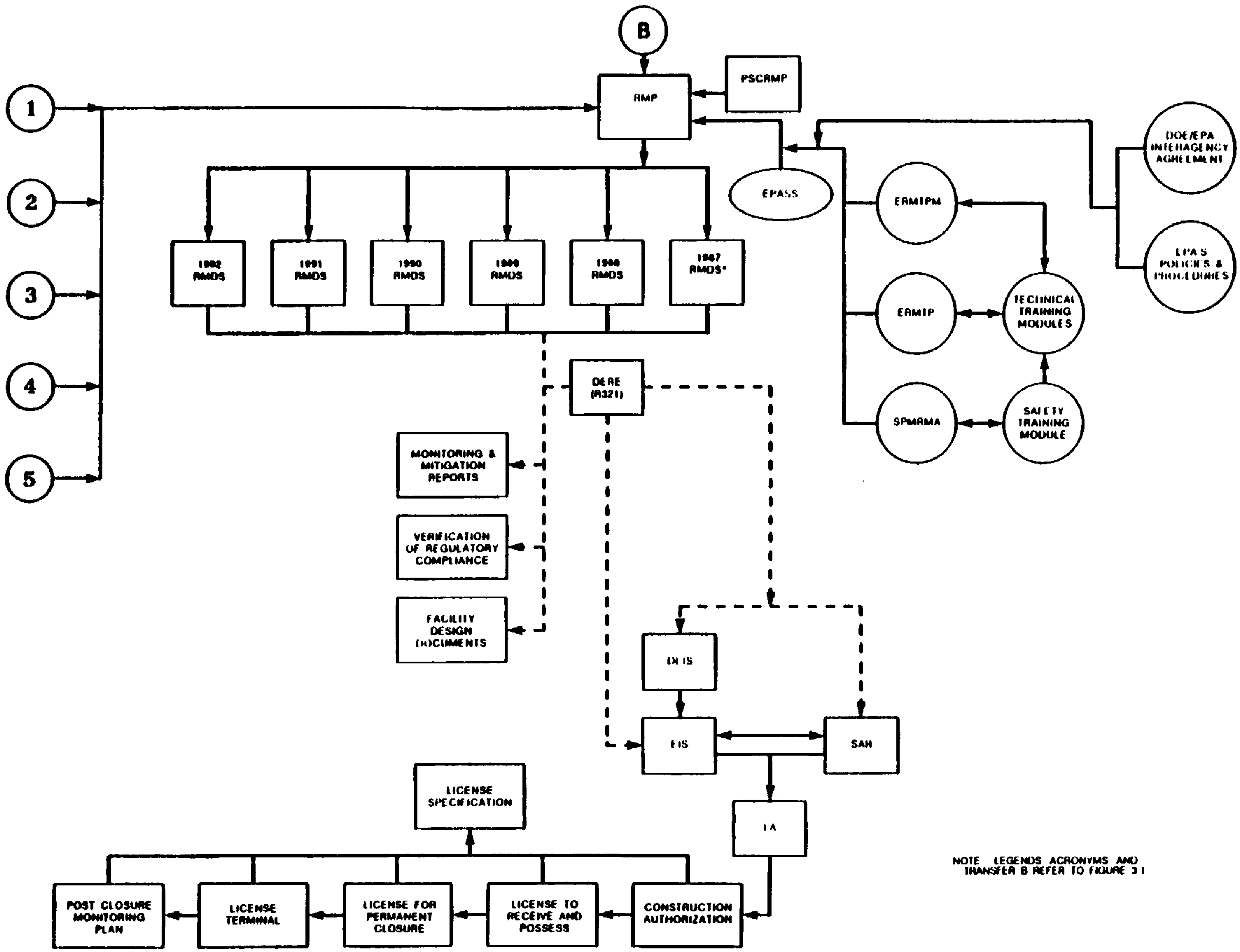

Figure 3-2. RMP documentation.

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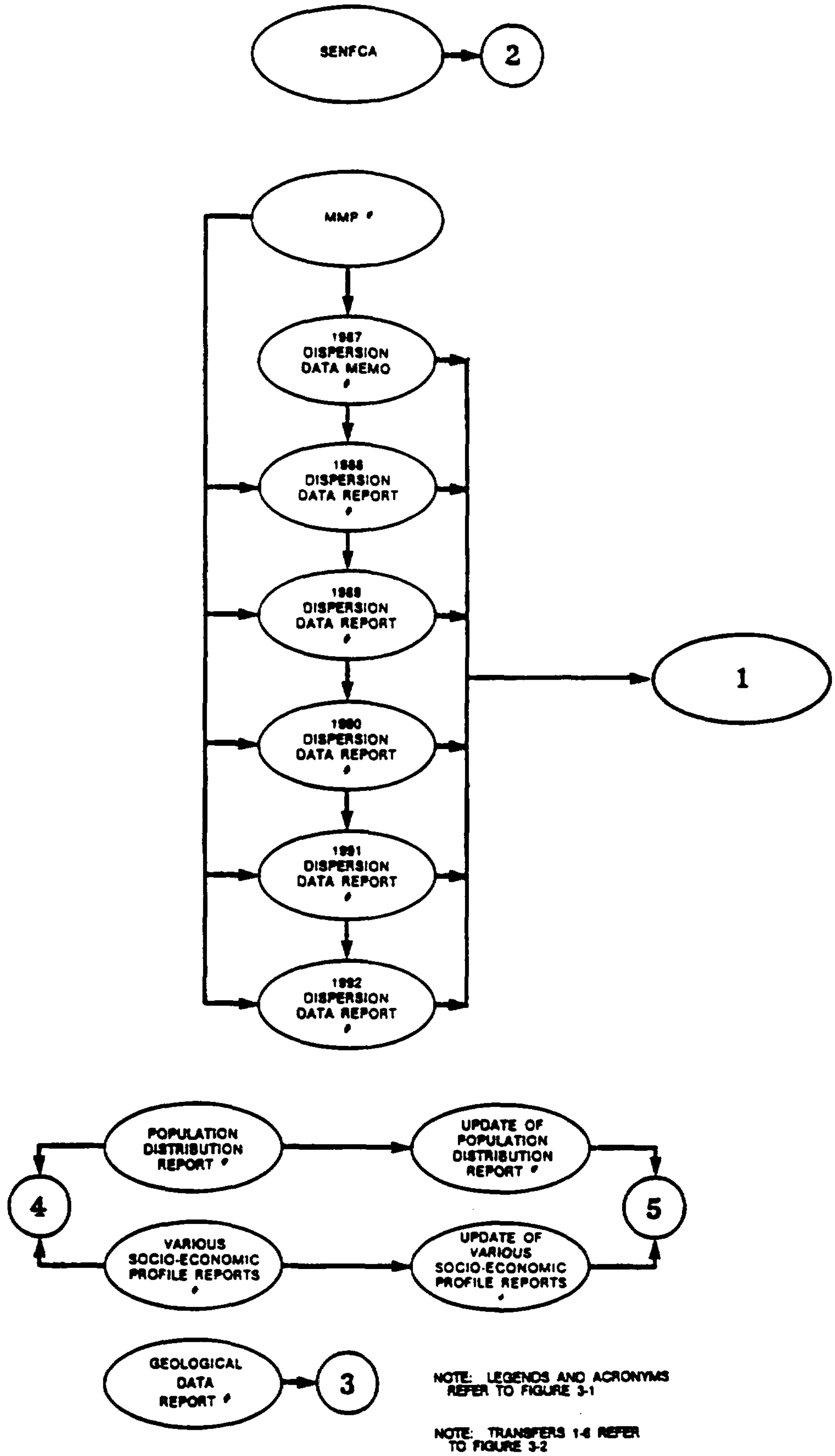

Figure 3-3. Nonradiological supporting technical reports.

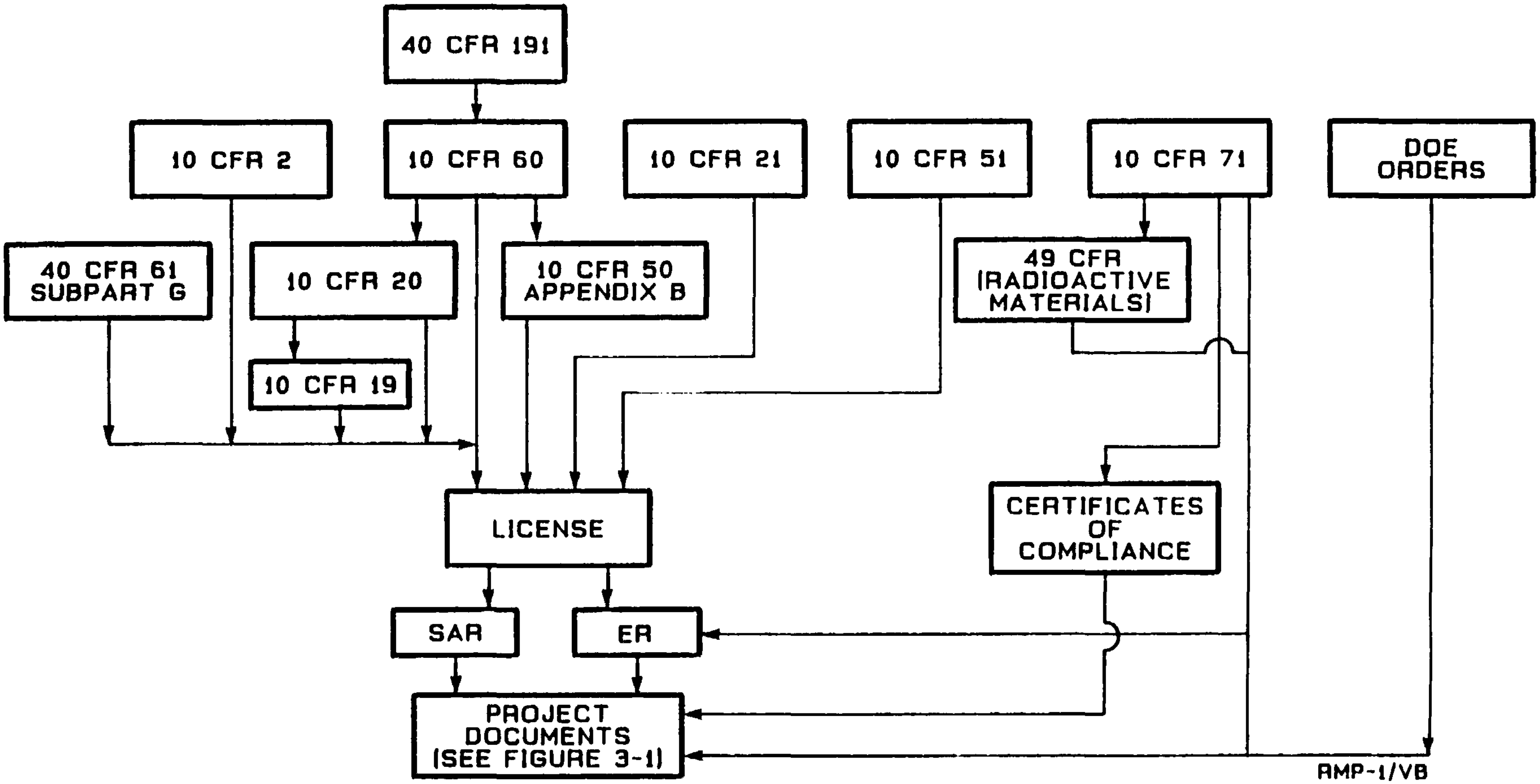

Figure 3-4. Document hierarchy for operations.

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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

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(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 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.

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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) 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 showed 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

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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 SCPs, consideration of comments received during SCP hearings, and after consultation on the Environmental Monitoring and Mitigation Plan (EMMP) with the State of Nevada. 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 only discussed 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 three potential sources of radioactive materials at the Yucca Mountain site:

1. Release of naturally occurring radionuclides from mining activities.

2. Discharge of groundwater containing radionuclides to the surface.

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

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Because only fractional amounts of rock are expected to be mined and a limited amount of groundwater released to the surface during site characterization, releases from these site characterization activities are estimated to be a small fraction of the natural background radiation. They will not constitute a significant impact. It is expected that the groundwater will contain only natural background radioactivity. The resuspension of the elevated background during site characterization is also expected to be small compared to natural background due to the low concentration of radioactivity present. However, since limited monitoring activity has occurred at and around the Yucca Mountain site, the EA analyses contain an inherent level of uncertainty. To verify the previous assumptions, therefore, monitoring is proposed in the areas of (1) radioactive material concentrations in air, soils, biota, and groundwater; and (2) external radiation background field.

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.

3.3.1.1.2 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

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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). 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.

3.3.1.1.2.1 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) and applicable DOE Orders implementing this requirement.

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3.3.1.1.2.2 Radon/radon daughter product releases

Subpart H of 40 CFR 60.92 (the Clean Air Act) 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).

3.3.1.1.3 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 DOE Order 5484.1

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...

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*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.

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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.

The requirements of Section 1 (relative to data collection needs before the initiation of significant site characterization activities) are addressed

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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 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

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"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 DOE Order 5480.1B

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

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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

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*Number to be determined.

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. . .

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 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) 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.

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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 4.1.1.5.

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 . . .

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(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.

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. 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 <u>10 CFR Part 20</u>

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 allc 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 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 President has approved sites for characterization, only those sections of this regulation which address selection of the final repository site for recommendation to the President are considered.

Section 960.3-1-5 states that "[e]valuation of individual sites and comparisons between and among sites shall be based on the postclosure and preclosure guidelines....The preclosure guidelines of Subpart D contain

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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 4.1.1.5) 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 4.1.1.2) will be sufficient to establish that exposures received due to the elevated background are ALARA.

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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 4.1.1.4), data from the field program mentioned previously, and environmental radiological monitoring data reports from all commercial nuclear activities within the area of interest.

*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.

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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.

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.

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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.

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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 has been to require such a program 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).

When operations are initiated, the operational environmental radiological monitoring program is implemented. The program is similar to the preoperational 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:

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

2. DOE Order 5480.1, Chapter XI, Section 4.b(2), or the DOE draft Order 5480.xx, "Radiation Protection of the Public and the Environment," Section 8.h(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) 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 and justify this monitoring program.

3.3.2 PROJECT-GENERATED REQUIREMENTS AND COMMITMENTS

The controlling Technical and Management Support Services (T&MSS) documents for the NNWSI Project are the Project Management Plan (PMP), the Configuration Management Plan (CMP), and the Systems Engineering Management Plan (SEMP). However, the needs addressed by the RMP are specifically identified in the NNWSI Project Issues Hierarchy and the Regulatory Compliance Plan (RCP), two Project documents shown in Figure 3-1.

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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? . . .

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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 environment field requirements, while programs and investigations refer to geotechnical site characterization activities.

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:

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

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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 will collect the following information to support resolution of the previous issues:

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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).

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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).

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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 for radiological monitoring activities), 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. 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, 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) and the Environmental Regulatory Compliance Plan (ERCP) 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.

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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

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Land access agreements and compliance with applicable nonradiological environmental regulations and requirements will also be addressed by the ERCP.

3.3.2.2 Regulatory Compliance Plan (RCP)

The RCP 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:

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.

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

4. The NNWSI Project Systems Engineering Management Plan (SEMP).

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/RW-0119).

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 and supporting documents. Satisfaction of these requirements is specifically addressed in Section 7 of this document and in the Scientific Investigation Plan for Environmental Radiological Monitoring Activities (SIP

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#1.2.3.6.1.2.T, Rev. 0) 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 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 administrative 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.

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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 and the Safety Plan for Meteorological and Radiological Monitoring Activities (SAIC 86/8006, DOE NV/10270-13, respectively), are two of the documents addressing these requirements.

3.3.2.4 Implementation documentation

Based on the requirements in Section 4.2 and, specifically, Sections 4.2.2.2 and 4.2.2.3, 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 and the Safety Plan for Meteorological Monitoring and Radiological Monitoring Activities for

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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.

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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 directed at 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 and prepare safety analysis reports.

4. Monitor the impacts of site characterization activities on the surrounding environment (Section 3.3.1.1.1).

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.

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The RMP will be revised, 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 farfield (beyond 15 kilometers) area already exists as part of the Nuclear Radiation Assessment Division's (NRAD'S) 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 this program, 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 characterization 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) mandates that the DOE obtain a license for its commercial repository operations, and this monitoring program, to support the licensing process, 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) is recommended as appropriate guidance by both the NRC and DOE, and this section will rely on that document as the primary source of the technical justification for the selection of radiological monitoring methodologies. The technical basis presented in these sections are 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 previously listed. Each objective is addressed separately.

4.2.1 CHARACTERIZATION OF THE WORKSITE ENVIRONMENT

Three characteristics of the worksite environment will be addressed: (1) the existing radioactivity concentrations which are present in the background environment at the site, (2) the potential radon emission from tuff at the site, and (3) the assessment of changes from ongoing activities.

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 activity.

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

4. Other indirect pathways such as ingestion of activity.

The direct exposure pathway is not projected to be significant. Various NTS participants have identified and posted (or decontaminated) significantly 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 rate recorders 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 tower as described in Section 6.1 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 will also 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 chains (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 chains. 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) partly fulfill the requirements of 10 CFR Part 960 (Section 3.3.1.1.5), (2) prepare a Safety Analysis Report (SAR), and (3) design a facility. NTS activities may have a

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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 and 4.5), 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. Ambient radiation data will be needed in the preparation of the SAR, and collection of those 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

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radon emission rate in the proposed underground facility at Yucca Mountain. The results from evaluation of these data would 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.

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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 low-level 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 any 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 activity 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.

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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 characterization. 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 laboratory or with approved field equipment) before release of significant quantities (a few gallons) of such water to the surface-water system. 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

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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 under the activities discussed previously 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 excpected to alter the radiological background conditions in the Yucca Mountain area.

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Table 4-1. Example of NTS Environmental Monitoring Reports

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

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Table 4-1. Example of NTS Environmental Monitoring Reports (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

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 normally collected will be supplemented with continuous radon data to ensure adequate background information is obtained. The radon background data collection activities, which should be finished before shaft construction and mining activities, will be completed by 1990. 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.

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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 or guidance, technical guidance, present NTS programs, public concern, and historical precedent, the general areas of interest for the radiological monitoring activities are (1) the area surrounding Yucca Mountain, and (2) 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) 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

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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 (further discussed in Section 5.2.2.1.1) 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. NUREG-0475 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 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 is 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.

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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 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)...."

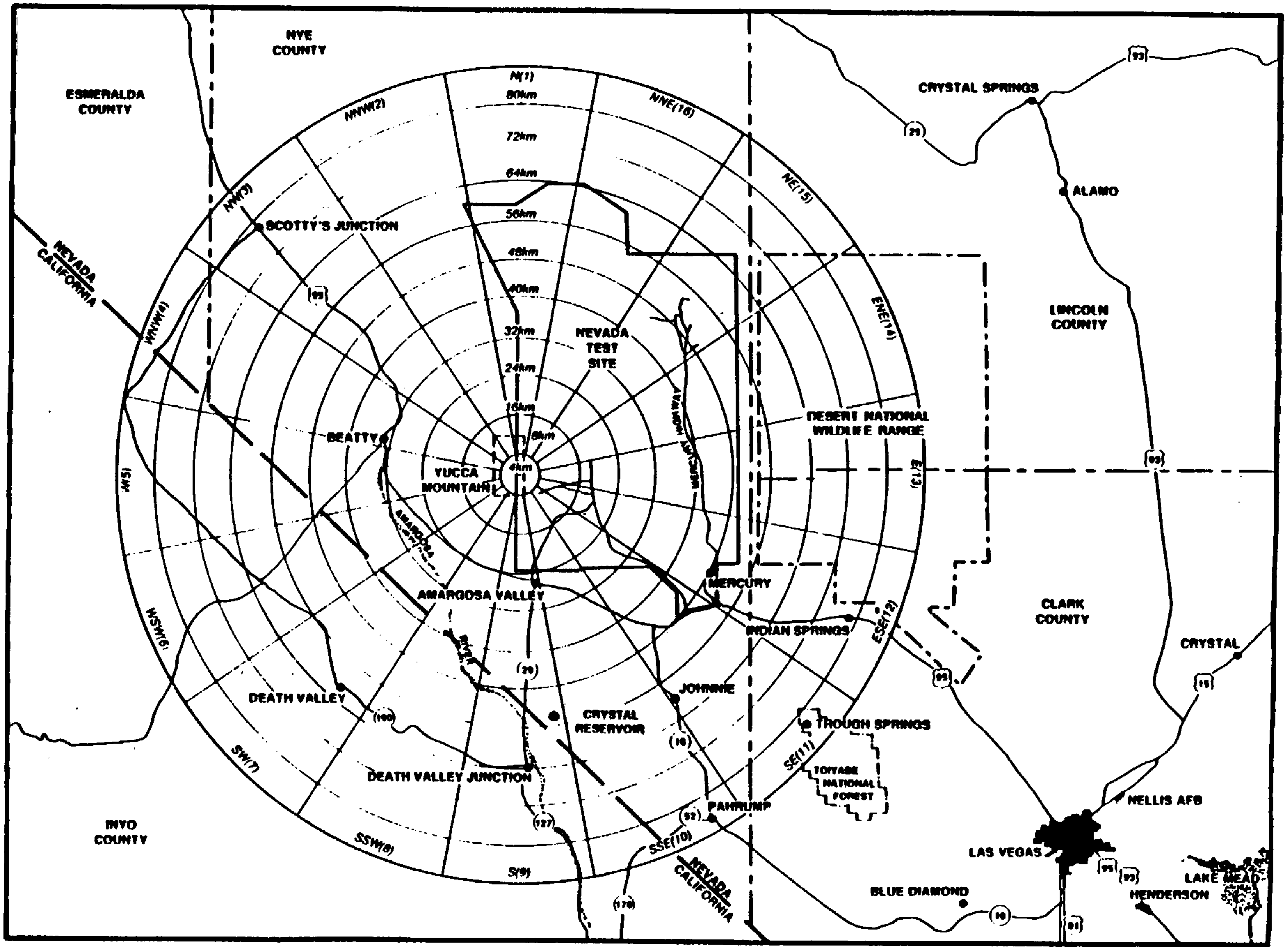

Figure 4-1. Yucca Mountain radiological grid.

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

Sample Grid Designation							
Grid designation				Inner-boundary (I.B.)		Outer-boundary (O.B.)	
Coordinates (x,y)	Radial (km)	Section	AIRDOS[a]	Distance (km)	Angle (°E of N)	Distance (km)	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

Radial designation				Direction designation					
X-Coordinates [AIRDOS #][a]	Radial (km)	I.B. (km)	O.B. (km)	Y-Coordinates [AIRDOS #]	Section	Angle	I.B.	(°E of N)	O.B. (inclu-sive)
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]AIRDOS number is the directional section number assigned to a segment for data input to the computer program AIRDOS-EPA.

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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 as shown 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 (e.g., Kr-85).

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

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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, Table 2) 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)

	Source							
		Spent fuel[d]						
Radionuclides	NTS[a]	> 0.01% 10 years	> 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	
K-40					x		β, γ	
C-14					x	x	β (.156)	4
Co-60		x		x			β, γ	2
Fe-55		x					TC, x-rays	1
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
Tc-99			x	x		x	β (.292)	1, 2, 4
Cs-134		x		x			β, γ	2
Cs-137/Ba-137m	x	x		x		x	β, γ	1, 2, 4, 6
Sm-151		x		x			β (.076) γ (.022)	1, 2
Zr-93/Nb-93m				x			β (.06) x-rays	2
Ru-106/Rh-106		x					β, γ	1
Sn-126/Sb-126m/ Sb-126						x	γ, β	2, 4
Xe-133	0						β, γ	5, 6
Xe-133m	0						γ	6
Xe-135	0						β, γ	6
I-129						x	β (.15) γ (.04) x-rays	4
I-131	0						β, γ	6
I-133	0						β, γ	6

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

Radionuclides	Source							Reference (See page 4 of table)
		Spent fuel[d]						
	NTS[a]	> 0.01% 10 years	> 1% 10,000 years	HLW	Naturally occurring[b]	40 CFR 191 Table 2	Emissions[c]	
I-135	0						β, γ	6
Cs-135						x	β (.21)	4
Sb-125,Te-125m		x					β, γ	1
Ce-144/Pr-144		x					β, γ	1
Pm-147		x					β (.224)	1
Eu-154		x					β, γ	1
Eu-155		x					β, γ	1
Ra-226			x		x	x	α	1, 4
Rn-220/D					x		α, β, γ	3
Rn-222/D					x		α, β, γ	3
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	α	1, 4
Pu-241		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

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

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

[a]The "O" indicates these isotopes 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 "O" also occur in potential waste forms for disposal at a repository.

[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 isotopes, 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)

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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. (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. (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 (1) collection of an air sample by compression or cryogenic techniques, (2) separation and purification of krypton and xenon by adsorption on chromatographic columns, or (3) 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), and ingestion (milk and other foodstuffs). The inhalation pathway is normally assessed by air sampling, while 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 samplers must be obtained. 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 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

*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.

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 NUREG-0475).

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 worst-case 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

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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.

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the sample (Ludwig, 1976). Implementation of this DOE guidance will satisfy the guidance in NUREG-0475 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.

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).*

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*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).

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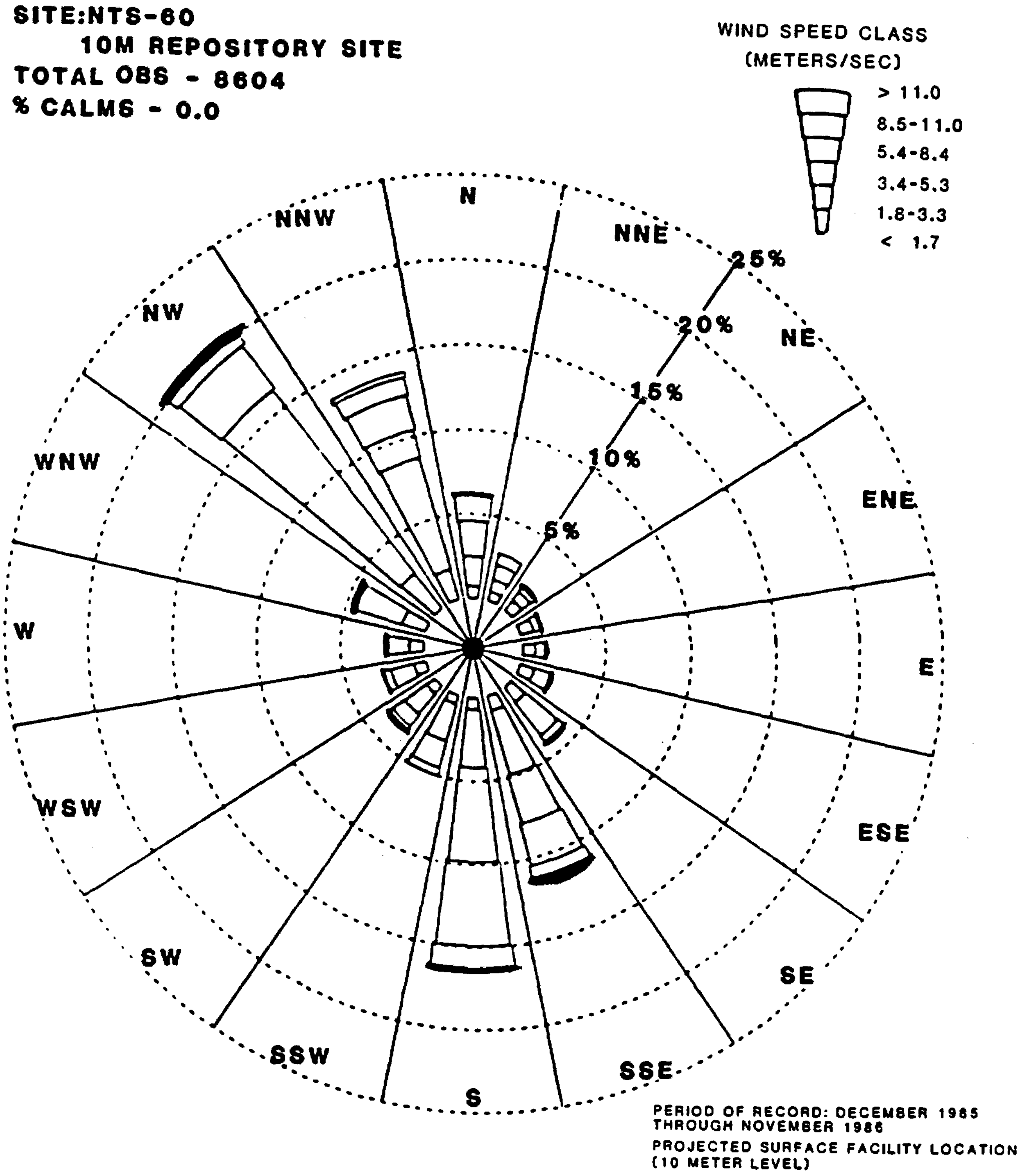

Figure 4-2. Annual wind rose for the 60-meter tower at the repository site (10-meter level).

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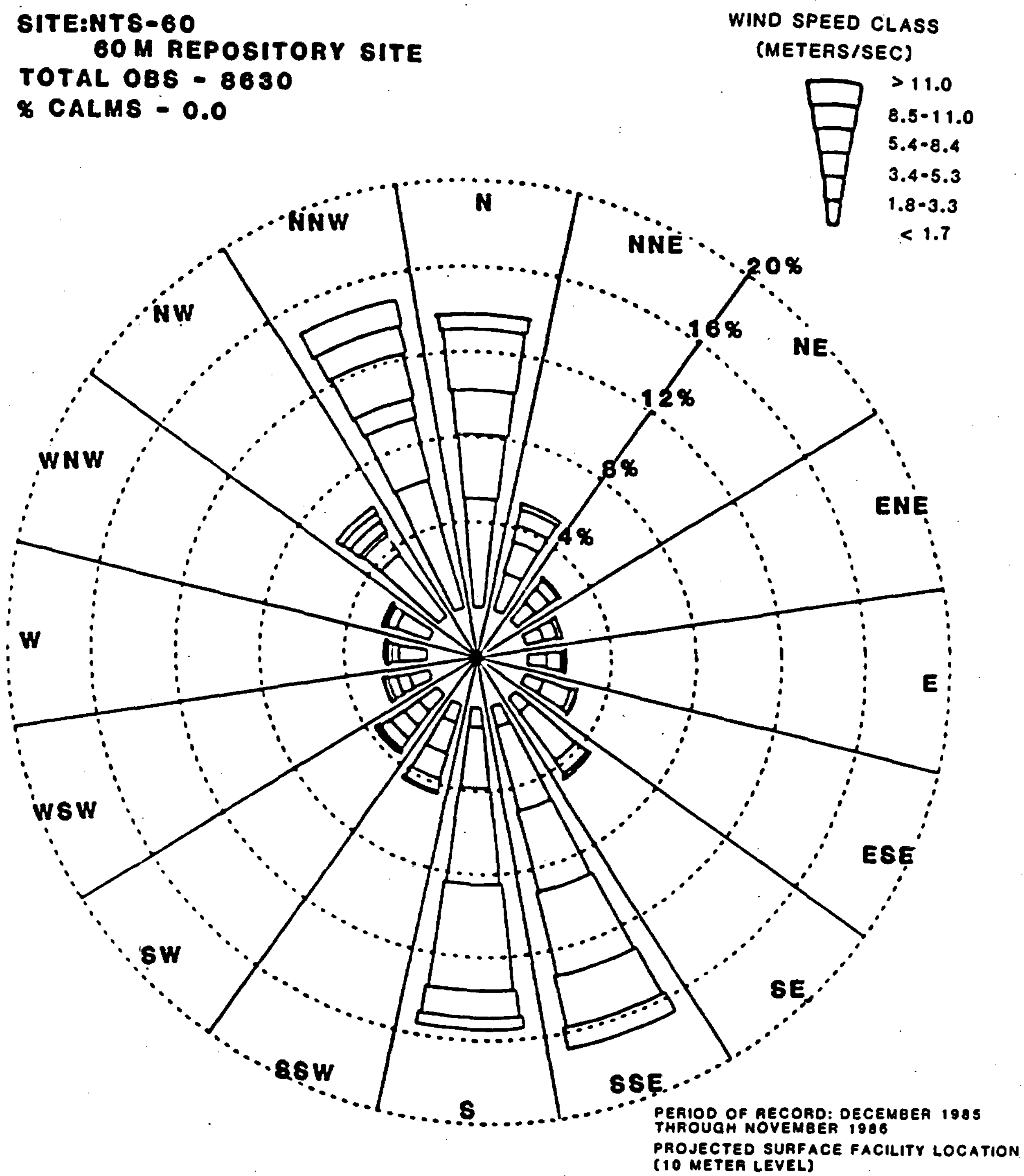

Figure 4-3. Annual wind rose for the 60-meter tower at the repository site (60-meter level).

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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 radioanuclide 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

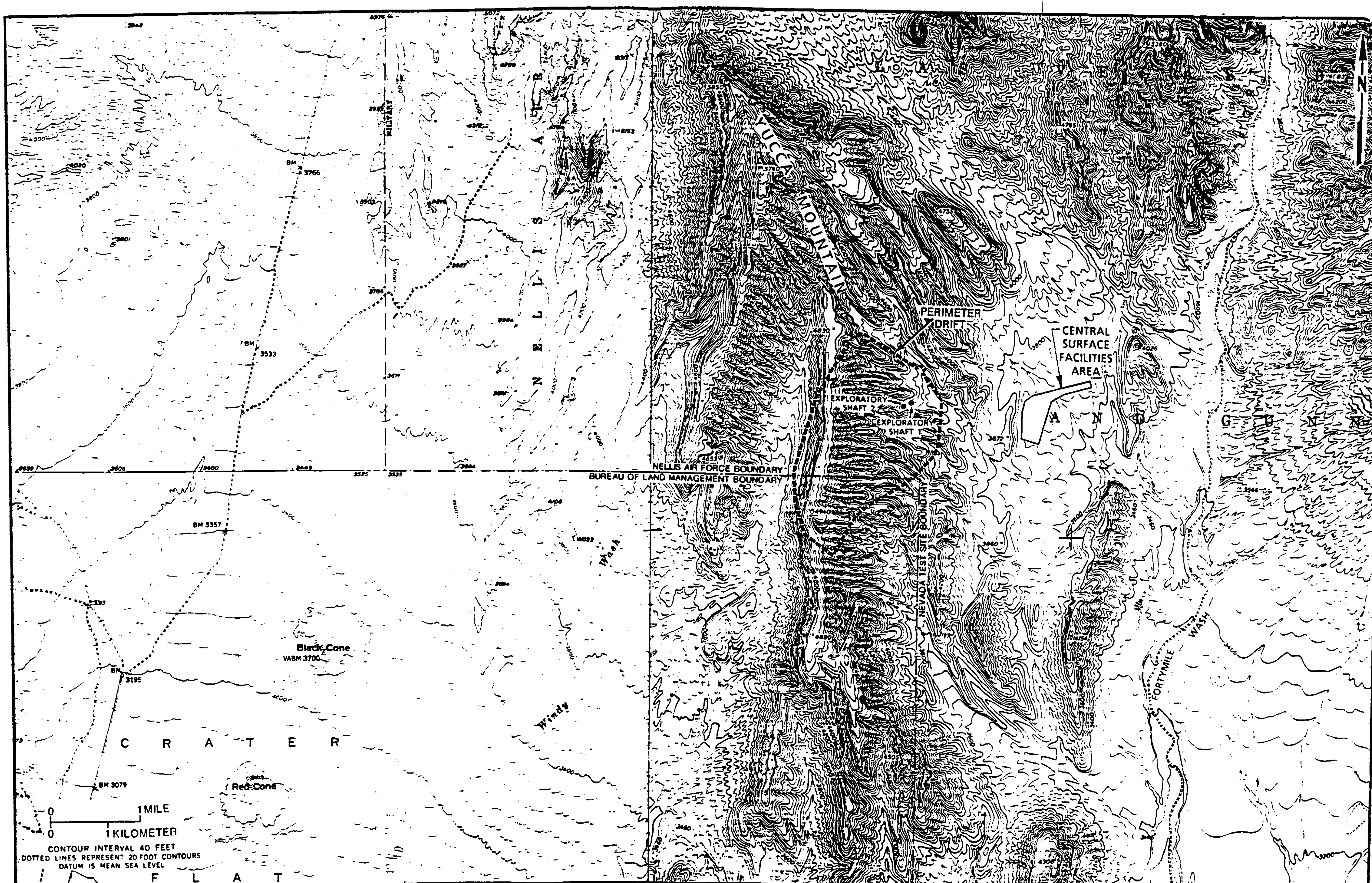

Figure 4-4. Yucca Mountain near-field topography.

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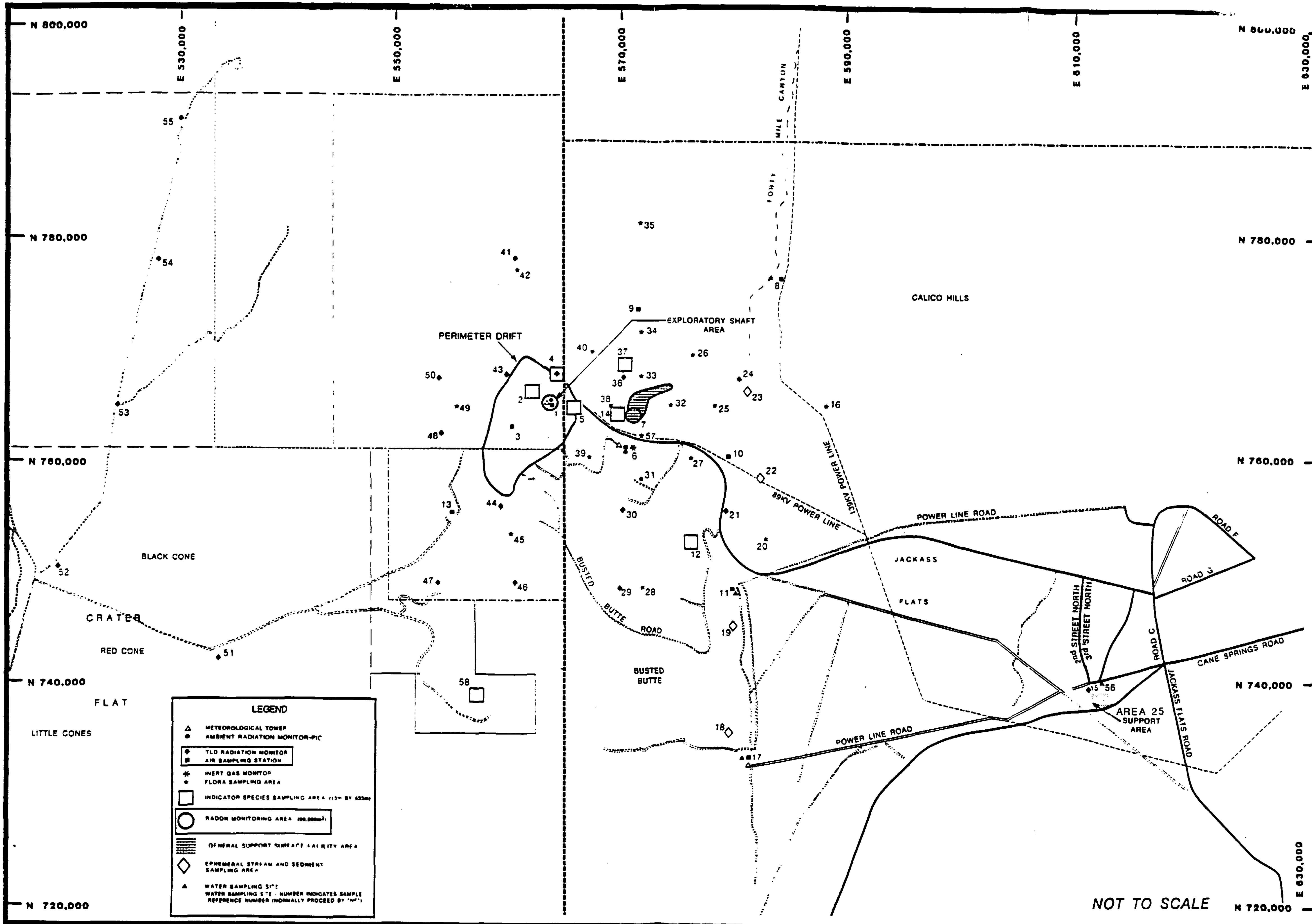

Figure 4-5. Near-field air sampling locations.

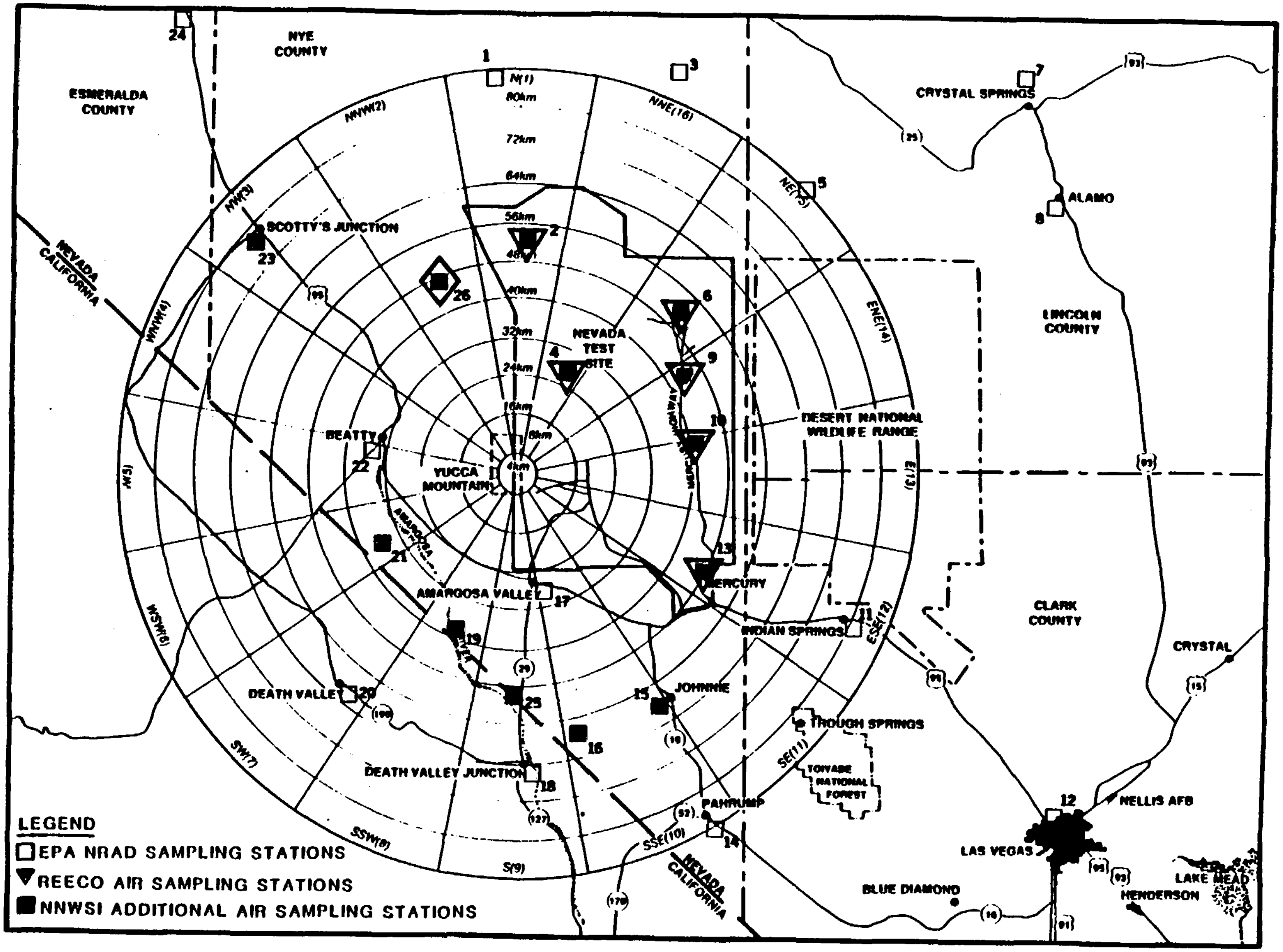

Figure 4-6. Far-field air sampling locations.

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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 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

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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 concentration potential leaving the NTS based on existing REECo monitoring
14[d], 15, 16, 18, 2, 19, 22[d]	Monitor primary agricultural and rural population area
7, 8, 11[d], 14[d], 15, 17[d], 18, 20, 22[e]	Monitor existing concentration at nearby population centers
24, 23, 26	Monitor significant area of the wind rose not covered by other monitoring
1, 3, 5[d], 7, 8[d], 23	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.

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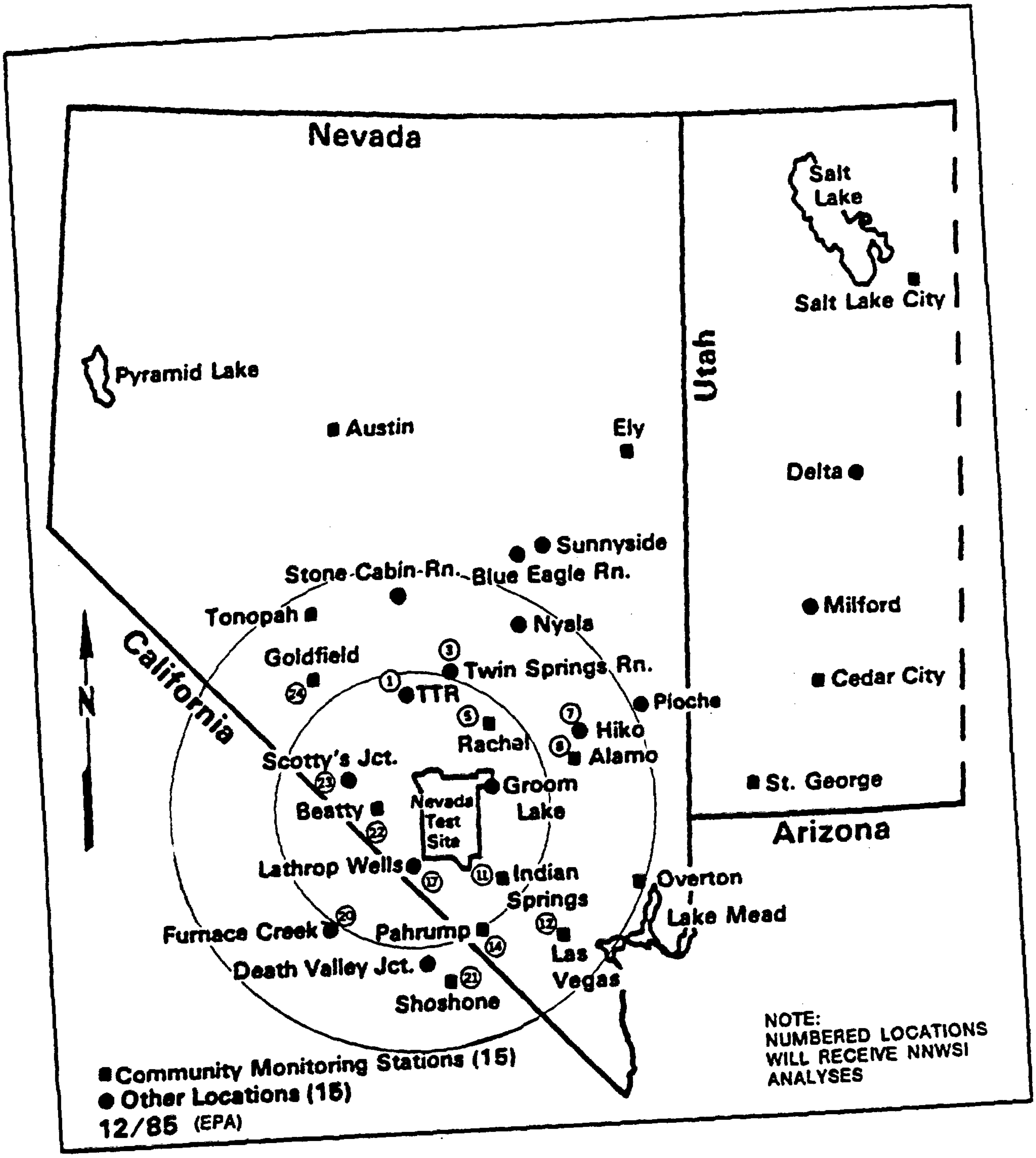

Figure 4-7. EPA Air Surveillance Network stations.

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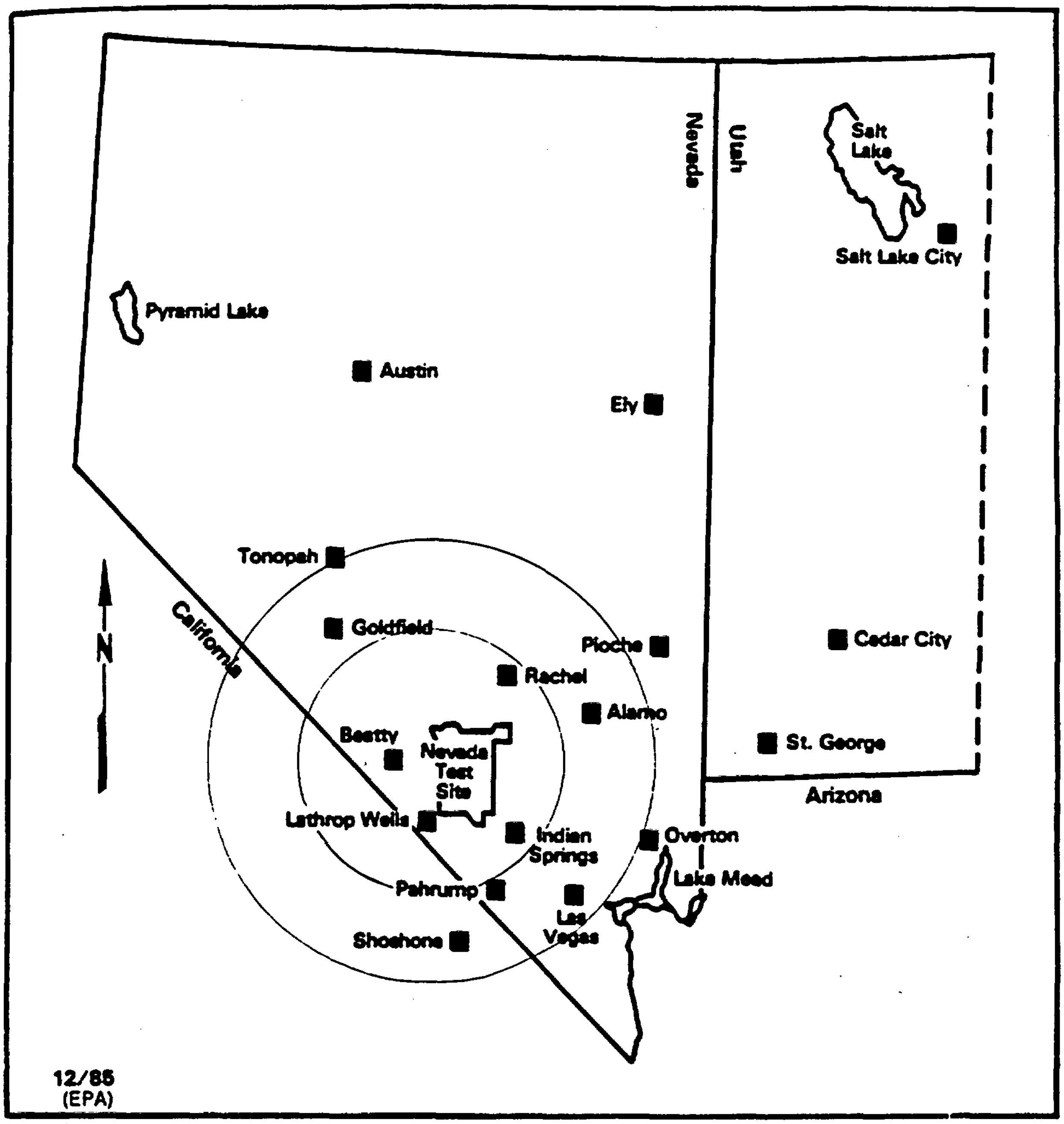

Figure 4-8. Inert gas and tritium surveillance network sampling locations.

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

For air sampling of nonparticulate material, 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.

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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, C-14, I-129, Tc-99, and Pu-241
Charcoal cartridge	Gamma Spectral Analysis
Inert gas monitor	Gas chromatography and liquid scintillation counting
Tritium monitor	Tritium
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 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.

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 milk or animal thyroids (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

Four separate activities (based on the characteristics of the media to be collected) will make up airborne radioactivity sampling: airborne particulate sampling, iodine sampling, 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 iodine isotopes, 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).

The samplers used to collect the samples are consistent with those used in ongoing NTS activities. 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

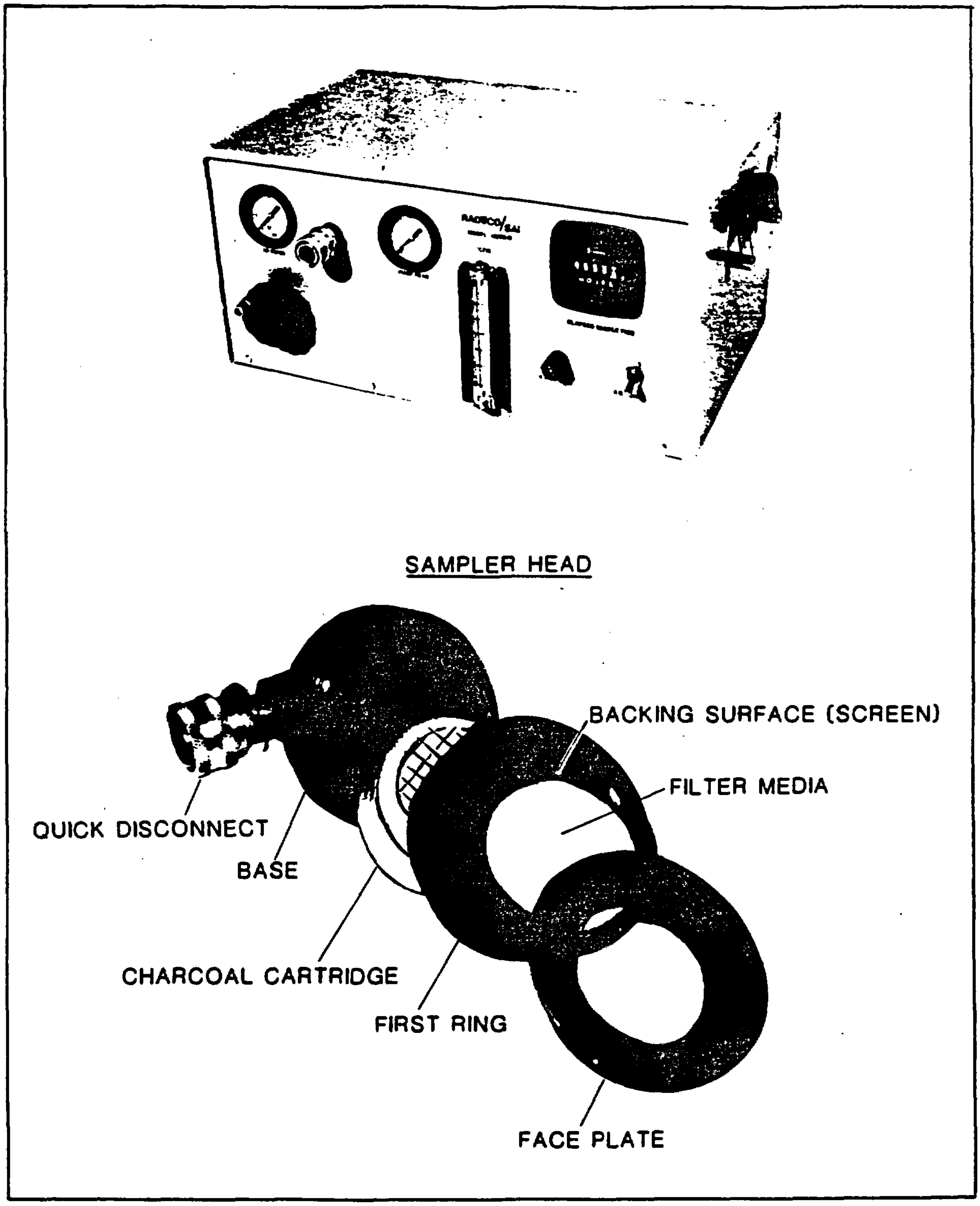

Figure 4-9. Continuous air sampler.

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 represents a volumetric flow rate through the filter at about 60 lpm (2 cfm). 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 2 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, and a gamma spectral analysis will be completed at least 72 hours after collection. The delay 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

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activity reporting are consistent with the recommendations of the EMSL in Harley (1986), NRC (1979), Corley et al. (1981), NUREG-0175, NCRP (1984), ORP (1980), and NUREG CR/4007. The samplers will be calibrated in a manner consistent with Regulatory Guide 8.25.

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 "Air Sampling Instrumentation," or a low flow-rate cascade impactor with characteristics consistent with a Sierra-Series 210 ambient cascade impactor. A 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.

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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.

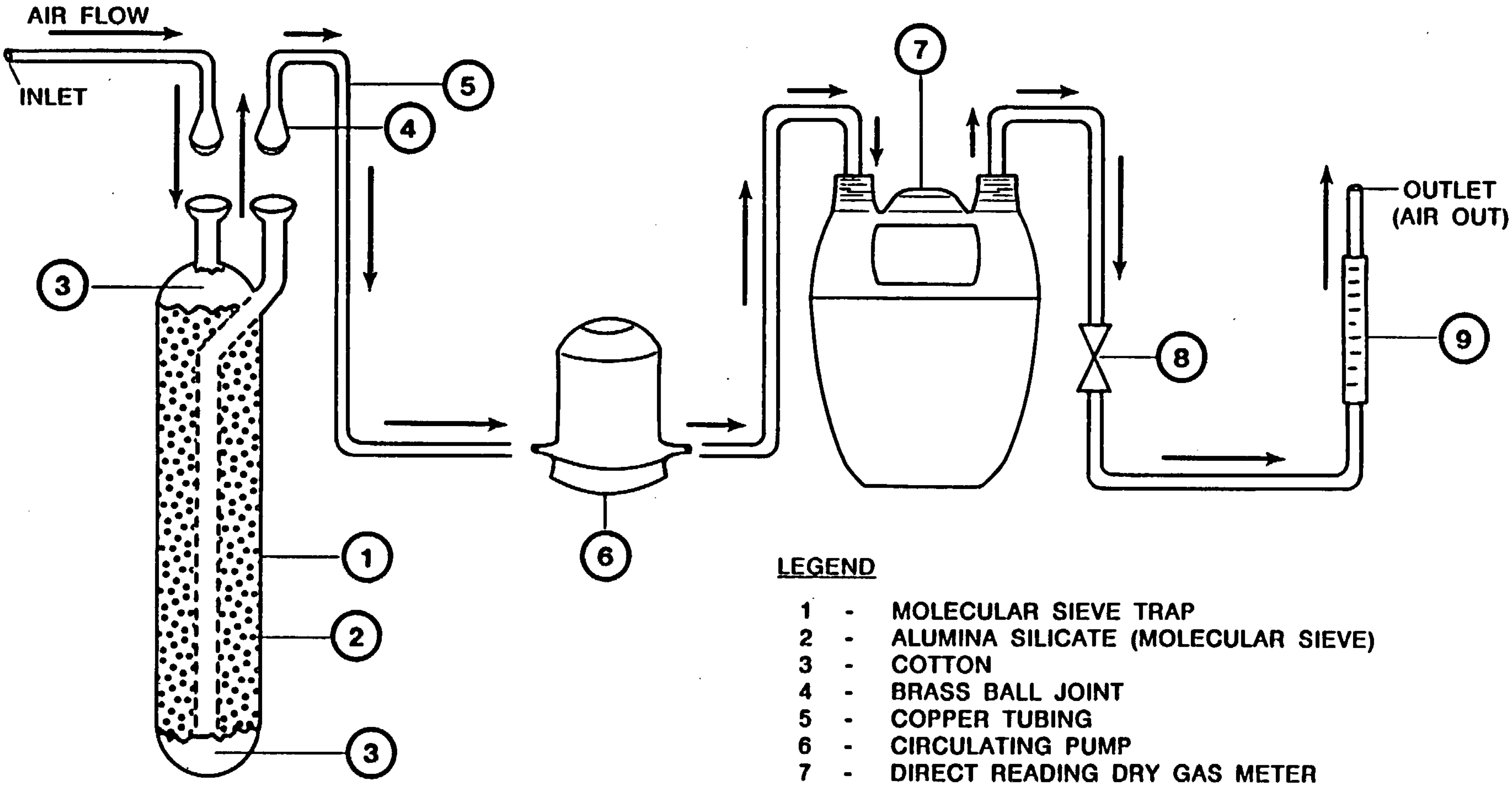
Tritium sampler. The tritium sampler consists of a moisture trap, a "fish pump" (aquarium aerator), a thermograph (recording thermometer), a miniature rotometer (air-flow gauge), and appropriate tubing -- all inside a compact refrigerator. Outside, there is a small, screened inlet attached to a tube 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^oC, 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.



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.

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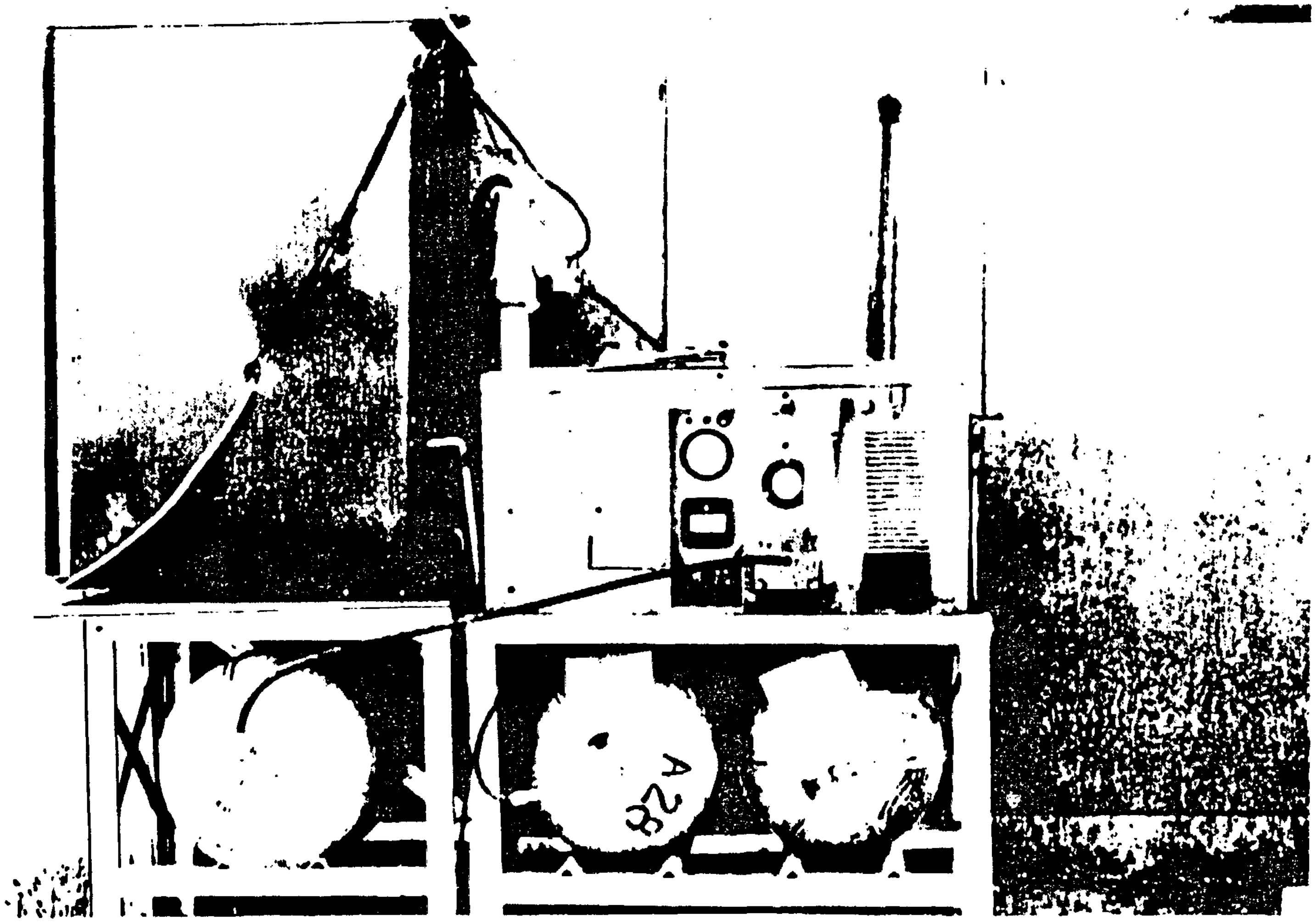
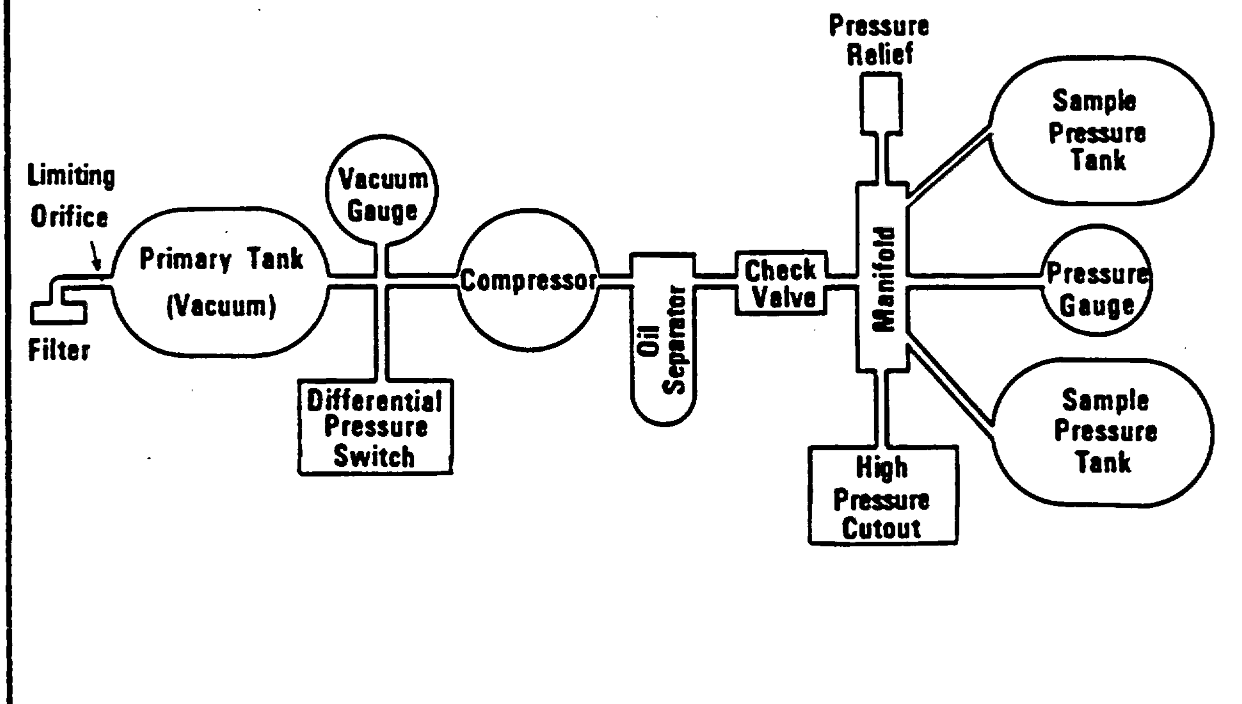
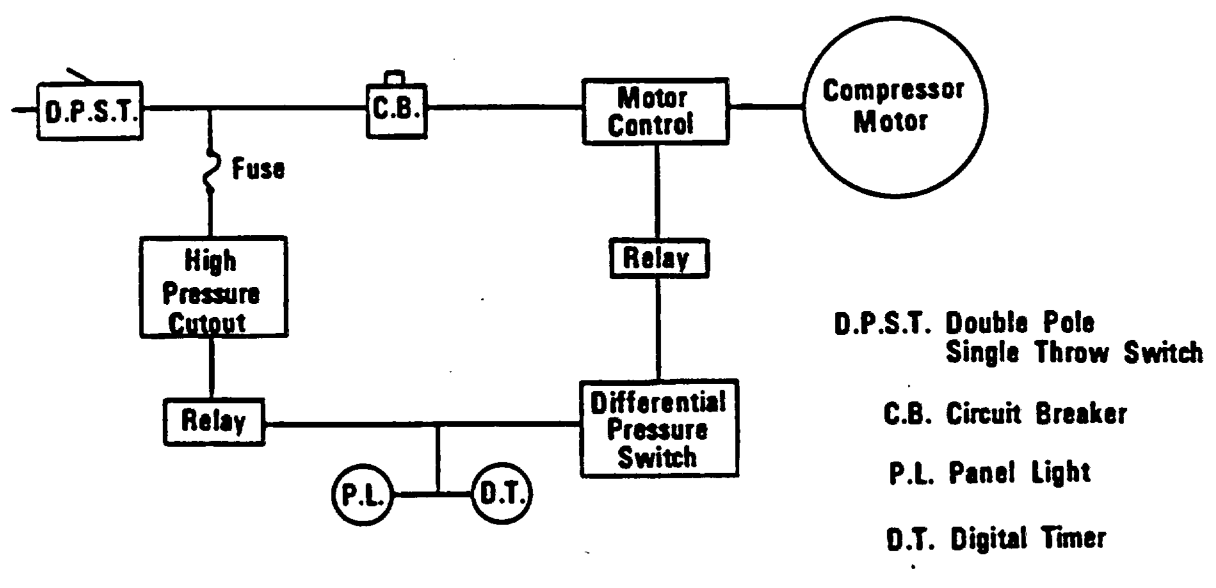


Figure 4-11. Tritium and inert-gas sampling.



Sampler Schematic



Sampler Electrical Schematic

Figure 4-12. Inert-gas sampling system.

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.

Further details on the samplers and the laboratory analyses of the samples are documented in Andrews (1977).

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.

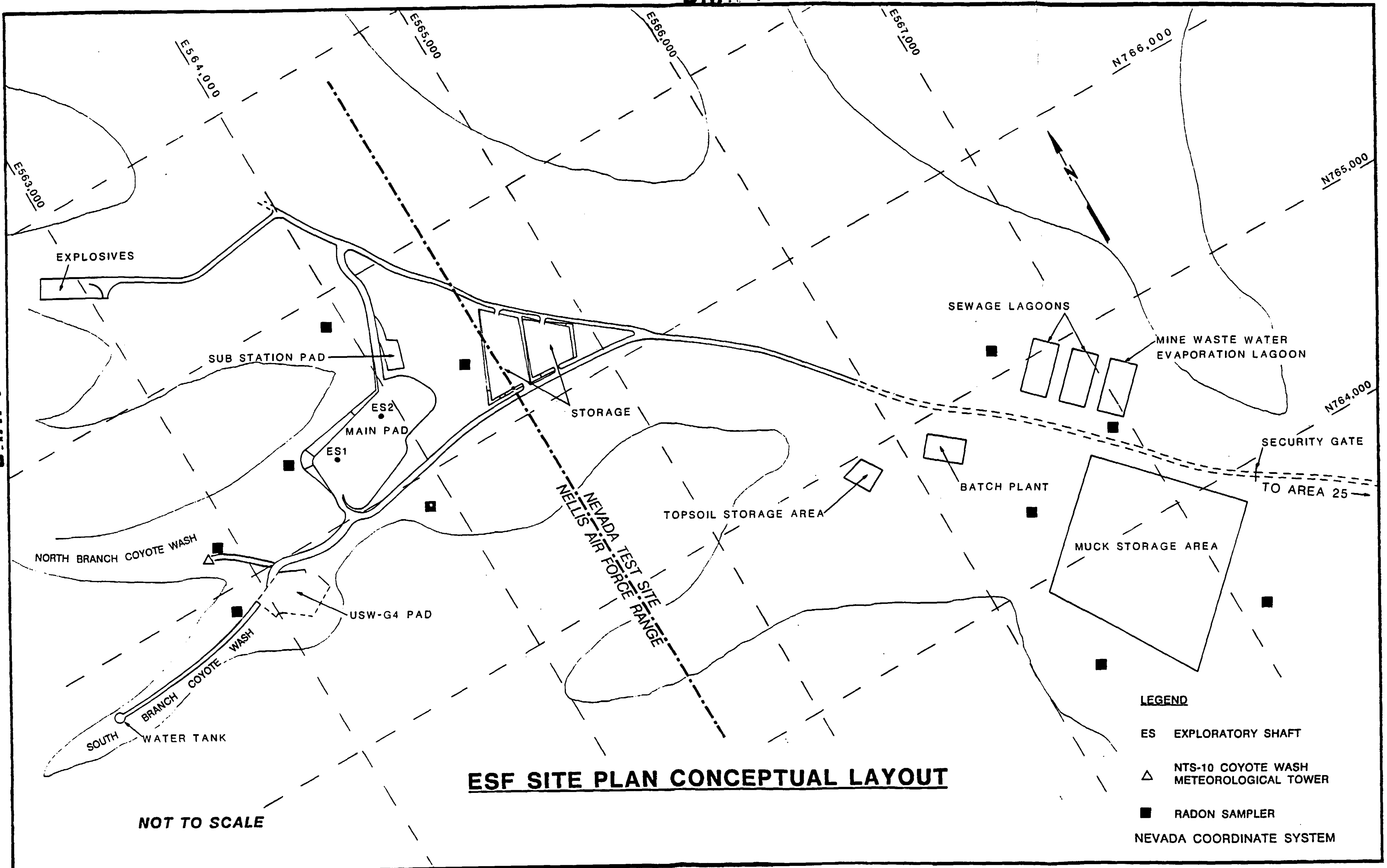


Figure 4-13. Draft ESF radon sampling locations.

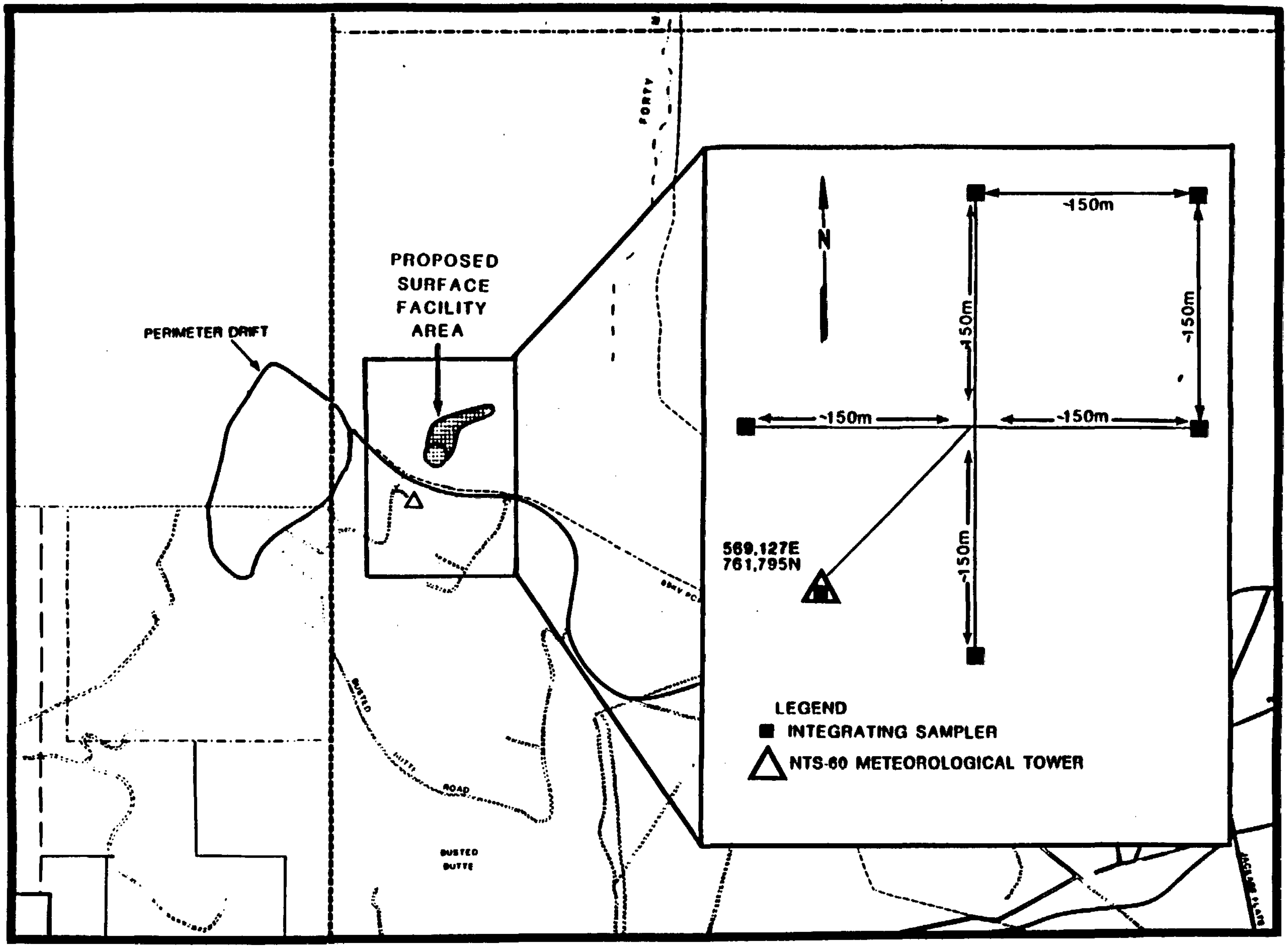


Figure 4-14. Proposed surface facility: Radon monitoring areas.

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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

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

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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, 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 each month between the exploratory shaft (when land access was obtained) and the 60-meter tower locations. The monthly 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.

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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 wind 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.

4.3.5 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

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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 beta, tritium, radiostrontium, gamma spectrometry, and specific radiochemical analysis for other selected nuclides. Gross alpha counting and alpha spectrometry may also be included, depending on potential release of alpha contaminants. 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

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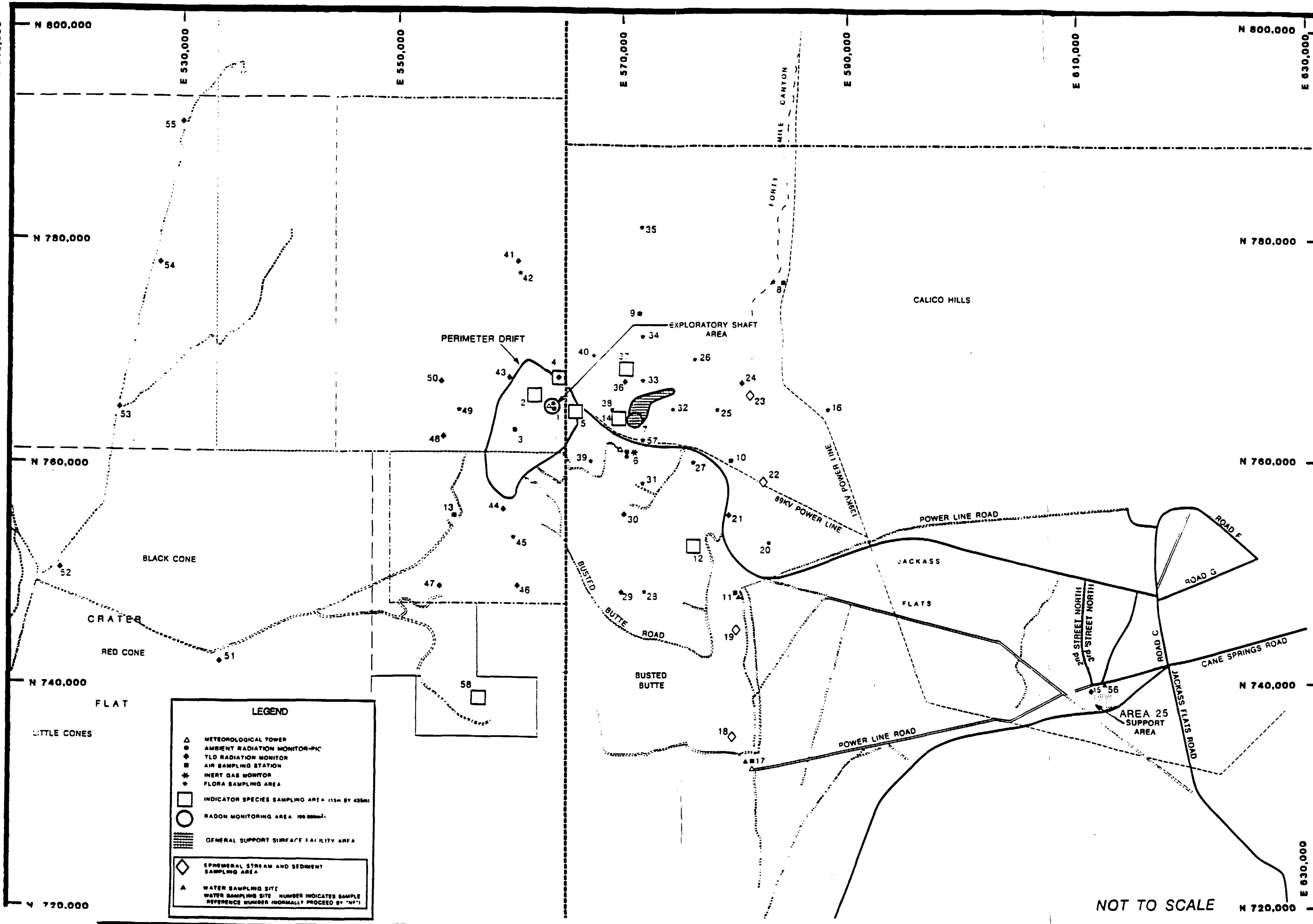

Figure 4-15. Near-field water sampling locations.

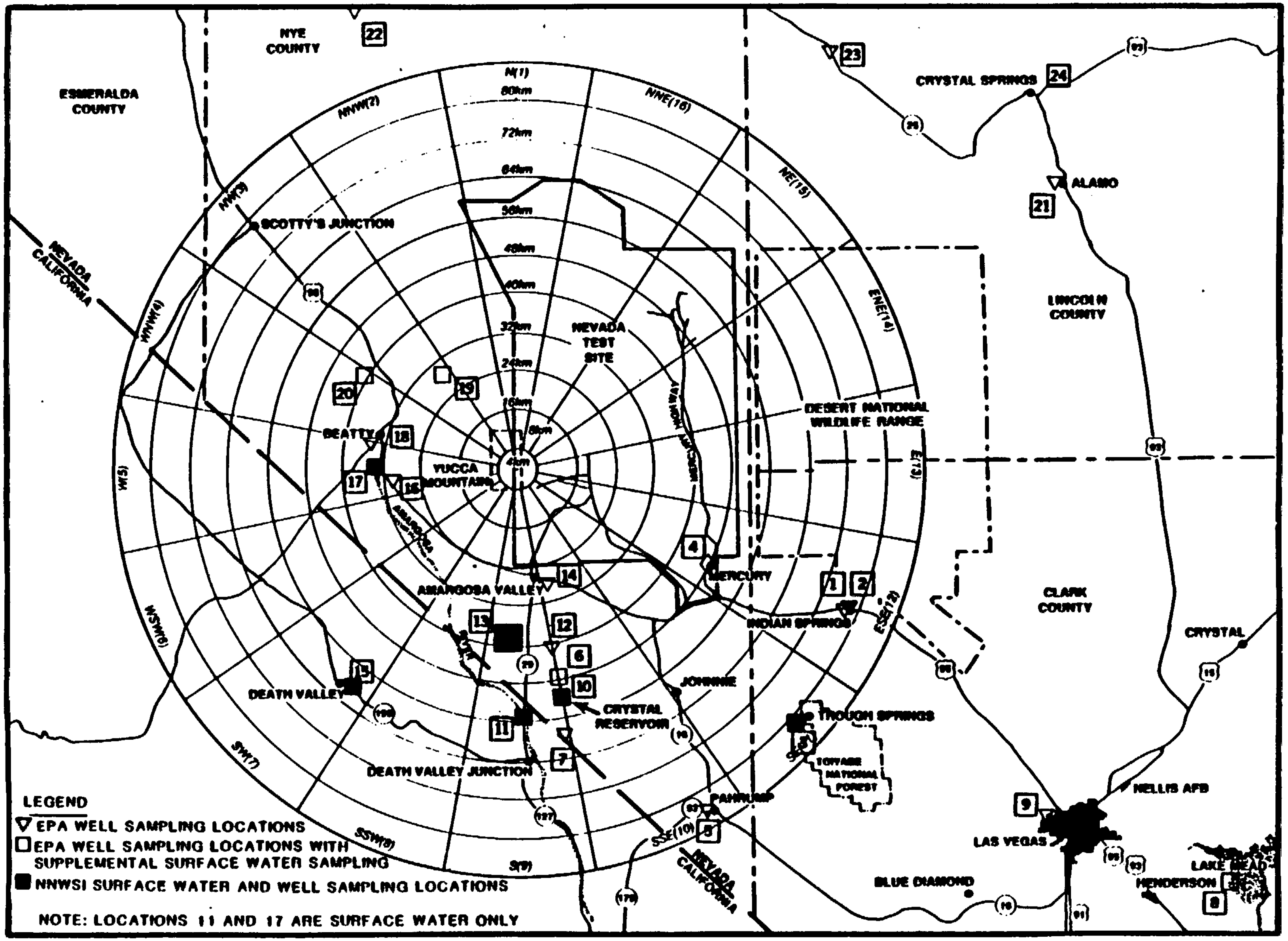

Figure 4-16. Far-field water sampling locations.

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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

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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) 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.

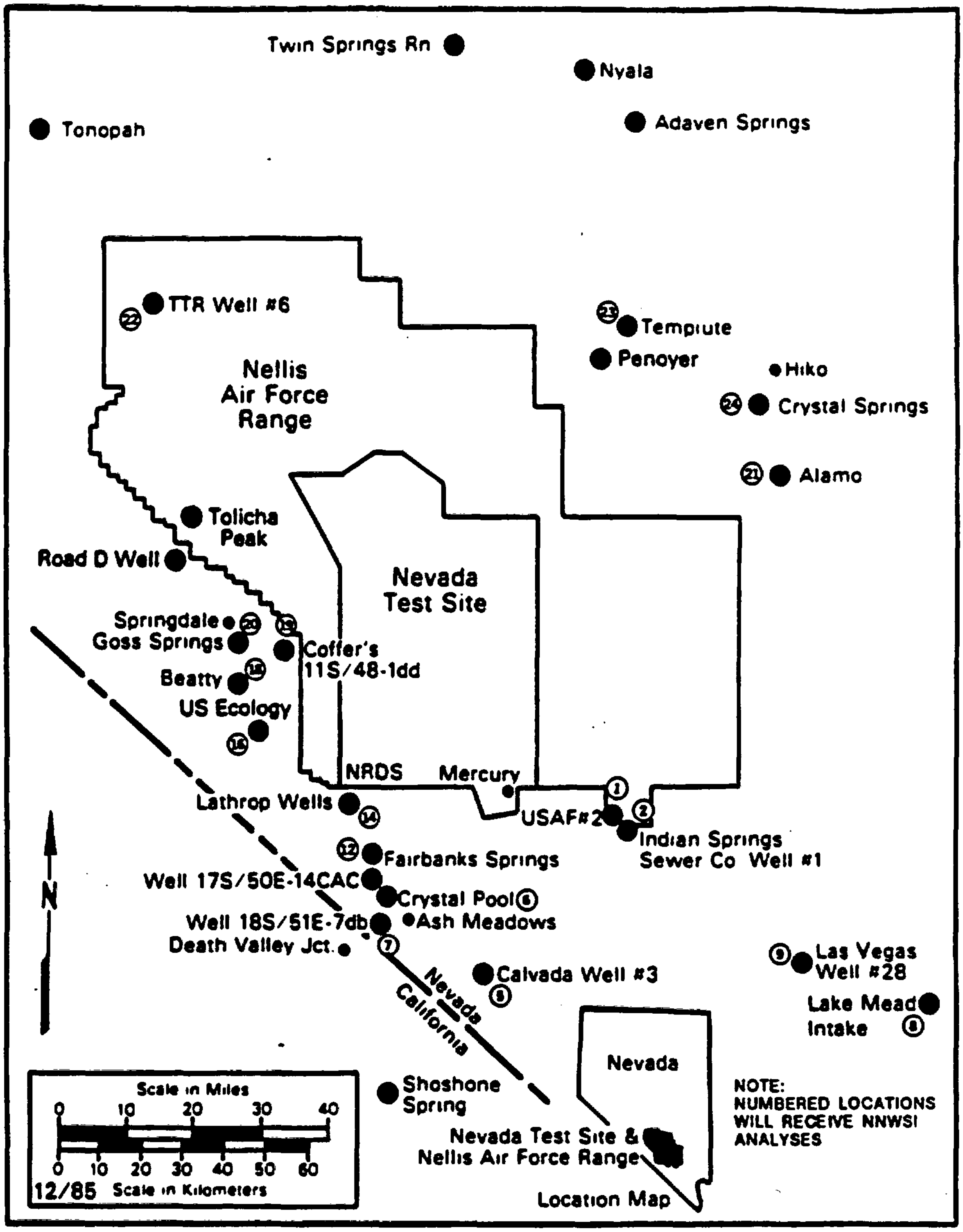

Figure 4-17. EPA drinking water sampling locations near the NTS (from wells and springs).

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The NNWSI Project 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.

As U.S. Geological Survey (USGS) test wells in the area are entered as part of the NNWSI Project program activities, water samples will be obtained, if available. Most of these samples will be archived. A limited 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 NUREG-0475 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 of 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.

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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 isotopes of the radionuclide, 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 0.5L samples is collected for tritium analysis. In special cases, a 10L sample may be necessary at selected locations to provide sufficient sample aliquots for analysis and special archiving (Appendix F). Typically only four 0.5L 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. When obtaining surface-water grab samples, the sample container will be rinsed twice with the water being sampled before taking the actual sample. When taking an aliquot from a larger water sample, extra effort will be made to make sure that the aliquot is representative of the entire sample.

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).

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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

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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 two possible exceptions: Fe-55 and Ni-63. Only about 5 percent of the samples typically being subjected to the full suite of analysis will be analyzed for Fe-55 and Ni-63 (these concentrations are expected to remain constant and the analyses are extremely difficult). 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.

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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. Gamma spectroscopy.

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

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.

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4.3.6 SOIL AND DRIFT SURFACE SAMPLING

DOE (1987c) 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, drift-wall 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).

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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 tilled areas or areas of unusual wind or precipitation influence when selecting soil sampling locations. An annual sampling frequency is planned to assess long-term accumulation 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. Surface soil sampling will be conducted in accordance with the Ring Method in AECDR (1974). 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).

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

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

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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's environmental surveillance guide 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), 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.

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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.

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

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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. The crops selected will consider that the primary pathway is deposition of airborne activity on plants. A local land use study will be conducted to determine where crops (if any) important in the local

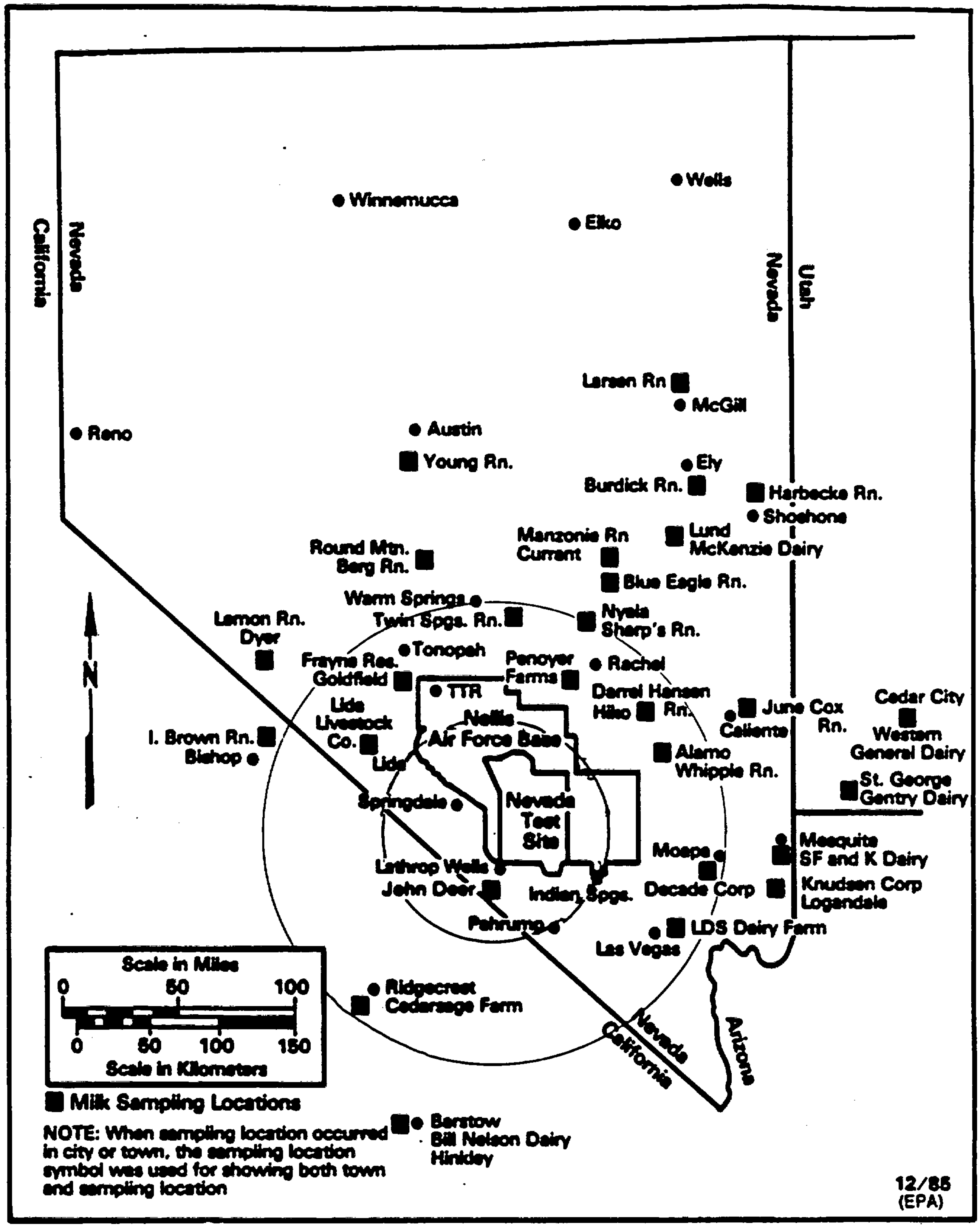

Figure 4-18. EPA milk sampling locations within 300 km of the Nevada Test Site.

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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 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.

Several 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. Twenty-kilogram samples generally fulfill this criterion and provide sufficient sample for most radionuclides of interest.

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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 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 labelled and preserved before delivery to the analytical laboratory. Samples will be stored in a cool location for up to eight hours. After this point they will be frozen to ensure sample preservation. All samples will be reduced to edible portions similar to those produced for human consumption prior to analysis and weighed within 24 hours, preferably

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before freezing. Wet weights are desired since consumption data is generally collected on that basis.

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. Table 4-7 indicates the current expected sampling regime based on limited data.

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

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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 <u>Forage in pathways to man</u>

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 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

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grazing lands north of the surface facility site are chosen for sampling, then Great Basin desert species will be sampled. Every effort will be made to collect the same three species of cattle forage from all eight locations over a two-year period.

Vegetation samples will be collected once a year 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 of the eight sample locations. 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. A total of nine cattle forage samples will be collected from each of the eight sample locations over a two-year period, for a total of 36 samples per year. 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. Beef 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, after the representative species is identified.

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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

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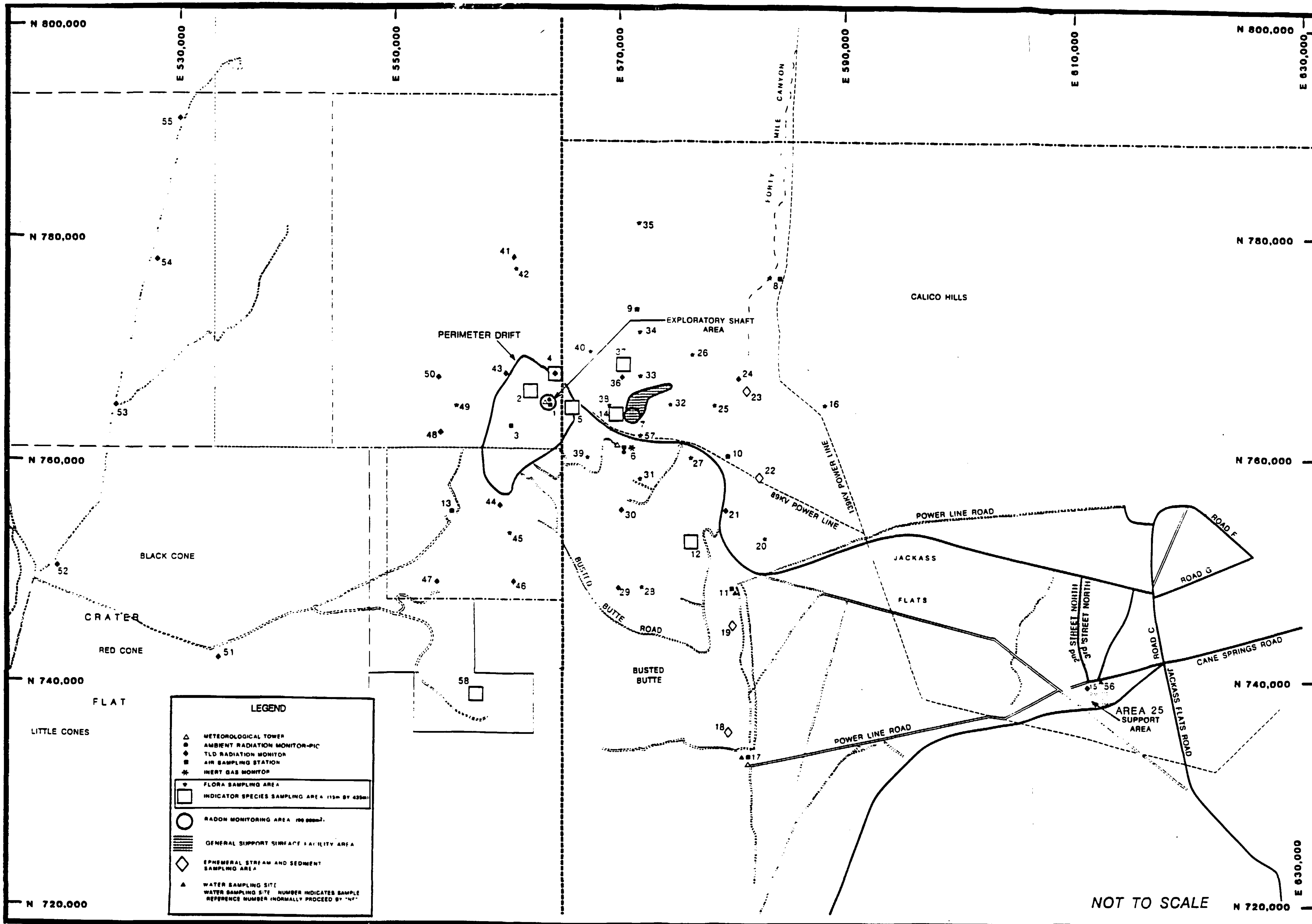

Figure 4-19. Near-field biota sampling locations.

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. Scat samples will continue to be collected, even after laboratory identification of forage plants is complete. Scat samples will be submitted periodically to the analytical laboratory, along with the vegetation samples, for radioanalysis.

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

Vegetation samples will be collected once a year in April when the majority of the deer forage will be in leaf and available to deer which have moved to lower elevations during the winter. Radio-telemetry 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

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temperature patterns, and therefore vegetative growth, will be considered in deciding exactly when samples will be collected each spring.

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. Sampling at the two- and five-kilometer distances will be conducted on the pattern already discussed. All 20 sampling locations will be sampled at least twice during the site characterization phase. An attempt will be 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.

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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.

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Eight small mammal monitoring locations consisting of lines of Sherman live traps will be established within the general areas on Yucca Mountain (Figure 4-19):

1. Two trap lines in the vicinity of the repository surface facilities (location 4).

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

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

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

5. One in the vicinity of the proposed exhaust shaft (location 4).

6. A control area on the west side of Yucca Mountain (location 56).

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. The abundance of these two species vary in the area, but in an area where one species presence is limited, the other will normally be abundant. Although both species should be trappable at each sampling location, it is likely that only one will be found in sufficient

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number to obtain an optimal sample. Merriam's kangaroo rat should be most abundant in 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. 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 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.

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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).

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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.

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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 each 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.

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4.3.8.1.1.1 TLD characteristics

A number of thermoluminescent (TL) materials are commercially available: lithium borate ($Li_2 B_4 O_7$), 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 TM. The Teflon TM-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

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.

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

TLD Phosphor	Form	Package	Exposure range	Minimum[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.

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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.

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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 TLD locations and frequency

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

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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 of plastic and lead	3

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

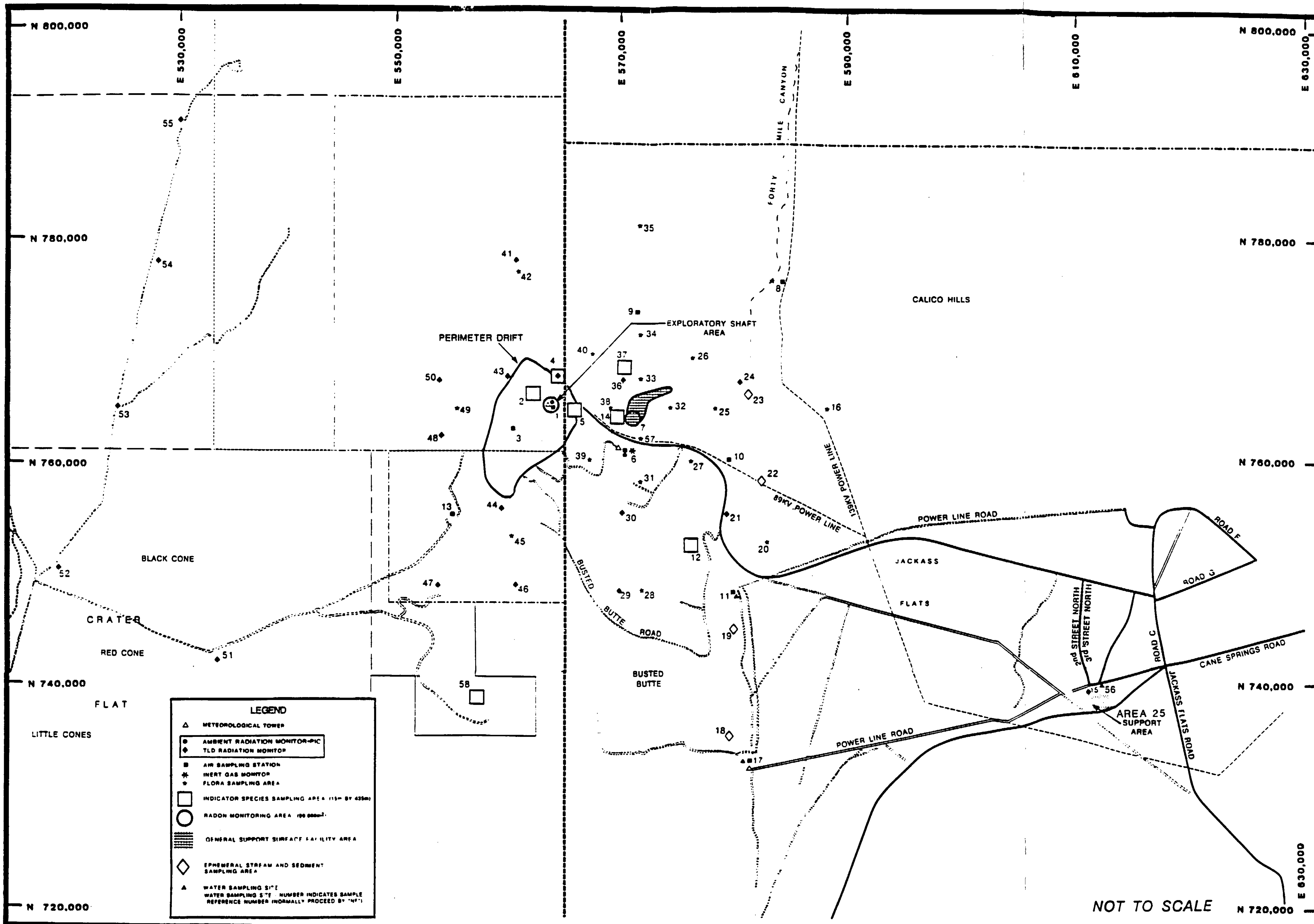

Figure 4-20. Near-field ambient sampling locations.

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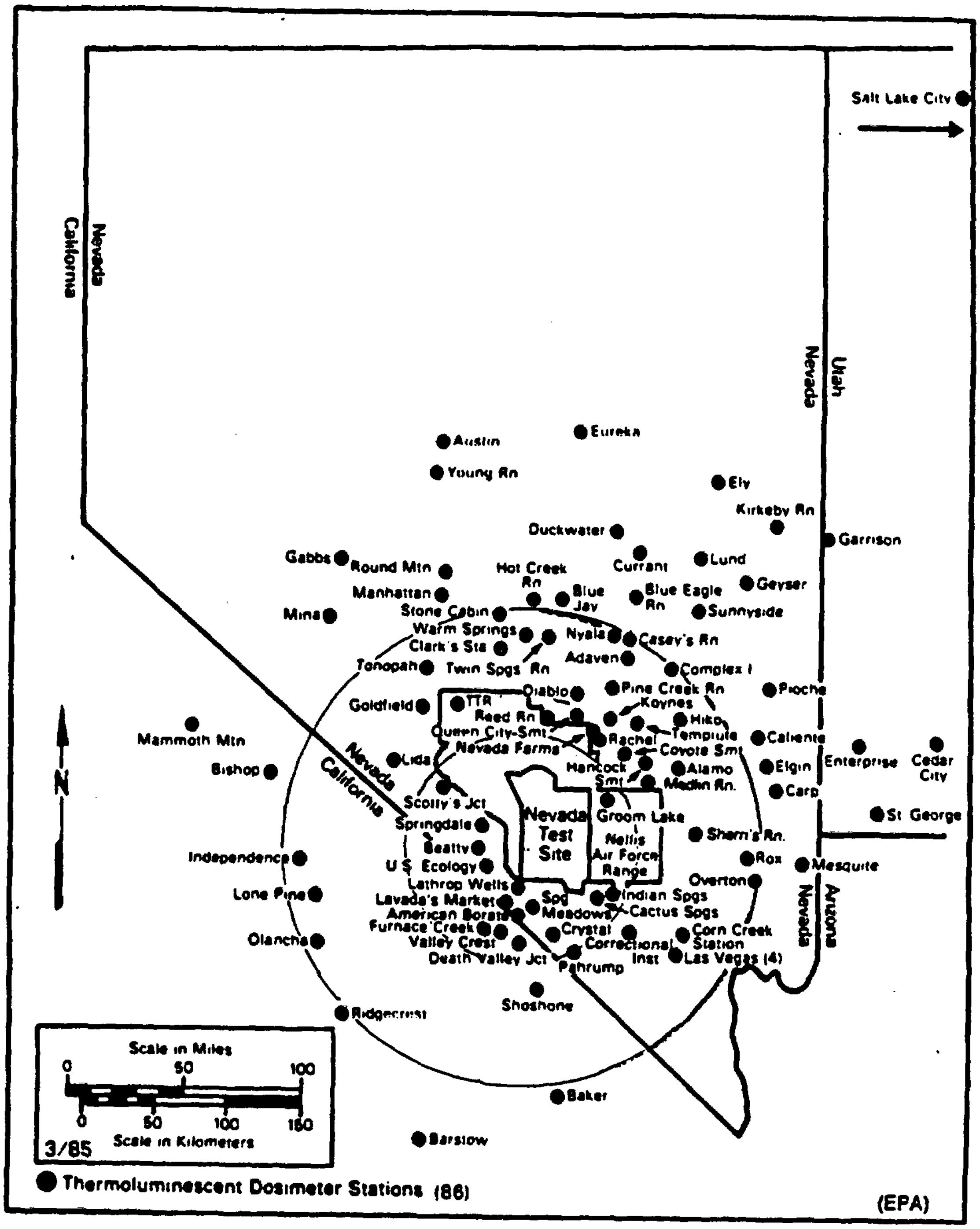

Figure 4-21. EPA TLD monitoring stations.

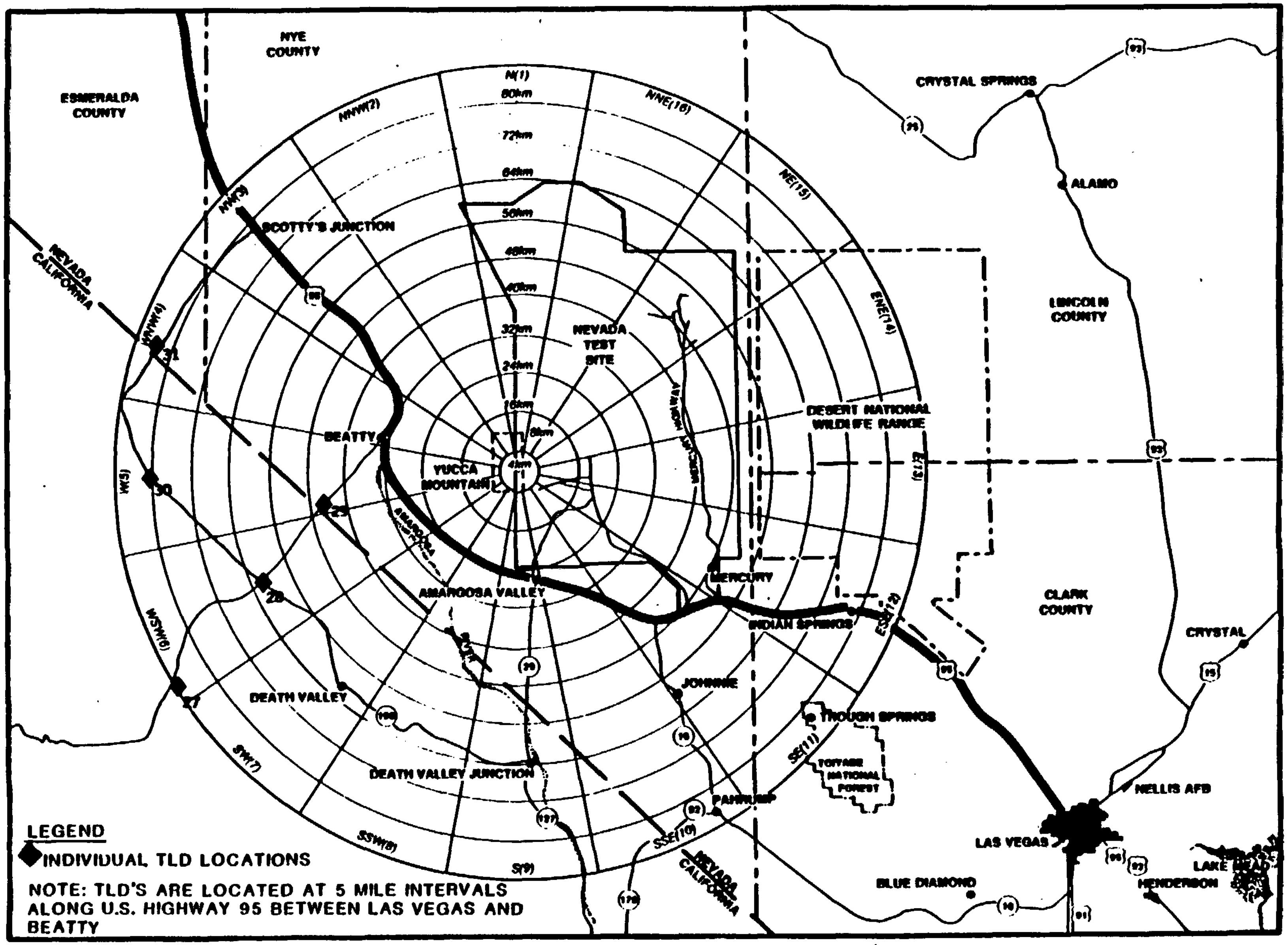

Figure 4-22. NNWSI Project supplemental TLD monitoring locations.

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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.

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.

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	(±)5%	Option	Line or battery	Continuous (200 hr on battery)	High
Stationary	G.M.	γ or β, γ	10 μR/hr to 100 mR/hr	100 keV to 2.4 MeV	(±)20%	Option	Line	Continuous	Moderate
Portable	Scintillator	γ	5 μR/hr to 50 mR/hr	--[a]	--	Option	Battery	100-300 hr	Moderate
Portable	Air Ionization	β, γ	10 μR/hr to 1000 mR/hr	40 keV to 1.3 MeV	(±)20%	--	Battery	100 hr	Moderate
Portable	G.M.	β, γ	5 μR/hr[b] to 2 R/hr	45 keV to 3 MeV	(±)20%	--	Battery	4 hr cont. 50 hr int.	Low

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

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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 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

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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 μR/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.

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4.3.8.1.4.1 Technical basis for in situ gamma spectroscopy

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.

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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 (xxxx) 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.

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4.3.8.1.4.2 Projected use of in situ gamma spectral data

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.

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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.

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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.

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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. 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.

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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 (Santa Barbara), the EPA Office of Radiation Programs (ORP), (Las Vegas, NV), REECo (the prime contractor at the Nevada Test Site), DOE/NV Nevada Test Site Operations Office (NTSO), 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.

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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-HPD, 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. The T&MSS Contractor will have primary responsibility for the other major tasks with significant support from the NRAD and EG&G.

4.4.1.3 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 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. The NRAD will provide its internal documentation under subtasks 1c, 1d, 1e, 1f, 1g, 1h, 1i, 1j, 2c, 2g, 3, and 4 with support from the the T&MSS Contractor.

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4.4.1.4 <u>Health Physics and Environmental Division (HPED)</u>

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 <u>EG&G/Energy Measurements</u>

EG&G/Energy Measurements, as the NNWSI Project's and the Nevada Test Site's 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 <u>Office of Radiation Programs (ORP)</u>

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.

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4.4.1.7 Reynolds Electrical and Engineering Company (REECo)

REECo is the prime contractor of the NTS. As such, REECo provides the general support services at the NTS. REECo will provide the support services to these 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 Nevada Test Site Operations Office (NTSO)

The NTSO is the DOE/NV organization responsible for NTS operations. The radiological monitoring program will comply with all applicable NTSO requirements and standards. The radiological monitoring program will, through the WMPO, request the NTSO 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.

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4.4.2 NTS 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 NTSO. The program will follow all applicable NTS 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:

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

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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.

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

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

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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

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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	150K	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			

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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.

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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 in support of other radiological issues, such as shielding design verification, impact analysis, review safety analysis, etc., support 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.

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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.

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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 exposure surface-water pathway is not required due to specific characteristics of the site. 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, 3.3.1.1.3.2, 3.3.1.2, 3.3.1.3, and 3.3.1.4.

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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, 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.

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 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 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. 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

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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?

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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.

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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.

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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.

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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.)

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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.

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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.

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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 safety analysis data on calculation results required are

1. Physical and chemical decay characteristics of radionuclides.

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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 (SAIC, to be issued). 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.

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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, to assess the change 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

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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

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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.

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.

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

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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.

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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.

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.

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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).

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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.

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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.

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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.

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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, 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.

Table 6-1. Characteristics of radioactive aerosols

Reference	Resuspension Normal	Resuspension Enhanced	Deposition	Particle size distribution	Location
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

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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.

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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."

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,

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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), 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.

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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.

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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

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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

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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.

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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.

*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).

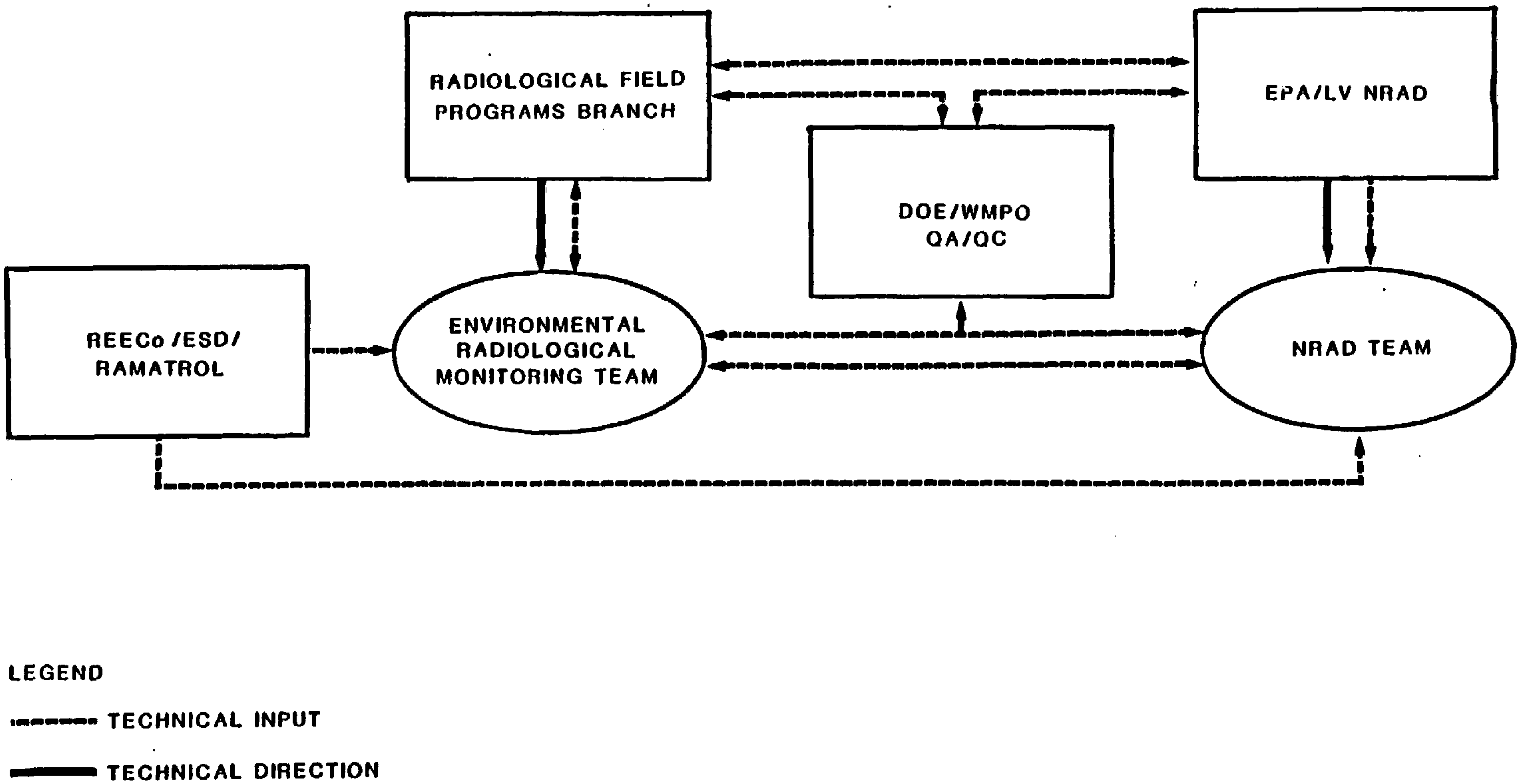

Figure 7-1. Field operations organization.

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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 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.

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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

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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.

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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

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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).

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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.

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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 GPA, 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.

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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.

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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.

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TOTAL ACTIVITY PLAN

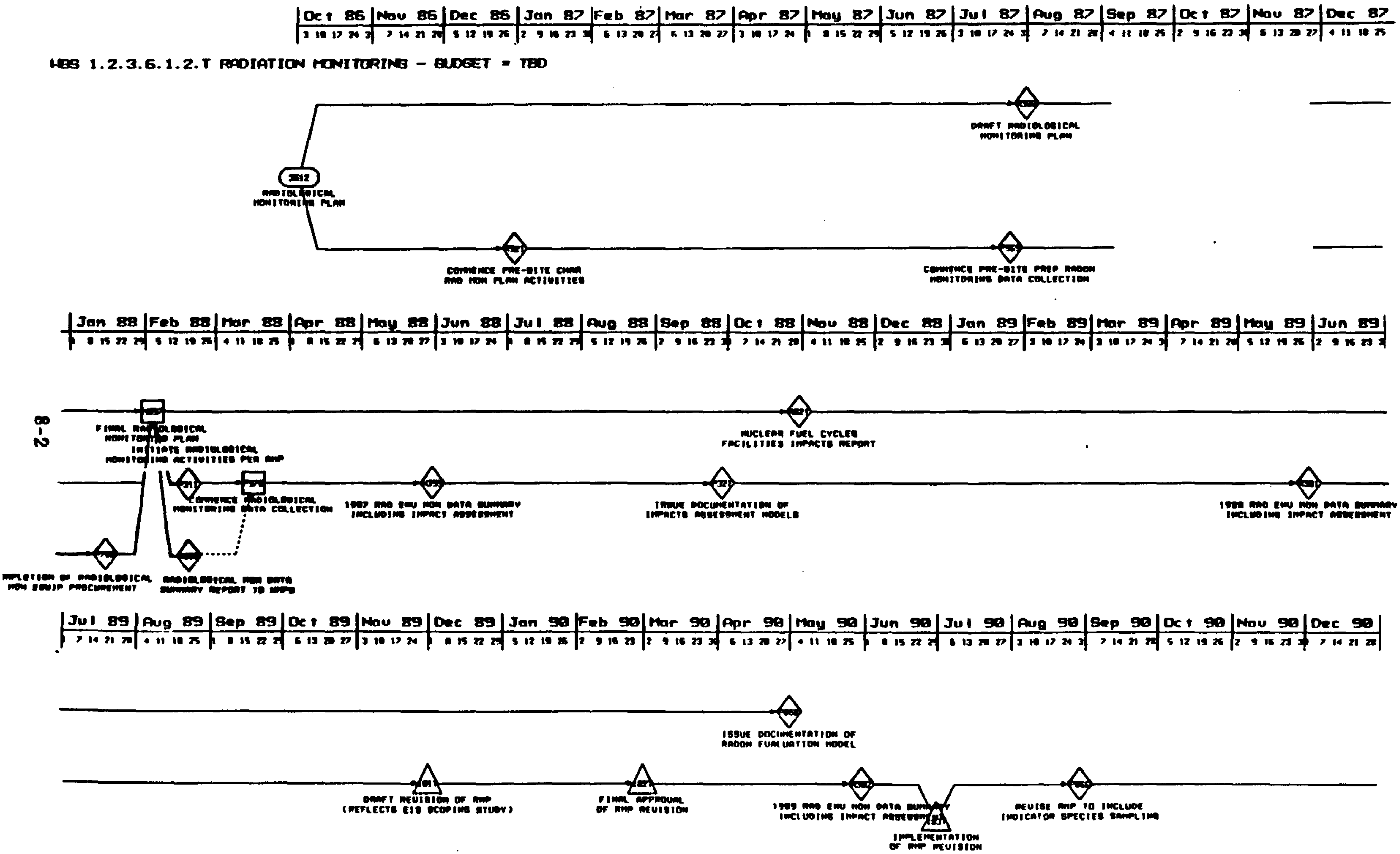

Figure 8-1. Total activity plan.

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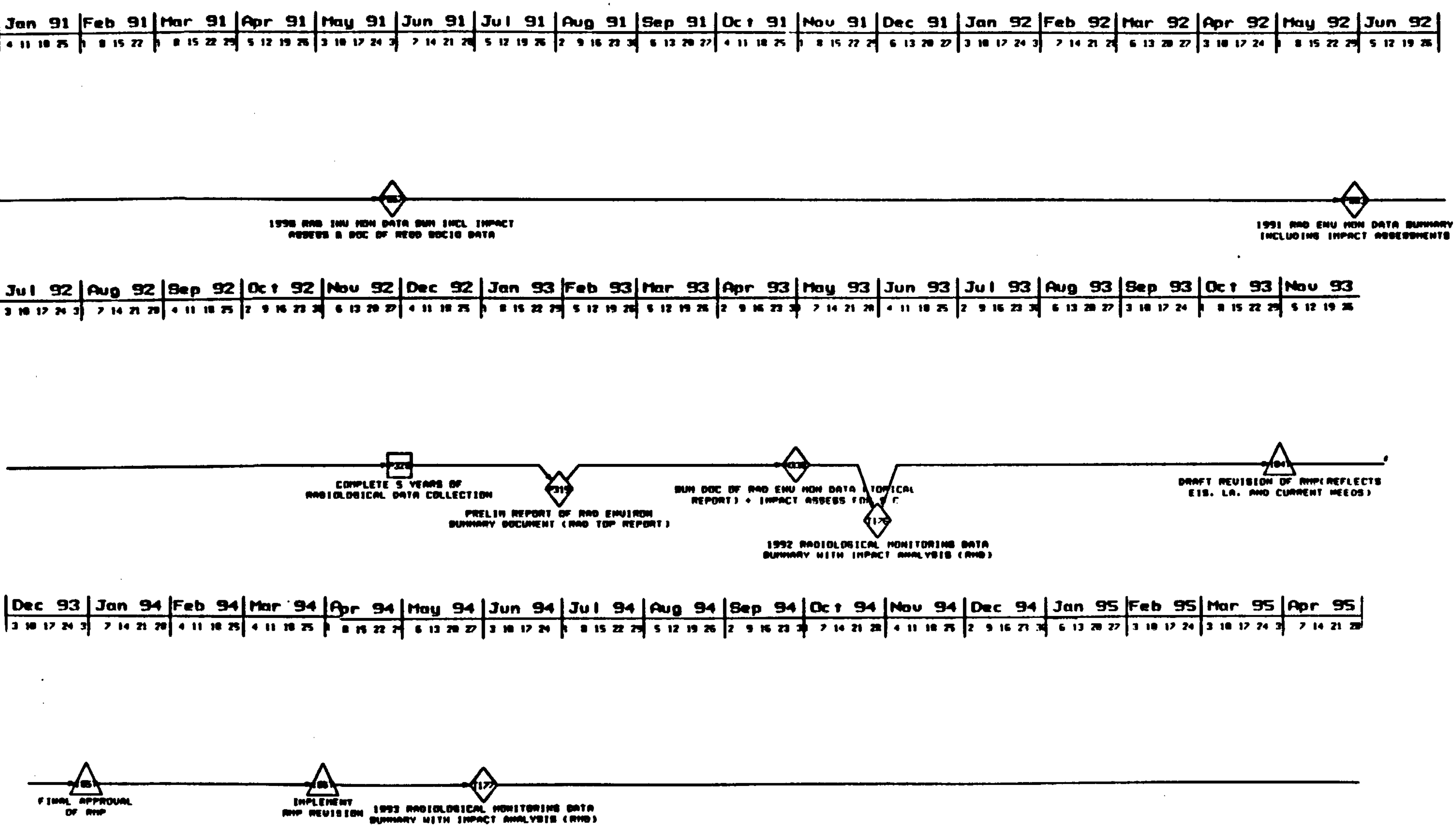

Figure 8-1. Total activity plan.

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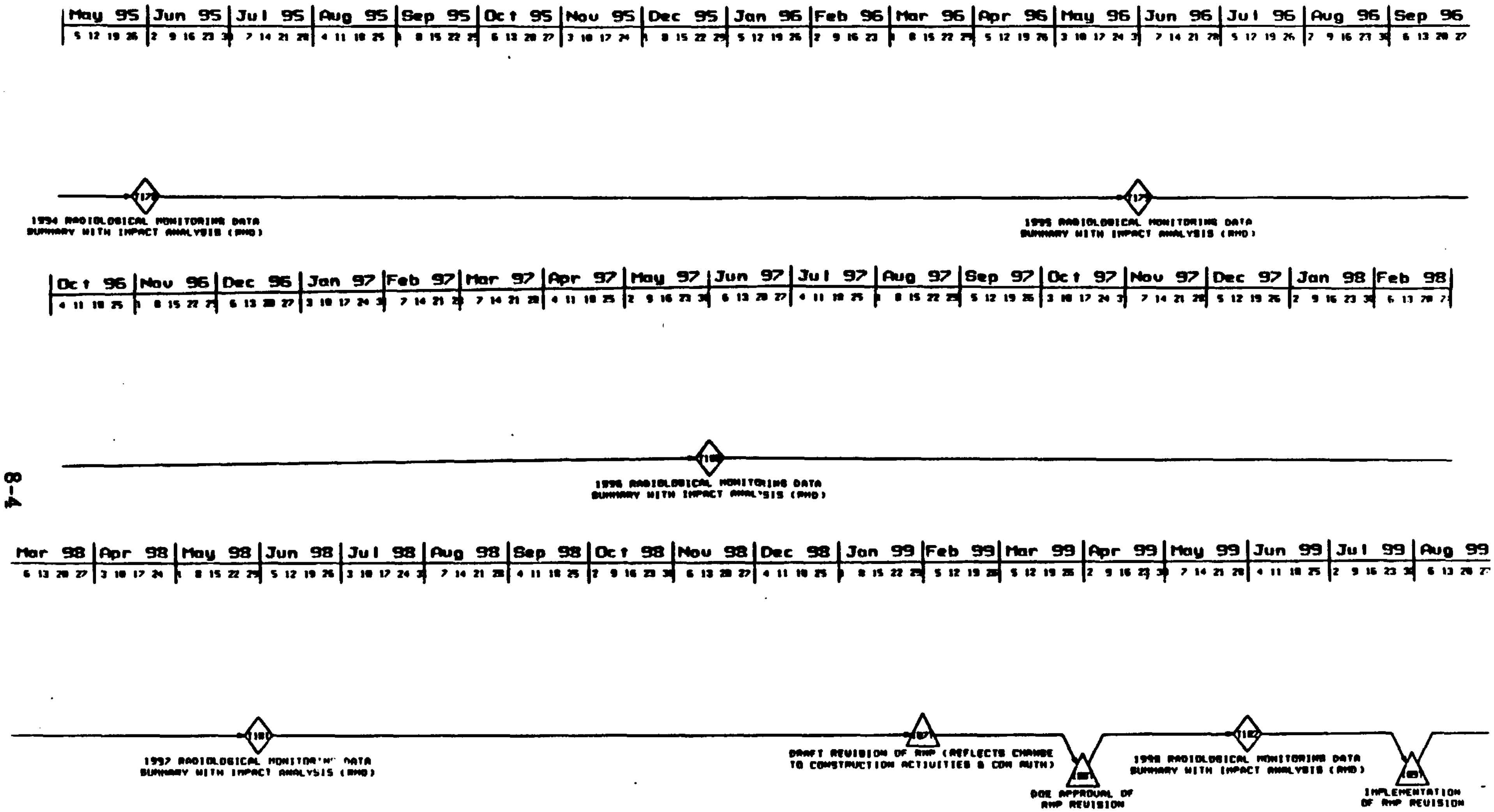

Figure 8-1. Total activity plan.

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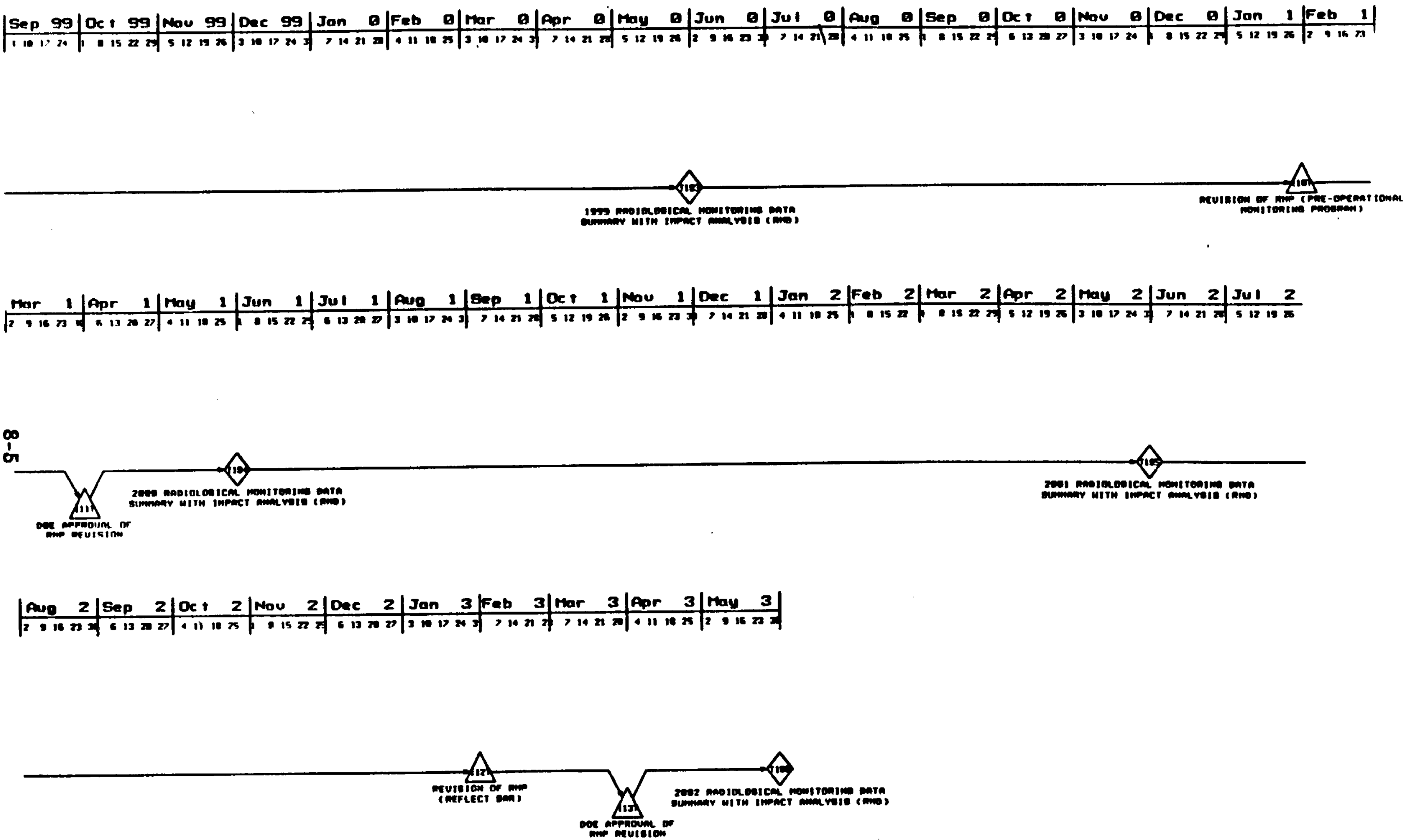

Figure 8-1. Total activity plan.

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Table 8-1. Implementation plan for RMP activities

Activity	Initiation	Completed[a]
Air sampling (60-meter tower/ particulate iodine only)	9/87	--
Air sampling/onsite	9/87 to 12/87	--
Air sampling/offsite	10/87 to 4/88	--
Water sampling (general)	10/87 to 4/88	--
Catch basin survey	1/88	6/88
Water sampling (catch basins)	6/88 to 9/88	--
Radon integrating samplers	9/87	--
Radon continuous monitoring	10/87	--
Initiate analysis capability development for Tc-99, C-14, and I-129	10/87	12/88
Soil/sediment sampling	10/87 to 4/88	--
In situ gamma spectral analysis	11/87 to 2/88	--
Milk sampling	Ongoing[b]	--
Near-field biota sampling	10/87 to 2/89	--
Survey of far-field biota in human food chain	12/87	12/89
Preliminary assessment of sampling needs in the biota (human food chain)	2/88	7/88
TLD monitoring implemented	10/87 to 2/88	--
High pressure ion chamber monitoring	10/87 to 2/88	--
ARM survey	--	1/88 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.

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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.

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.

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.

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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.

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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. 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.

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	30K		
PSCRMP	Data Analysis	5K	10K				
PSCRMP	Data Reporting	1K	5K				
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	20K		80K		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 one technical to provide support unavailable from EPA due to their manpower limitations (Note: one radiochemist will only be required during analytical program development [circa/year])

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Table 8-3. Program costs

Item	PSCRMP SAIC	PSCRMP NRAD	PSCRMP CAPITAL	1st Year (FY 1988) SAIC	1st Year (FY 1988) NRAD	1st Year (FY 1988) EG&G CAPITAL	Yearly SAIC	Yearly NRAD	Yearly EG&G CAPITAL
Program personnel	111K	85K	--	450K	205K	--	130K	118	--
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	203K[b]	100K	4	15
Associated Cost (Training, Travel, References, and Documents Publishing)	--	--	--	40K	--	--	80K	--	--
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.

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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.

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REFERENCES

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REFERENCES

AEC (U.S. Atomic Energy Commission), 1974. "Measuring, Evaluating, and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants," Revision 1, Regulatory Guide 1.21.

AEC (U.S. Atomic Energy Commission), 1972. "Onsite Meteorological Programs," Regulatory Guide 1.23.

AEC (U.S. Atomic Energy Commission), 1974. "Measurements of Radionuclides in the Environment, Sampling and Analysis of Plutonium in Soil," Regulatory Guide 4.5.

AEC (U.S. Atomic Energy Commission), 1974. "Measurements of Radionuclides in the Environment, Strontium-89 and Strontium-90 Analyses," Regulatory Guide 4.6.

AEC (U.S. Atomic Energy Commission), 1973. "Guide for Administrative Practices in Radiation Monitoring," Regulatory Guide 8.2.

AEC (U.S. Atomic Energy Commission), 1973. "Occupational Radiation Exposure Record Systems," Regulatory Guide 8.7.

AEC (U.S. Atomic Energy Commission), 1973. "Acceptable Concepts, Models, Equations, and Assumptions for a Bioassay Program," Regulatory Guide 8.9.

AEC (U.S. Atomic Energy Commission), 1974. "Applications of Bioassay for Uranium," Regulatory Guide 8.11.

AECDR (Atomic Energy Commission Directorate of Regulation), 1974. "Measurement of Radionuclides in the Environment--Sampling and Analysis of Plutonium in Soil," Regulatory Guide 4.5, U.S. Nuclear Regulatory Commission, Washington, D.C.

APHA (American Public Health Association), 1971. Standard Methods.

ANSI (American National Standards Institute), 1975. American National Standards - Performance, Testing, and Procedural Specifications for Thermoluminescent Dosimetry: Environmental Applications, ANSI N545-1975, American National Standards Institute, Inc., New York, New York.

ASTM (American Society for Testing Materials), 1986a. 1986 Annual Book of ASTM Standards, Section 12, Volume 12.02, Nuclear, Solar, and Geothermal Energy, American Society for Testing Materials, Philadelphia, Pennsylvania.

ASTM (American Society for Testing Materials), 1986b. 1986 Annual Book of ASTM Standards, Section 11, Volume 11.02, Water and Environmental Technology, American Society for Testing Materials, Philadelphia, Pennsylvania.

DRAFT

ASTM (American Society for Testing Materials), 1987a. ASTM Standards: Water and Environmental Technology, Volume 11.01/Water (1), American Society for Testing Materials, Philadelphia, Pennsylvania.

ASTM (American Society for Testing Materials), 1987b. ASTM Standards: Water and Environmental Technology, Volume 11.02/Water (11), American Society for Testing Materials, Philadelphia, Pennsylvania.

Andrews, Vernon E., 1977. "Noble Gas Sampling System," U.S. Energy and Development Administration, EMSL-LV-539-7.

Anspaugh, L. R., P. L. Phelps, P. H. Gudiksen, C. L. Lindeken, and G. W. Huckabay, 1974. "The In Situ Measurement of Radionuclides in the Environment with a Ge(Li) Spectrometer," in Proceedings of the Second International Symposium on the Natural Radiation Environment, J. A. S. Adams, W. M. Lowder, and T. Gesell (eds.), Atomic Energy Commission, Washington, D.C.

Atomic Energy Act of 1954 (AEA) (as amended), U.S. Code, Title 42, Sec. 2021 (h).

Letter from R. I. Brasier, SNL/LATA, to Jean Younker, SAIC, dated May 8, 1985. Population Distribution of Yucca Mountain Site (NNWSI Project, T&MSS contractor file number NNA.870323.0370.)

Batchelder, H. M., et al., 1977. "Effluent Information System (EIS) and Onsite Discharge Information System (ODIS) Users Manual," U.S. Department of Energy, Division of Operational and Environmental Safety, Washington, D.C.

Beck, H., and G. dePlanque, 1966. The Radiation Field in Air Due to Distributed Gamma-Ray Sources in the Ground, HASL-195, Health and Safety Laboratory, New York, New York.

Beck, H. L., J. DeCampo, and C. Gogolak, 1972. In Situ Ge(Li) and NaI(Tl) Gamma-Ray Spectrometry, HASL-256, Health and Safety Laboratory, New York, New York.

Begovich, C. L., 1986. "ANDROS: A Code For Assessment of Nuclide Doses and Risks With Option Selection," Oak Ridge National Laboratory, ORNL-5889.

Bland, J. S., et al. 1978. "Radiological Environmental Monitoring By NRC Licensees For Routine Operations of Nuclear Facilities," Environmental Standards Branch, U.S. Nuclear Regulatory Commission.

Boyns, P. K., 1975. Aerial Radiological Survey of the Savannah River Plant (Aiken, South Carolina), Date of Survey: June 2-25, 1974, EG&G-1183-1665, EG&G Inc., Las Vegas, Nevada.

Bureau of Radiological Health, 1970. "Radiological Health Handbook," Public Health Service Publication No. 2016, U.S. Department of Health, Education, and Welfare, Washington, D.C.

DRAFT

Burke, G. de Planque, T. F. Gessel, and K. Becker, 1976. "Second International Intercomparison of Environmental Dosimeters Under Field and Laboratory Conditions," paper presented at the Health Physics Tenth Midyear Topical Symposium, Saratoga Springs, New York.

Burnham, K. P., D. R. Anderson, and J. L. Laake, 1980. Estimation of density from line transect sampling of biological populations, Wildlife Monogram 72.

Burson, Z. G., (in preparation). An Aerial Radiological Survey of ERDA's Oak Ridge Facilities and Vicinity, Survey Period: 1973-1974, EG&G report.

Chang, Wallace Y., 1986. "Evaluation of Regulatory Guides Potentially Useful To Geologic Respository Development," Ebasco Services Inc., BMI/ONWI-588.

Clark County Department of Comprehensive Planning, 1983. Population Data, Las Vegas, Nevada.

Collins, E. and T. P. O'Farrell, 1985. 1984 Biotic studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada, EG&G Report No. EGG 10282-2057.

Committee on the Biological Effects of Ionizing Radiations, National Research Council, 1980. "The Effects on Population of Exposure to Low Levels of Ionizing Radiation: 1980," National Academy Press, Washington, D.C.

Corley, J. P. and C. D. Corbit, 1982. "A Guide For Effluent Radiological Measurements At DOE Installations," DOE/EP-0096 (PNL-4139D).

Corley, J. P., D. H. Denham, R. E. Jaquish, D. E. Michels, A. R. Olsen, and D. A. Waite, 1981. A Guide For: Environmental Radiological Surveillance at U.S. Department of Energy Installations, DOE/EP-0023, U.S. Department of Energy, Washington, D.C.

Corley, J. P. and D. H. Denham, 1977. "A Guide for Environmental Radiological Surveillance at ERDA Installations," U.S. Energy and Research Development Administration, ERDA 77-24 (March 1977c).

Corley, J. P., et al., 1987. "Requirements for Radiological Effluent Monitoring and Environmental Surveillance for U.S. Department of Energy Operations."

Croff, A. G., 1980. "ORIGEN.2 Isotope Generation and Depletion Code - Matrix Exponential Method," Radiation Shielding Information Center, CCC-371.

Currie, L. A., 1984. "Lower Limit of Detection: Definition and Elaboration of Proposed Position for Radiological Effluent and Environmental Measurements," National Bureau of Standards, NUREG/CR-400.

Deal, L. J., and J. F. Doyle III, 1975. An Overview of the Aerial Radiological Measuring System (ARMS) Program, EG&G-1183-1637, EG&G, Inc., Las Vegas, Nevada.

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17-Dec-87

DRAFT

Denham, D. H., D. A. Waite, and J. P. Corley, 1974. Summary of Selected AEC Contractor Environmental Surveillance Techniques and Capabilities, BNWL-B-384, Battelle, Pacific Northwest Laboratories, Richland, Washington.

DOE (U.S. Department of Energy), 1985. "Mission Plan for the Civilian Radioactive Waste Management Program, Overview and Current Program Plans," DOE/RW-005, three volumes, Washington, D.C.

DOE (U.S. Department of Energy), 1986a. "Environmental Assessment Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0073, three volumes, Washington, D.C.

DOE (U.S. Department of Energy), 1986b. "Office of Geologic Repositories Issues Hierarchy For A Mined Geologic Disposal System," DOE/RW-0101, Washington, D.C.

DOE (U.S. Department of Energy), 1986c. "Environmental, Safety, and Health Program For Department of Energy Operations," DOE Order 5480.1B, U.S. Department of Energy, Environmental, Safety, and Health Division, Washington, D.C.

DOE (U.S. Department of Energy), 1981. "Environmental Protection, Safety, and Health Protection Program For DOE Operations," DOE Order 5480.1A, U.S. Department of Energy, Environmental Protection, Safety and Emergency Preparedness Division, Washington, D.C.

DOE (U.S. Department of Energy), 1982. "Hazardous and Radioactive Mixed Waste Management," DOE Order 5480.2, U.S. Department of Energy, Office of Operational Safety, Washington, D.C.

DOE (U.S. Department of Energy), 1987a. "Environmental Protection, Safety, and Health Protection Standards," DOE Order 5480.4, U.S. Department of Energy, Environmental Guidance Division, Washington, D.C.

DOE (U.S. Department of Energy), 1987b. "Environmental Protection" (Draft), DOE Order 5480.12, U.S. Department of Energy, Environmental Guidance Divison, Washington, D.C.

DOE (U.S. Department of Energy), 1987c. "Radiation Protection of the Public and the Environment" (Draft), DOE Order 5480.XX, U.S. Department of Energy, Environmental Guidance Division, Washington, D.C.

DOE (U.S. Department of Energy), 1987d. "Environmental Protection, Safety, and Health Protection Information Reporting Requirements" (Draft), DOE Order 5484.1, U.S. Department of Energy, Environmental Guidance Division, Washington, D.C.

DOE (U.S. Department of Energy), 1987e. "OCRWM Mission Plan Amendment," DOE/RW-0128, Washington, D.C.

Douglas, 1967. ______________________________.

DRAFT

Doyle, J. F., 1974. "The Aerial Radiological Measuring System (ARMS) Program," in Proceedings of Second International Symposium on the Natural Radiation Environment, J. A. S. Adams, W. M. Lowder, and T. Gesell (eds.), U.S. Atomic Energy Commission, Washington, D.C.

Dunning, Donald E., (no date). "Estimates of Internal Dose Equivalent From Inhalation and Ingestion of Selected Radionuclides," WIPP-DOE-176 (Revised), Westinghouse Electric Corporation.

Dunning, D. E., Jr., et al., 1980. "RADRISK Estimates of Radiation Doses and Health Effects from Inhalation or Ingestion of Radionuclides," Radiation Shielding Information Center, CCC-422.

Eckerman, K. F. and D. G. Lash, 1977. "In-House User's Guide for GASPAR," U.S. Nuclear Regulatory Commission, Radiological Assessment Branch.

Elder, J. C., et al., 1986. "A Guide to Radiological Accident Consideration for Siting and Design of DOE Nonreactor Nuclear Facilities," LA-10294-MS, Los Alamos National Laboratory, Los Alamos, New Mexico.

Engel, R. L., et al., 1966. "ISOSHIELD Kernel Integration Code -- General Purpose Isotope Shielding Analyses," Radiation Shielding Information Center, CCC-79.

Environmental Instrumentation Group, 1972. Instrumentation for Environmental Monitoring, LBL-1, Volumes 1-4, University of California, Lawrence Berkeley Laboratory, Berkeley, California (Vol. 1--Air, Vol. 2--Water, Vol. 3--Radiation, Vol. 4--Biomedical).

EPA-ORP (U.S. Environmental Protection Agency, Office of Radiation Programs) 1972. Environmental Radioactivity Surveillance Guide, ORP/SID 72-2, U.S. Environmental Protection Agency, Washington, D.C.

EPA (Environmental Protection Agency), 1977. Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities, EPA/530/SW-611.

Evans, Robley D., 1972. The Atomic Nucleus, McGraw-Hill Book Co.

Fitzgerald, J. J., 1967. Mathematical Theory of Radiation Dosemetry, Gordon and Breach.

Fitzsimmons, Peter K., 1987. Letter to Donald L. Vieth dated January 13, 1987, titled "Science Applications International Corporation Licensing Exemption For Use of Byproduct Material" (HPD/ROB:JRB-191).

Fleischhauer, H. L., 1984. Procedures for Sampling Radium-Contaminated Soils, GJ/TMC-13, Bendix Field Engineering Corporation for U.S. Department of Energy, Grand Junction, Colorado.

Fowler, E. B., W. Henderson, and F. Milligan (compilers), 1971. Proceedings of Environmental Plutonium Symposium-- August 4-5, 1971, LA-4756, University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

DRAFT

Friesen, B., 1982. Radiological Support Project Final Report, NVO-213, U.S. Department of Energy, Las Vegas, Nevada.

Gilbert, R. O., 1987. Statistical Methods for Environmental Pollution Monitoring, Van Nostrand Reinhold Publishers.

Giles, K. R. and J. Cooper, 1985. Characteristics and Migration Patterns of Mule Deer on the Nevada Test Site, EPA-600/4-85/030, Environmental Protection Agency, Environmental Monitoring Systems Lab, Las Vegas, Nevada.

Gnugnuli, Giorgio, and Dan E. Martin, 1980. "MILDOS Calculation of Radiation Doses from Uranium Recovery Operations," Radiation Shielding Information Center, CCC-398.

Gonzalez, Daniel A., 1986. "Radiological Effluent and Onsite Area Monitoring Report for the Nevada Test Site (January 1985 through December 1985)," DOE/NV/10327-28, Reynolds Electrical and Engineering Company.

Grossman, R. F., and R. W. Holloway, 1985. "Concentrations of Krypton-85 Near the Nevada Test Site," in Environmental Science and Technology, Vol. 19:1128 et seq., American Chemical Society.

Hall, R. J., et al., 1977. "An Assessment of the Risk of Transporting Plutonium Dioxide and Liquid Plutonium Nitrate By Train," BNWL-1996 Battelle Pacific Northwest Laboratories.

Harley, J. H., 1986. HASL Procedures Manual (revised annually), HASL-300, Environmental Measurements Laboratory, U.S. Department of Energy, New York, New York.

Harris, C. E., 1987. An assessment of techniques for monitoring San Joaquin kit fox population abundance on Naval Petroleum Reserve #1, Kern County, California, EGG 10282-2159, EG&G, Inc.

Healy, J. W., 1984. A Proposed Interim Standard for Plutonium in Soils, LA-5483-MS, University of California, Los Alamos Scientific Laboratory, Los Alamos, New Mexico.

Hendee, W. R., 1967. "Radiation Response of LiF at Low Doses," Health Phys. 13:1235-1236.

Hidy, George M., 1984. Aerosols and Industrial and Environmental Science, Academic Press.

Houston, J. R., et al., 1976. "DACRIN Airborne Radionuclide Organ Dose Calculation," Radiation Shielding Information Center, CCC-273.

Hoy, J. E., 1971. "Environmental Radiation Monitoring with Thermoluminescent Dosimeters," Health Phys. 21:860-862.

IAEA (International Atomic Energy Agency), xxxx. "Objectives and Design of Environmental Monitoring Programs for Radioactive Contaminants," IAEA Safety Series No. 41.

DRAFT

ICRP (International Commission on Radiation Protection), 1959. "Report of Committee II on Permissible Dose for Internal Radiation," ICRP Publication 2, Pergamon Press.

ICRP (International Commission on Radiation Protection), 1977. "Radiation Protection," Annals of the ICRP, ICRP Publication 26, Pergamon Press.

ICRP (International Commission on Radiation Protection), 1979. "Limits for Intakes of Radionuclides by Workers," Annals of the ICRP, ICRP Publication 30, Pergamon Press.

ICRP (International Commission on Radiation Protection), 1983. "Radionuclide Transformation Energy and Intensity of Emission," Annals of the ICRP, ICRP Publication 38, Pergamon Press.

Jackson, T. L. et al., 1984. "Preliminary Safety Assessment Study for the Conceptual Design of a Repository in Tuff at Yucca Mountain," SAND83-1504, Sandia National Laboratories, Albuquerque, N. Mexico.

Jaeger, R. G., et al., 1975. "Engineering Compendium on Radiation Shielding," Springer - Verlag.

Kahn, 1972. ____________________.

Kathren, R. L., et al., 1980. "A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable (ALARA)," DOE/EV/1830-T5.

Kocher, D. C., 1981. "Radioactive Decay Data Tables," DOE/TIC-11026.

Laake, J. L., K. P. Burnham, and D. R. Anderson, 1979. User's manual for program TRANSECT, Utah State University Press, Logan, Utah.

Lioy, Paul J., et al., 1983. Air Sampling Instrumentation for Evaluation of Atmospheric Contaminants, 6th Edition, American Conference of Government Industrial Hygienists.

Ludwig, F. L., 1976. "Siting Air Monitoring Stations," Environmental Science and Technology 12(7).

McBrien, S., and L. Jones, 1984. Nevada Nuclear Waste Storage Investigations: Socioeconomic Impacts of Constructing a High-Level Waste Repository at Yucca Mountain, SAND84-7201, Sandia National Laboratories, Albuquerque, New Mexico.

Meyer, H. R., and J. Purvis, 1985. "Development of an Interference - Corrected Soil Radium Measurement System," Transactions of the American Nuclear Society, 50:184-187, American Nuclear Society, LaGrange Park, Illinois.

Mohrand, R. A., and L. A. Franks, 1982. Compilation of ^{137}Cs Concentrations at Selected Sites in the Continental United States, EGG-1183-2437-Rev, EG&G, Inc., Goleta, California.

DRAFT

Moore, R. E., et al., 1979. "CAAC Code System for Implementation of Atmospheric Dispersion Assessment Required by the Clean Air Act," Radiation Shielding Information Center, CCC-426.

Myrick, T. E., B. A. Berven, and F. F. Haywood, 1983. "Determination of Selected Radionuclide in Surface Soil in the United States," Health Phys. 45:631-642.

National Academy of Sciences, 1980. "The Effects on Population of Exposure to Low Levels of Ionizing Radiation, 1980."

National Institute of Health, 1985. "Report of The National Institute of Health Ad Hoc Working Group To Develop Radioepidemiological Tables," NIH Publication No. 85-2748, U.S. Department of Health and Human Series.

NCRP (National Council on Radiation Protection and Measurements), 1976. "Environmental Radiation Measurements," NCRP No. 50.

NCRP (National Council on Radiation Protection and Measurements), 1984. "A Handbook of Radioactivity Measurements Procedures," NCRP No. 58.

NNWSI (Nevada Nuclear Waste Storage Investigations) Project, 1986. "Environmental Monitoring and Mitigation Plan For Site Characterization," Working Draft.

NNWSI (Nevada Nuclear Waste Storage Investigations) Project/Waste Management Project Office, "Quality Assurance Program Plan," NVO-196-18.

NNWSI (Nevada Nuclear Waste Storage Investigations) Project, "NNWSI Project Work Breakdown Structure Dictionary" (Controlled Document).

NRC (U.S. Nuclear Regulatory Commission), 1977. "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR 50 Appendix," Regulatory Guide 1.109.

NRC (U.S. Nuclear Regulatory Commission), 1976. "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors," Regulatory Guide 1.110.

NRC (U.S. Nuclear Regulatory Commission), 1977. "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Revision 1, Regulatory Guide 1.111.

NRC (U.S. Nuclear Regulatory Commission), 1976. "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors," Revision O-R, Regulatory Guide 1.112.

NRC (U.S. Nuclear Regulatory Commission), 1983. "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," Regulatory Guide 1.145.

DRAFT

NRC (U.S. Nuclear Regulatory Commission), 1975. "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," Revision 1, Regulatory Guide 4.1.

NRC (U.S. Nuclear Regulatory Commission), 1976. "Preparation of Environmental Reports for Nuclear Power Stations," Regulatory Guide 4.2, Revision 2.

NRC (U.S. Nuclear Regulatory Commission), 1977. "Performance, Testing, and Procedural Specifications for Thermoluminescence Dosimetry, Environmental Applications," Revision 1, Regulatory Guide 4.13.

NRC (U.S. Nuclear Regulatory Commission), 1979. "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment," Revision 1, Regulatory Guide 4.15.

NRC (U.S. Nuclear Regulatory Commission), 1978. "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be As Low As is Reasonably Achievable," Revision 3, Regulatory Guide 8.8.

NRC (U.S. Nuclear Regulatory Commission), 1975. "Operating Philosophy for Maintaining Radiation Exposures As Low As is Reasonably Achievable," Revision 1-R, Regulatory Guide 8.10.

NRC (U.S. Nuclear Regulatory Commission), 1979. "Applications of Bioassay for I-125 and I-131," Revision 1, Regulatory Guide 8.20.

NRC (U.S. Nuclear Regulatory Commission), 1978. "Bioassay at Uranium Mills," Regulatory Guide 8.22.

NRC (U.S. Nuclear Regulatory Commission), 1980. "Calibration and Error Limits of Air Sampling Instruments for Total Volume of Air Sampled," Regulatory Guide 8.25.

NRC (U.S. Nuclear Regulatory Commission), 1980. "Applications of Bioassay for Fission and Activation Products," Regulatory Guide 8.26.

NRC (U.S. Nuclear Regulatory Commission), 1981. "Radiation Protection Training for Personnel at Light-Water-Cooled Nuclear Power Plants," Regulatory Guide 8.27.

NUREG-0475, "Radiological Environmental Monitoring by NRC Licensees for Routine Operation of Nuclear Facilities."

NWPA (Nuclear Waste Policy Act), 1983. "Nuclear Waste Policy Act of 1982," Public Law 97-425, 42 USC 10101-10226, Washington, D.C.

O'Farrell, T. P., and E. Collins, 1983. 1982 Biotic survey of Yucca Mountain, Nevada Test Site, Nye County, Nevada, EGG 10282-2004, EG&G, Inc.

O'Farrell, T. P., and E. Collins, 1984. 1983 Biotic studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada, EGG 10282-2031, EG&G, Inc.

DRAFT

ORP (Office of Radiation Programs), 1980. Health Physics Society Committee Report PSR-1 (J. E. Watson, Chairman), U.S. Environmental Protection Agency EPA 520/1-80-012.

REECo (Reynolds Electrical and Engineering Company) /Environmental Sciences Division. "REECo Standard Procedures," REECo (Controlled Document).

REECo (Reynolds Electrical and Engineering Company)/Environmental Sciences Division. "REECo Safety Manual," REECo (Controlled Document).

Radiation Shield Information Center, 1975. "KENO-IV/CRC An Improved Multi-group Monte Carlo Criticality Code System for Cross Section Processing," Oak Ridge National Laboratory CCC-436.

Rhoades, W. A., and R. L. Childs, 1982. "DOT IV Version 4.3 One- and Two-Dimensional Transport Code System," Radiation Shielding Information Center, CCC-429.

Rockwell, Theodore III, 1956. "Reactor Shielding Design Manual," McGraw-Hill Book Co., Inc.

Rogers, V. C., et al., 1984. "Radon Attenuation Handbook For Uranium Mill Trailings Cover Design," Roger and Associates Engineering Corp., NUREG/CR-3533.

Ryan, L., 1984. Letter from L. Ryan (State of Nevada, Office of Community Services) to D. Shalmy (Clark County Department of Comprehensive Planning), April 5, 1984; transmitting preliminary population forecasts of Nevada counties.

Sagendorf, J. G., and J. T. Gull, 1977. "XOQDOQ--Program for Meteorological Evaluation of Routing Effluent Releases at Nuclear Power Stations," NUREG-0234.

SAIC (Science Applications International Corporation), 1987a. "Preliminary Site Characterization Radiological Monitoring Plan," DOE/NV/10270-14 (SAIC-86/8007).

SAIC (Science Applications International Corporation), 1987b. "Population Densities Along Nevada Transportation Routes," DOE/NV/10270-12 (SAIC-86/8005).

SAIC (Science Applications International Corporation) (to be issued). "Environmental Pathway Analysis Scoping Study for the Yucca Mountain Site," DOE/NV-10576-8 (SAIC-87/8010).

SAIC (Science Applications International Corporation), "Environmental Radiological Monitoring Technical Procedure Manual," (Controlled Document.)

SAIC (Science Applications International Corporation), 1986. "Scientific Investigation Plan (SIP) For Environmental Radiological Monitoring Activity," NNWSI Project T&MSS SIP #1.2.3.6.1.2.T, Rev. 0.

DRAFT

Sarri, S. and R. Hoffer, 1984. "NNWSI Preliminary Radiological Monitoring Plan for the Environment," SAND83-7131.

Scalf, M. R., et al., 1981. Manual of Ground-Water Sampling Procedures, NWWA/EPA Series, National Water Well Association.

Sill, C. W., and R. L. Williams, 1971. "Rapid Identification and Determination of Alpha Emitters in Environmental Samples," in Rapid Methods for Measuring Radioactivity in the Environment, p. 201, International Atomic Energy Agency, Vienna, Austria.

Smith, D. D., 1977. "I-129 In Animal Thyroids from Nevada and Other Western States," Environmental Monitoring and Support Laboratory, EPA-600/3-77-067.

Smith, Donald D., and J. S. Coogan, 1984. "Population Distribution Around the Nevada Test Site - 1984," Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency EPA-600/4-84-067.

Soldat, J. K., 1971. Modeling of Environmental Pathways and Radiation Doses from Nuclear Facilities, BNWL-SA-3939, Battelle, Pacific Northwest Laboratories, Richland, Washington.

State of California, "Mine Safety Orders," Administrative Code, Title 8, Chapter 4, Subchapter 12, State of California.

State of Nevada, Department of Transportation, ca. 1984. Nevada Map Atlas, fifth edition, Carson City, Nevada.

State of Nevada, OCS (Office of Community Services), 1984. Nevada Statistical Abstract 1983-1984, Carson City, Nevada.

Stubbendieck, J., S. L. Hatch, and K. J. Hirsch, 1986. North American Range Plants, 3rd edition, University of Nebraska Press, Lincoln, Nebraska, and London, England.

Taylor, John M., and Sharon L. Daniel, 1977. "RADTRAN ANalyzer of Radiological Portion of the Environmental Impact from the Commercial Transportation of Radioactive Material," Radiation Shielding Information Center, CCC-367.

Till, John E., and H. Robert Meyers, 1983. "Radiological Assessment A Textbook on Environmental Dose Analysis," NUREG/CR-3332 (ORNL-5968).

Trevathan, M. S., and K. R. Price, 1985. "Ambient Krypton-85 Air Sampling at Hanford," in Proceedings of the Fifth DOE Environmental Protection Information Meeting, U.S. Department of Energy, Washington, D.C.

USDA (U.S. Department of Agriculture) Forest Service, 1937. Range Plant Handbook, U.S. Government Printing Office, Washington, D.C.

USGS (U.S. Geological Survey), 1977. National Handbook of Recommended Methods for Water-Data Acquisition, Office of Water Data Coordination, U.S. Geological Survey.

DRAFT

Waite, D. A., 1973a. Analysis of an Analytical Technique for Distributing Air Sampling Locations Around Nuclear Facilities, BNWL-SA-4676, Pacific Northwest Laboratory, Richland, Washington.

Waite, D. A., 1973b. An Analytical Technique for Distributing Air Sampling Locations Around Nuclear Facilities, BNWL-SA-4534, Pacific Northwest Laboratory, Richland, Washington.

Waite, D.A., et al., 1986. "Preclosure Radiological Calculations to Support Salt Site Evaluations," Office of Nuclear Waste Isolation, Battelle Memorial Institute, BMI/ONWI-541, Revision 1.

Whicker, F. Ward, and T. B. Kirchner, 1987. "Pathway: A Dynamic Food-Chain Model to Predict Radionuclide Ingestion After Fallout Deposition," Health Physics, Vol. 52 #6 (June 1987), Pg. 717.

Woolfolk, S. W., 1985. "ACT-ARA: A Code System for Calculating Changes in Radiological Source Terms with Time," Radiation Shielding Information Center, CCC-372.

DRAFT

CODE OF FEDERAL REGULATIONS

10 CFR Part 20, 1983. Title 10, "Energy," Part 20, "Standards for Protection Against Radiation," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 50, 1986. Title 10, "Domestic Licensing of Production and Utilization Facilities," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 60, 1983. Title 10, "Energy," Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 960, 1984. Title 10, "Energy," Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 961, 1985. Title 10, "Energy," Part 961, "Standard Contract for Disposal of Spent Nuclear Fuel and/or High Level Radioactive Waste," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 30, 1980. Title 30, "Mineral Resources," Part 57, "Health and Safety Standards - Metal and Non-Metallic Underground Mines," U.S. Government Printing Office, Washington, D.C.

40 CFR Part 61, 1985. Title 40, "Protection of Environment," Part 61, "National Emission Standards for Hazardous Air Pollutants," U.S. Government Printing Office, Washington D.C.

40 CFR Part 190, 1985. Title 40, "Protection of Environment", Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations," U.S. Government Printing Office, Washington D.C.

40 CFR Part 191, 1985. Title 40, "Protection of Environment," Part 191, "Environmental Standards for the Management and Disposal of Spent or Nuclear Fuel, High-Level and Transuranic Radioactive Wastes: Final Rule," Federal Register Vol. 50, No. 182, September 19, 1985.

40 CFR Part 192, 1985. Title 40, "Protection of Environment," Part 192, "Standards for Remedial Action in Inactive Uranium Mill Processing Sites," U.S. Government Printing Office, Washington, D.C.

49 CFR Part 177, 1983. Title 49, "Transportation," Part 177, "Carriage by Public Highway," U.S. Government Printing Office, Washington, D.C.

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APPENDIX A

PROJECT DESCRIPTION

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PROJECT DESCRIPTION

PREFACE

This appendix is based on the Yucca Mountain Environmental Assessment (EA) (DOE, 1986). Revised and more detailed information on the facility design is available in the Site Characterization Plan Conceptual Design Report (MacDougall, to be issued). Revised and more detailed information on the site characterization phase will be available in the Site Characterization Plan and associated study plans (to be issued).

A.1 SITE CHARACTERIZATION ACTIVITIES

The activities discussed in the RMP are part of the NNWSI Project activities. This section contains a description of the site characterization activities currently planned for the Yucca Mountain site. The activities consist primarily of field studies, the construction of the exploratory shaft facility (ESF), and the tests conducted in the ESF.

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A.1.1 FIELD STUDIES

Since 1978, the DOE has been conducting tests and surveys in the vicinity of the Yucca Mountain site to obtain preliminary information on the geologic, hydrologic, and geophysical characteristics of the site and the surrounding area. These tests and surveys include exploratory drilling and testing, the geomechanical and geochemical testing of core samples, geophysical surveys, hydrological tests, and geologic mapping. Similar tests and surveys may be conducted at Yucca Mountain through site characterization.

A.1.1.1 Exploratory drilling

Exploratory drilling and testing activities provide data that allow the three-dimensional characterization of the geologic, thermomechanical, hydrologic, and geochemical characteristics of the site and the surrounding area. By drilling exploratory holes, one can

1. Collect cores; describe the geology of the cores; and determine the physical, mechanical, thermal, and geochemical properties of the cores.

2. Investigate geophysical properties below the surface.

3. Measure in situ stress.

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4. Test hydraulic conditions in the unsaturated and saturated zones.

5. Collect water samples for chemical analysis.

Since 1978, the DOE has drilled several exploratory holes and has conducted geologic and hydrologic investigations at Yucca Mountain. Additional environmental impacts might be expected from further exploratory drilling at the site for site characterization. The following discussions identify the types of drilling activities that potentially create impacts that must be evaluated.

Each drill site must be prepared to accommodate a drill rig and crew. Site preparation activities include clearing and grading the site and staging area, constructing a raised and leveled drill pad, constructing a parking area and equipment yard, excavating fill dirt from either adjacent or nearby areas, and constructing a mud-and-cuttings pit. It is assumed that an average of 1 ha (2.5 acres) per drill site would be disturbed by site preparation. After the site has been prepared, an exploratory hole would be drilled, and associated core logging, geophysical logging, and hydrologic testing would be performed.

Equipment and facilities that would be used at the drill site include a diesel-powered drill rig, pumps for circulating the drilling fluid, drill pipe, drilling and coring tools, two trailers for supervisory and laboratory space, an electric generator, and an air compressor. Solid waste would be hauled from the site to an existing landfill on the NTS. The water that would be used for drilling, dust suppression, compaction, and human

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consumption would be trucked daily to the drill site. Waste drilling fluids and cuttings would be confined in the mud-and-cuttings pits.

Some of the downhole geophysical logging would be performed with a contained and retrievable radiation source such as Cs-137, and Am-241/Be. The use of such sources is a common practice in geologic characterization. Logging tools with radiation sources are used to remotely determine the degree of water saturation, rock density, and other physical characteristics.

Hydrologic tests would also be performed using radioactive materials. The introduction of radioactive tracer material is a common technique for investigating the movement of water in geologic media (Bedmar, 1983; Rao, 1983). The radionuclides commonly used as artificial tracers to determine the movement of groundwater include I-131, Cr-51, Rb-86, Ru-103, and Br-82. These materials have short half-lives ranging from one day to tens of days. Movement of the tracer through water or rock can be readily determined because the background concentration of the tracer in the water or rock is zero. The behavior of radionuclides during transport can also be predicted more accurately if tests are conducted with tracers that are known to mimic the behavior of the important chemical species present in the radioactive waste.

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A.1.1.2 Geophysical surveys

Geophysical surveys provide a means to obtain information about the subsurface geologic conditions without having to drill deep boreholes. The surveys can be used to map the geometry of geologic structures at depth and to recognize contacts in stratigraphic sequences. Some geophysical techniques are useful for detecting major changes in rock density at depth, magnetic or electrical properties that may indicate the presence of an igneous intrusive body (pluton), or a metallic ore body. Each of these techniques may require land surveying and geologic reconnaissance either on foot or by off-road vehicles or aircraft.

A.1.1.3 Geologic mapping

Geologic mapping is conducted to record the surface features and characteristics of exposed rock in the area. This type of mapping uses aerial photography and requires detailed field observations either on foot or by using off-road vehicles. Occasionally, the surface study is supplemented by shallow subsurface investigations requiring trenching. Typically, the trenches are approximately 2 m (7 ft) wide, range from 1 to 3 m (3 to 10 ft) deep, and are from 30 to 60 m (100 to 200 ft) long. The walls of shallow trenches are kept straight, smooth, and as nearly vertical as possible. Deeper trenches are terraced for safety reasons, and may be as wide as 8 m (25 ft). Trenching and additional geologic mapping would be performed during site characterization.

A.1.1.4 <u>Standard operating practices for reclamation of areas disturbed by field studies</u>

Standard operating practices for reclamation and habitat restoration include:

1. Removing and disposing of concrete and surface debris from drill pads to a landfill at the NTS.

2. Disking or ripping of drill-pad areas and then roads to relieve compaction and to mix the surface soil with the underlying soil.

3. Filling the mud-and-cuttings pit (after removal of drilling fluids or sludge, as appropriate) and geologic study trenches with stockpiled topsoil or material removed during excavation.

4. Contouring disturbed areas to reestablish natural drainage patterns, to minimize erosion, and to blend with the surrounding land contours.

5. Distributing available stockpiled topsoil over the recontoured area in a manner that minimizes erosion and encourages moisture retention.

6. Ripping or disking the compacted unpaved roads that are no longer used and recontouring and stabilizing the disturbed road area to minimize erosion and encourage revegetation.

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Because (1) reclamation and habitat restoration in fragile, arid ecosystems are not completely understood and (2) long periods of time are required to reestablish mature vegetation associations, the effectiveness of habitat restoration is not clear. Consequently, the process will have to be evaluated and adjusted in response to continuing restoration studies.

A.1.2 EXPLORATORY SHAFT FACILITY (ESF)

During site characterization, the DOE will construct an ESF to provide access for detailed study of the potential host rock as well as the overlying and underlying strata. The excavation and construction of this ESF would be the primary source of potential environmental impacts during site characterization. The ESF would consist of (1) an exploratory shaft large enough for the transport of people, materials, and equipment (inside finished diameter of 3.7 m (12 ft)), (2) underground testing areas, (3) a secondary egress shaft (inside diameter of 3.7 m (12 ft)), and (4) the surface facilities needed to support construction and testing (Figure A-1). Both shafts would extend slightly beyond the proposed depth of the repository. The underground testing areas would be excavated from breakout rooms at three levels. A main test facility with drifts and rooms would be excavated into the host rock from the middle breakout room. The secondary egress shaft would be used for ventilation and would provide another means of egress from the underground areas. It would be connected to the exploratory shaft by a drift.

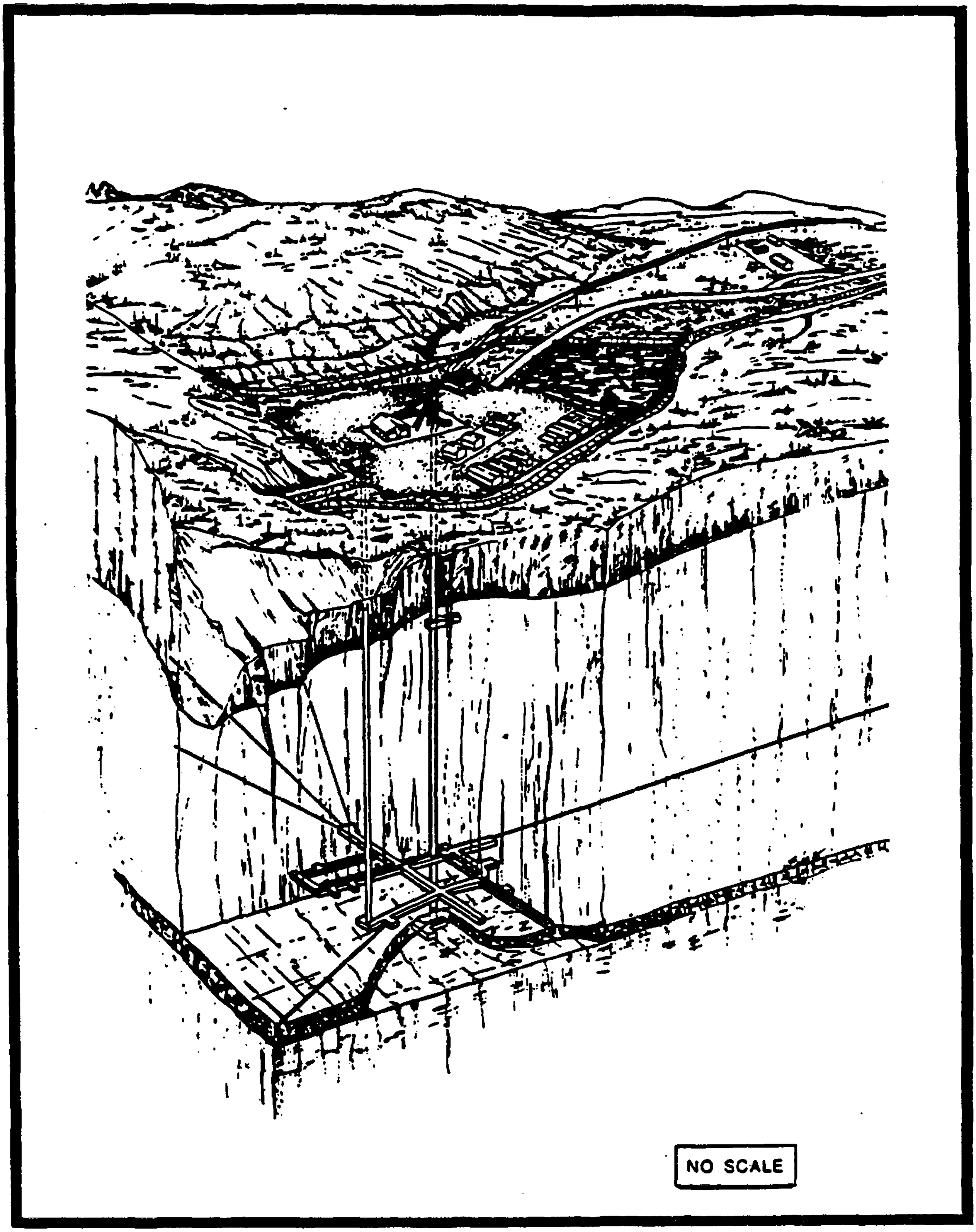

Figure A-1. Three-dimensional illustration of the exploratory shaft facility.

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The ESF would be located in Coyote Wash on the eastern side of Yucca Mountain at an elevation of about 1,300 m (4,200 ft). Figure A-2 shows the proposed site, utility lines, and the access road. It also shows the administrative boundaries of the NTS, the Nellis Air Force Range, and the Bureau of Land Management (BLM). This site was selected from five sites that were considered as possible locations for the exploratory shaft (Bertram, 1984).

The following sections describe the presently conceived ESF, the plans for testing, and the items being considered to minimize environmental damage and satisfy applicable local, state, and Federal requirements.

A.1.2.1 Surface facilities

Construction of the surface facilities is expected to take from six to seven months to complete. The site would first be cleared and graded; then it would be stabilized with 15 cm (6 in.) of gravel. Existing natural drainage channels would be diverted to control potential runoff from a probable maximum precipitation event. Site preparation would require cut-and-fill to provide a level pad (the exploratory shaft site pad) for the surface structures and the parking area. About 70,000 m^3 (2,500,000 ft^3) of fill material would be removed from borrow areas east and west of the pad. Both the exploratory shaft and the secondary egress shaft would be located on this exploratory shaft site pad. In addition, an auxiliary pad would be located about 240 m (800 ft) to the east of the main pad and would be used

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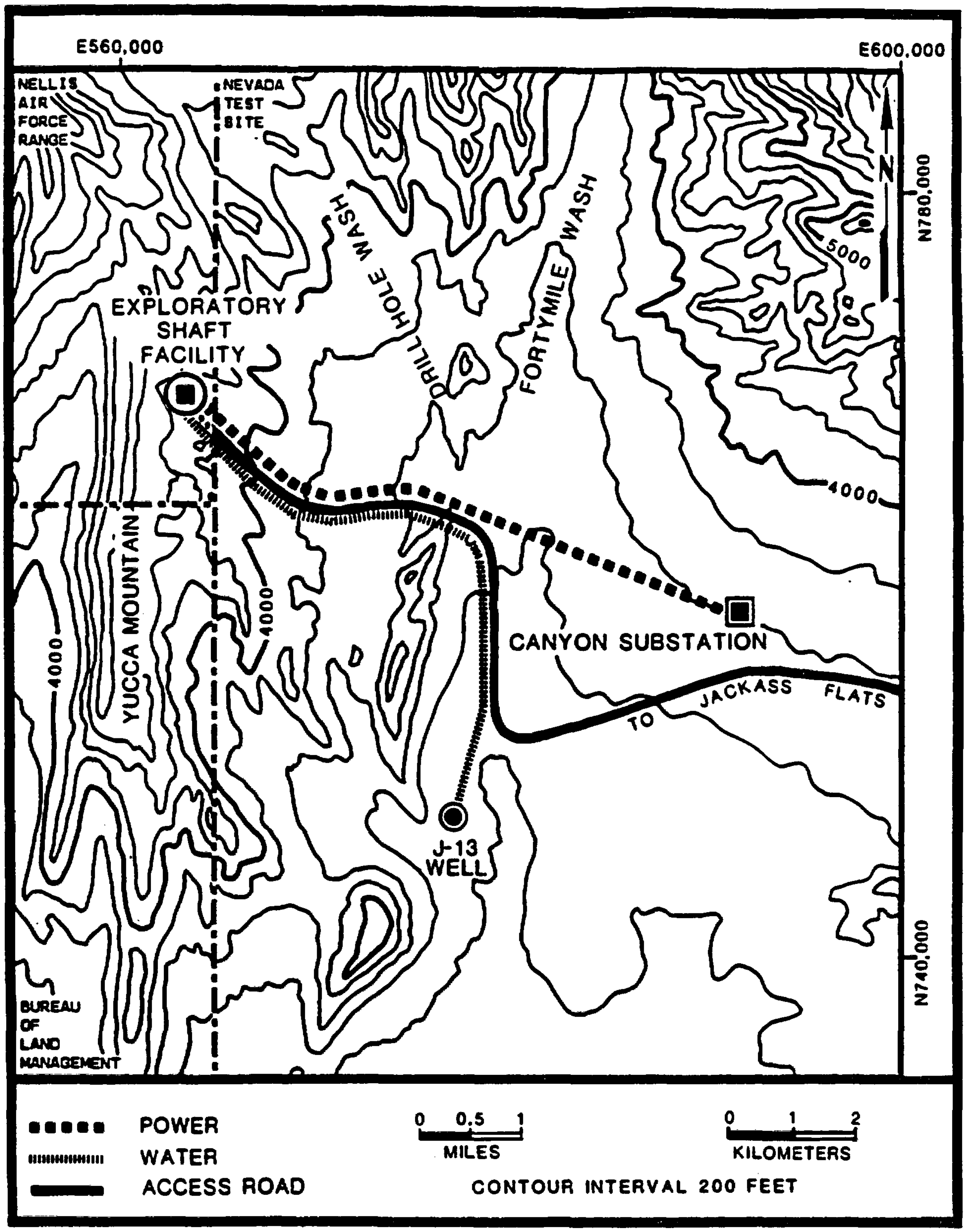

Figure A-2. Location of proposed exploratory shaft facility and utilities.

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for a visitor center and to accommodate support buildings, trailers, and additional parking. The surface area that would be required for all of the exploratory shaft facilities is about 8 ha (20 acres).

The parking area and the access road would be paved with a double oil-and-chip layer. The access road from Jackass Flats has been improved to the boundary of the NTS to accommodate heavy equipment. The road is 7 m (23 ft) wide, has 1-m (3-ft) shoulders, and is surfaced with a double oil-and-chip layer. The remaining 400 m (1,300 ft) of the road to the exploratory shaft site pad would be constructed on fill to maintain a grade that would not be greater than 10 percent. This road would disturb a path 50 m (160 ft) wide, including drainage channel modification.

Prefabricated metal buildings would be assembled at the site on concrete foundations to provide space for shops, a warehouse, hoist houses, and the integrated data system. The main hoist house would accommodate two hoists. Another hoist house would be erected near the secondary egress shaft. Several trailers would be located on the exploratory shaft pad and used for change rooms, office and laboratory space, data acquisition, and a first-aid room. Showers and lockers would be provided for the technical staff and for the mining crew. Most structures would have restrooms, electric space and water heating, and air conditioning.

Magazines would be required for the storage of explosives. The size and location of the magazines would depend on the maximum amount of explosives and detonators to be stored at any time and the provisions of appropriate regulations (such as the California Mine Safety Act).

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The water supply would be pumped from existing well J-13 on the NTS through a 10 km (6.2 mi) long, 15 cm (6 in.) diameter polyvinylchloride pipe buried about 0.6 m (2 ft) below grade. The pipeline, constructed in the bed of the old access road to the NTS boundary, is adjacent to the new paved road. One pumping station is at well J-13 and a booster pumping station is at about the half-way point (based on elevation).

Sewage will be disposed of by means of collection piping from all buildings and trailers to a septic tank and drain field located east of the ESF (beyond the perimeter of the proposed repository subsurface facility). Rock removed from the underground workings will be stored in a rock-storage pile. The location of the rock-storage pile has not yet been determined, but it will be placed to the east of the ESF beyond the perimeter of the proposed repository subsurface facility. The rock debris removed from the construction of the shafts, from breakout rooms, from the drift connecting the two shafts, and from the main underground test facility would be transported to the surface and hauled to the rock-storage pile. The 0.6-ha (1.5-acre) rock-storage pile area would be sufficient to accommodate the 39,000 m^3 (1,300,000 ft^3) of broken rock that would be produced during shaft and drift mining. Dust from the dumping operation would be controlled by appropriate wet suppression techniques. Water and other fluids that would be used for core drilling, including air-water mist, bentonitic mud with water control agents, and polymer foam would be disposed of on the rock-storage pile. The rock-storage pile will be bermed and lined with an impermeable liner to minimize discharge of these fluids to the surface or to the

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groundwater. This berm would be designed to contain a volume of 1,400 m^3 (375,000 gal) of liquid. Solid refuse would be hauled to an existing landfill on the NTS.

A concrete batch plant would be established to provide storage and mixing of the materials that would be used to make concrete and grout for site characterization activities. Approximately one acre will be cleared for the batch plant. Aggregate (crushed rock), sand, and perhaps cement would be stored in this area. These materials would be mixed with water to make concrete and grout. Water would also be used to wash out the trucks that would be used to mix and carry the concrete and grout. Both the washdown water and the batches that do not meet specifications would be disposed of on the rock-storage pile. Some equipment and trucks may be washed down at the batch plant, and the wash water may be disposed of at the batch plant site. Approximately 110 m^3 (30,000 gal) of water may be used for washdown during surface and subsurface construction.

The ventilation fans located at the surface would be capable of providing 1,135 m^3/min. per minute (40,000 ft^3/m^3) of air to the underground workings. The ventilation system would meet all the requirements of the Tunnel and Mine Safety Orders of the State of California as specified by DOE Orders 5480.1A and 5480.4 (DOE, 1981, 1984). With a rock temperature of 27°C (80°F) at the 370-m (1,200-ft) depth, the system would maintain underground temperatures at a level that is suitable for a work regimen of 75 percent work and 25 percent rest. The fans would have reverse flow capability to exhaust smoke, fumes, and dust from blasting in the underground workings. Shaft ventilation after blasting (smoke-out) would normally be accomplished

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by sucking out the gases produced by the blasting before they have a chance to diffuse throughout the drift.

Backup fans and emergency power for the ventilation system would also be provided. Two air compressors would supply primary and backup capability for air drilling of underground boreholes. Each would have a capacity to compress 40 m^3/min. (1,500 ft^3/min.) of free air to a gage pressure of 860 kPa (125 $lb/in.^2$) on a sustained basis. This system would include foundations, electrical supply controls, and distribution piping. The air compressors would be located near the power substation to separate the shaft and buildings from the noise.

Although large quantities of water are not expected to be encountered in the underground facilities, it is possible that perched water zones and percolation seepages could release some water to the underground facilities during construction and testing. Such water would be collected in a sump and then pumped to the surface and discharged on the rock-storage pile. There would be a backup sump pump and emergency power. The quantity of water removed from the shafts would be estimated and recorded.

A.1.2.2 Exploratory shaft and underground workings

The current plans are to mine the exploratory shaft to a total depth of about 450 m (1,480 ft), which is about 23 m (75 ft) below the contact between the overlying Topopah Spring Member and the underlying tuffaceous beds of

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Calico Hills. This total depth would provide about 15 m (50 ft) of penetration into the pervasively zeolitized interior of the Calico Hills unit and would leave undisturbed a minimum thickness of about 85 m (280 ft) of the Calico Hills unit above the water table. The design diameter of the excavated shaft is 4.3 m (14.1 ft), and the finished diameter would be 3.7 m (12.1 ft).

After the surface facility has been completed, the exploratory shaft would be mined using a conventional drill-blast-muck mining technique. Explosives would be placed into small holes drilled in the rock and detonated; the resulting rubble would be collected and hoisted from the shaft. Conventional mining, instead of drilling, was selected because it would allow geologic and hydrologic conditions above, below, and within the candidate host rock to be examined during exploratory shaft construction. Conventional mining would minimize the potential introduction of water and other contaminants into the unsaturated zone, thereby reducing the possibility of affecting the results of the tests designed to measure the groundwater flux and the undisturbed moisture content of the rock.

The mucking operation may be somewhat more dusty than it would be in a typical mine because minimal amounts of water would be used to suppress dust in the shaft. Normally, the rubble would be sprayed with water before mucking to provide additional dust control. However, in the exploratory shaft, water would be used sparingly so that tests to characterize the unsaturated zone would not be affected. All water used in shaft construction, including the water used for making liner concrete, would be tagged with a suitable tracer. The quantity of water entering the shaft, the humidity in the air supply, and the humidity in the exhaust ventilation air would be metered and recorded.

Breakout rooms would be excavated at the 160- and 310-m (520- and 1,020-ft) levels during shaft construction. The shaft would be mined to 450 m (1,480 ft) before a final breakout room would be excavated at the bottom of the shaft. The main underground test facility would then be mined from the middle breakout room at 370 m (1,200 ft). Current plans are to mine the underground test facility and drifts using conventional drill-blast-muck methods.

A.1.2.3 Secondary egress shaft

According to the current plans, a 200-mm (8-in.) pilot hole would be drilled from the surface using a down-hole compressed-air hammer drill. Because this type of drill uses air in the drilling process instead of a waterbased drilling fluid, it avoids introducing water into the host rock. The pilot hole would be drilled to a depth of 370 m (1,200 ft), which is the depth of the main underground test facility. A dust-filtering system would be used to catch airborne dust.

The method of mining is expected to be similar to that used for the exploratory shaft (Section A.1.2.2). The rock debris would be removed through the exploratory shaft and would be dumped on the rock-storage pile.

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The water necessary for cooling and for dust suppression during drilling would be tagged with a suitable tracer (probably sodium bromide) to differentiate it from any in situ water in the unsaturated zone. Most of the water would be removed along with the rock debris and deposited on the rock-storage pile where it would evaporate.

After drilling, the secondary egress shaft would be lined with a steel casing. A hoist, head frame, and hoist house would then be constructed.

A.1.2.4 Exploratory shaft testing program

The goal of the exploratory shaft testing program is to obtain the information required to assess the intrinsic ability of the geologic setting at Yucca Mountain to isolate high-level waste. Information would also be acquired that would assist in the design of engineered components, such as drifts, emplacement holes, and waste disposal containers. The underground test program is being designed to provide information needed to address compliance with Federal regulations related to performance and siting criteria for high-level waste repositories. Before individual tests are started, the engineering test plans would be prepared for those tests.

The tests in the ESF that are being considered at this time can be grouped into two general categories: construction phase tests (tests that would be initiated concurrently with shaft sinking), and in situ phase tests

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(tests that would be initiated after shaft sinking is complete). Some of the construction phase tests would continue into the in situ test phase.

Construction phase tests. Ten construction phase tests are planned. One of the ten tests (shaftwall mapping, photography, and hand specimen sampling) would be conducted routinely after each round of blasting as the shaft is sunk. Three of the tests require large block samples that would be collected from 15 to 30 locations in the shaft. The pore waters that would be extracted from the large block samples would be chemically analyzed and dated using Cl-36 techniques. Laboratory measurements of geomechanical properties are also planned on these samples. The fifth test, unsaturated zone water sampling, would only occur if perched water was found during shaft sinking, which is not considered likely.

The basic shaftwall mapping is expected to require one to two hours after each round of blasting, but if large blocks or water samples are to be collected, an additional one to two hours may be required.

The remaining five tests would be at selected depths. These tests represent nonroutine operations and would require planned pauses in shaft sinking operations from several hours to several days. The five tests are

1. Vertical coring.

2. Lateral coring to confirm the adequacy of geologic and hydrologic conditions before constructing breakouts at the 160-m (520-ft)

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level, at the 370-m (1,200-ft) level, and at the shaft bottom at 450 m (1,480 ft).

3. Overcore drilling to measure in situ stress conditions.

4. Breakout room tests to assess the constructability and the stability of repository-sized drifts.

5. Shaft-convergence tests between the 160-m (520-ft) and 310-m (1,020-ft) breakouts.

In situ phase tests. Fifteen in situ phase tests are currently planned. These tests would begin after the shaft has been completed to the required depth. Most of the in situ tests would be at the 310-m (1,020-ft) level. The in situ phase tests can be grouped into six categories according to the site information that would be obtained. Geologic information on fracture frequency and orientation would be obtained by mapping the walls of the drifts in the testing area. Lateral coring would provide geologic information on the continuity and structure of the proposed host rock. Hydrologic data would be obtained from permeability and infiltration tests both in the Topopah Spring Member and in the underlying tuffaceous beds of Calico Hills. Geochemical tests would investigate the potential for retardation of radionuclide movement by various physical and chemicalsorption processes. Geomechanical tests would simulate the effects on the host rock of the temperature increases caused by the heat emitted by the emplaced waste. Tests are also planned to assess the stability of mined openings and

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to make other in situ measurements required to design a safe repository. The tests in the remaining category would investigate the physical and chemical characteristics of the emplacement environment to provide information necessary for proper design of waste disposal containers and engineered barriers.

A.1.2.5 Final disposition

The Nuclear Waste Policy Act of 1982 (Section 113) (NWPA, 1983) requires that the site characterization plan for a candidate site contain provisions for the decontamination and decommissioning of the site. Radiation sources used in geophysical logging would be fully contained and retrievable. Radioactive materials that would be used as tracer material in hydrologic tests have short half-lives ranging from several hours to tens of days. The current plans for site characterization at Yucca Mountain do not include the use of high-level radioactive materials. Therefore, no decontamination is expected to be needed after site characterization. The final disposition of the ESF would depend on the results of the site characterization program and the DOE decisions about sites for the first and the second repository. Thus, there are three possible exploratory shaft dispositions:

1. The site characterization program may show that Yucca Mountain is unsuitable for a radioactive-waste repository. In this case, the ESF would be either decommissioned or preserved for other uses.

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2. The site may be shown to be suitable, but the first repository may be built at another site. In this case, the ESF would not be decommissioned until a final decision was made as to whether the site is needed for the second repository.

3. The site may be shown suitable and be selected for the first repository. In this case, the ESF would be incorporated into the repository.

To develop decommissioning strategies fully, final decisions about techniques for shaft sealing may require data from site characterization.

If the Yucca Mountain site is eliminated from consideration as a potential repository site and no alternative uses are identified, then decommissioning would begin as soon as possible after the decision. In addition to the shaft sealing, decommissioning would include the removal of all buildings, fences, trailers, electric generators and distribution equipment, communications equipment, and explosives magazines.

The excavation and removal of subsurface utilities are generally more costly and more environmentally disturbing than leaving them buried in place. Consequently, if the site is abandoned, any portion of the utilities that extends above the ground would be cut off below grade, and the structures would be covered during the reclamation of the surface. Other subsurface structures would be backfilled and closed if no longer needed.

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A.1.3 OTHER STUDIES

Some ongoing activities, including both field and laboratory studies, would be continued during site characterization. These activities are perceived to have little or no potential for environmental impacts. Among them are studies of past hydrologic conditions, paleohydrology, tectonics, seismicity, volcanism, and ground motion induced by weapons testing. Laboratory analyses of cores and water from boreholes would be made. The repository-sealing technology developed in the laboratory would be tested in the field, and techniques for dry horizontal drilling would be developed to provide that capability if it is required in the exploratory shaft.

A.1.3.1 Geodetic surveys

Geodetic surveys to monitor any tectonic movements that may occur in the Yucca Mountain area began in 1983 and would be continued during site characterization. The surveys use a 70-km (43-mile) level line that extends from the southwest corner of Crater Flat at U.S. Highway 95 along existing roads in Crater Flat; crosses Yucca Mountain, Jackass Flats, and Skull Mountain; and finally ends in Rock Valley. In addition, a quadrilateral network has been installed across selected faults in the Yucca Mountain area. Both the installation of bench marks and the initial survey were completed in June 1983. A resurvey was made near the end of 1983, and yearly resurveys will be made to measure changes, if any, of the Earth's crust in this area. Wherever possible, the required bench marks were installed along existing

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roadways. However, some bench marks were installed where no roads exist. Future access to these bench marks would require the use of either an off-road vehicle or a helicopter.

A.1.3.2 Horizontal core drilling

Experimental horizontal core drilling from the surface was conducted at Fran Ridge in 1983 to develop prototype dry-drilling techniques for use in the exploratory shaft. Surface core drilling at Fran Ridge required a bladed road for access; a drill pad, about 30 by 46 m (100 by 150 ft), for emplacement of the horizontal boring machines; and a smaller pad, 18 by 6 m (60 by 20 ft), for electric power generators. Additional prototype drilling may be conducted during site characterization.

A.1.3.3 Studies of tectonics, seismicity, and volcanism

Potentials for faulting, earthquakes, volcanic activity, and accelerated erosion in the Yucca Mountain area are being assessed. Studies include investigating the rate, intensity, and distribution of faulting; monitoring and interpreting present seismicity; studying the history of volcanism; and evaluating past rates of erosion and deposition. Volcanic and tectonic studies focus on the history of Pliocene and Pleistocene activity within the southern Great Basin, particularly the Yucca Mountain region. These studies

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use data from boreholes, trenches, mapping, geophysical surveys, and seismic-monitoring stations. The studies would be continued during site characterization.

A.2 POST LICENSE APPLICATION ACTIVITIES

The function of a repository is the permanent isolation of high-level radioactive waste as well as the isolation of radioactive waste generated at the repository from the handling of incoming wastes. The total quantity of waste to be emplaced at the repository is limited by the Nuclear Waste Policy Act of 1982 (NWPA) to the equivalent of 70,000 metric tons uranium (MTU) until a second repository is in operation (NWPA, 1983).

Some of the most important features of a conceptual repository design are illustrated in Figure A-3. The conceptual design of the prospective repository consists of a surface facility, a subsurface facility, and a means of access from one facility to the other. Figure A-3 shows ramps as the means of access from the surface to the underground repository where mined access drifts connect with other mined drifts in which the waste is emplaced. The waste would be emplaced in holes drilled either horizontally into the walls of the emplacement drifts or vertically into the floors. According to the current design concept, the repository would receive 62,000 MTU of spent fuel and 8,000 MTU-equivalent of defense high-level waste. It would be constructed in two stages and would be able to receive spent fuel as early as five years out of the reactor.

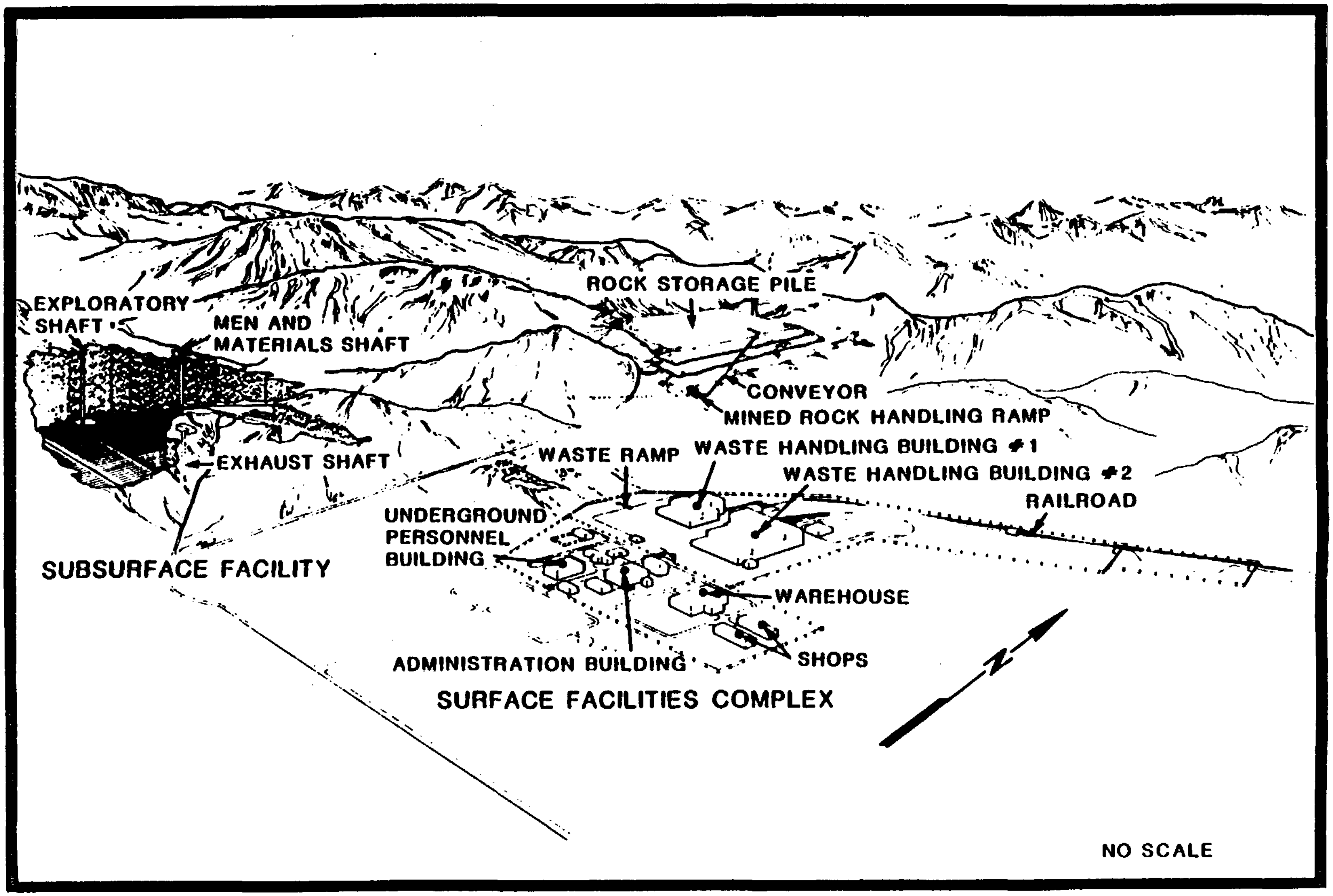

Figure A-3. Artist's rendition of the proposed Yucca Mountain repository.

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Under the design concept (DOE, 1985) the repository would receive defense high-level waste at a rate of 400 MTU-equivalent per year beginning in 2003, the sixth year of operation. The waste would be in the form of borosilicate glass contained in waste disposal containers approximately 0.6 m (2 ft) in diameter, 3 m (10 ft) high, and weighing about 1.8 metric tons (4,000 lbs). Shipment would be by either truck or rail. If the shipment is by truck, this design would result in approximately three shipments per day for defense waste or 800 waste disposal containers per year. In either the two-stage repository concept or the current design concept, the Stage 1 waste-handling building, designed to receive up to 400 MTU per year, would no longer be used to receive spent fuel when the Stage 2 facility becomes fully operational. In the current design concept, the Stage 1 facility could then be used for the receipt and handling of defense waste beginning in 2007. Since the defense waste has lower thermal and radiation levels than spent fuel, the Stage 1 facility would be totally suitable to perform this function.

The addition of defense waste to the inventory would have little effect on the characteristics of the two-stage repository concept. The defense waste disposal containers would be placed into the waste disposal container, welded, inspected, transported underground, and placed in the disposal location. Additional personnel would be required for waste-handling and emplacement crews, but the number required for approximately three additional packages per day is considered to be within the uncertainties of the manpower estimate for the two-stage repository concept. The waste-handling ramp into the repository could accommodate the additional packages, and the mining activities could prepare the emplacement holes on schedule. Since repository

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area is based on thermal loading, the overall size of the repository would not be increased.

For most of the emplacement phase, the average age will be greater than 10 years with an estimated 5 to 10 percent aged as little as 5 years. The two-stage repository concept, described in this document, is based on 10-year-old fuel.

Since the President has selected Yucca Mountain for site characterization, the design of the repository is progressing from feasibility and conceptual studies, to SCP conceptual design, to advanced conceptual design, license application design, and final procurement and construction design. The SCP conceptual design and advanced conceptual design will resolve the current uncertainties in the design and serve as the basis for the environmental impact statement that will be prepared during site characterization.

The design changes that have just been explained will be resolved in the future. The remainder of this section summarizes the assumptions on which the evaluation of the Yucca Mountain site is based.

The surface facility would be along the eastern foothills of Yucca Mountain. The subsurface facility would be located approximately beneath the ridge line of Yucca Mountain. The proposed highway access would originate at U.S. Highway 95, approximately 1 km (0.5 mi) west of the town of Amargosa Valley, and extend about 26 km (16 mi) northward to the site. Rail access options are presently under evaluation.

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The lifetime of a repository at Yucca Mountain, before it is permanently closed, may be divided into several periods: construction, operations, and decommissioning. These periods are discussed in detail in Sections A.1.1 through A.1.4. Stage 1 and a portion of the Stage 2 facilities would be constructed and some of the subsurface facilities would be excavated during the first 4.3 years of the 7.3-year construction period. The Stage 2 facilities would be completed in the last three years of the construction period, which would overlap with the first three years of the operations period. The operations period, which would last for 50 years, would consist of two phases. The first phase is the 28-year emplacement phase. During this phase, the radioactive waste would be received and emplaced, and the underground facilities and surrounding environment monitored. The second phase, the 22-year caretaker phase, would follow completion of waste-emplacement operations; the facilities as well as the surrounding environment would continue to be monitored, and the retrievability option would be maintained in compliance with NRC requirements for ensuring retrievability at any time up to 50 years after waste emplacement begins (10 CFR Part 60). If a decision to retrieve the waste were made during the caretaker phase, the lifetime of the Project would be extended approximately 30 years during which actual waste retrieval would be accomplished. A decision to close and decommission the repository could be made at any time during the caretaker phase. The decommissioning and closing of the repository would last for an eight-year period under the vertical-emplacement alternative or for a three-year period under the horizontal-emplacement alternative.

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A.2.1 CONSTRUCTION

The construction period begins after construction authorization is received from the NRC. Repository construction would proceed in two phases that would begin simultaneously. Phase 1 construction consists of construction and acceptance, and startup testing of the Stage 1 surface facility and underground facilities required to accept and emplace 400 MTU per year. Phase 2 construction consists of the completion of all the facilities, including the Stage 2 wastehandling building, required to consolidate and accept 3,000 MTU per year. Phase 2 construction overlaps the operations period. Underground excavation, which would begin in the construction period, would continue through most of the operations period.

Most surface construction would occur at the main surface facilities complex. Construction of these facilities is discussed in the following section (Section A.2.1.1). Surface construction away from the main surface facility complex would include highways and rail connections, mine ventilation buildings, and other ancillary facilities. Surface facilities constructed away from the main surface facility complex are described in Section A.2.1.4.

A.2.1.1 <u>The surface facilities</u>

The actual location of the surface facilities has not yet been determined. However, a candidate location has been identified for the purpose of preparing this document. The candidate location for these facilities is

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along the gently sloping east side of Yucca Mountain, as shown in Figure A-4. The surface facilities complex proposed at Yucca Mountain would encompass approximately 60 ha (150 acres) of land, all of which would be enclosed by a security fence.

A preliminary site plan of the proposed surface facilities at Yucca Mountain is shown in Figure A-5. The surface facilities in the complex would be used for waste-handling and packaging operations in support of the underground activities and to provide general repository support services. The restricted-access area for waste-handling and packaging facilities would include buildings and equipment for receiving and packaging all incoming wastes (Section A.2.2.1.2 for more details). A facility would also be constructed for processing all the radioactive waste generated by onsite operations, such as protective clothing, decontamination fluids, and ventilation filters.

Support facilities for the repository would include offices for administrative, management, and engineering staff; a firehouse; medical, training, and computer centers; a vehicle maintenance and repair shop; security buildings; a machine and sheet metal shop; and an electrical shop. Warehouses would be constructed to store bulk materials, equipment, spare parts, and supplies.

Facilities for environmental and instrument laboratories would also be constructed. Surface facilities in support of the underground operations include personnel change-rooms and showers, as well as space to store mining equipment and vehicles.

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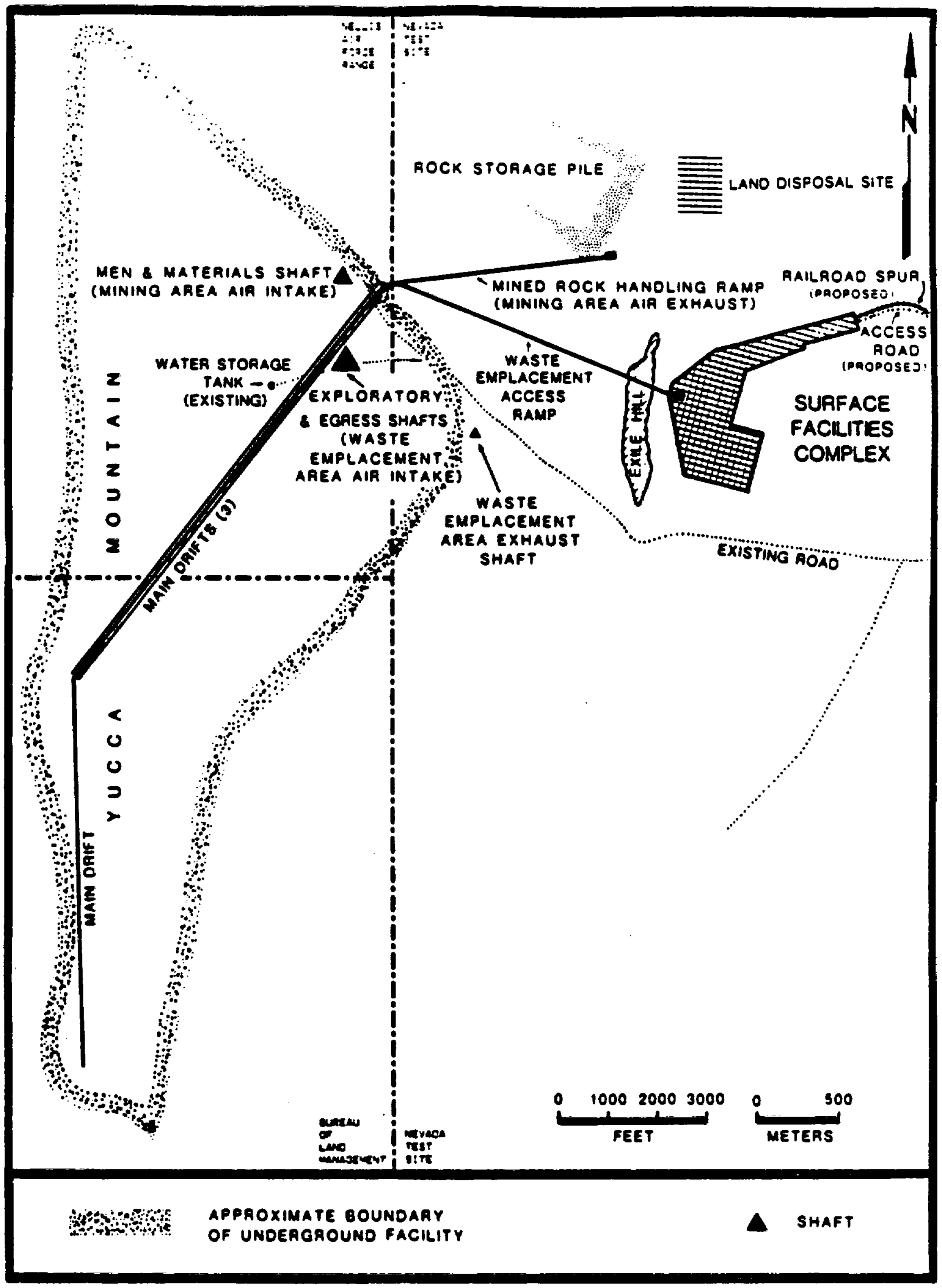

Figure A-4. Two-stage repository site plan. Modified from MacDougall (1985).

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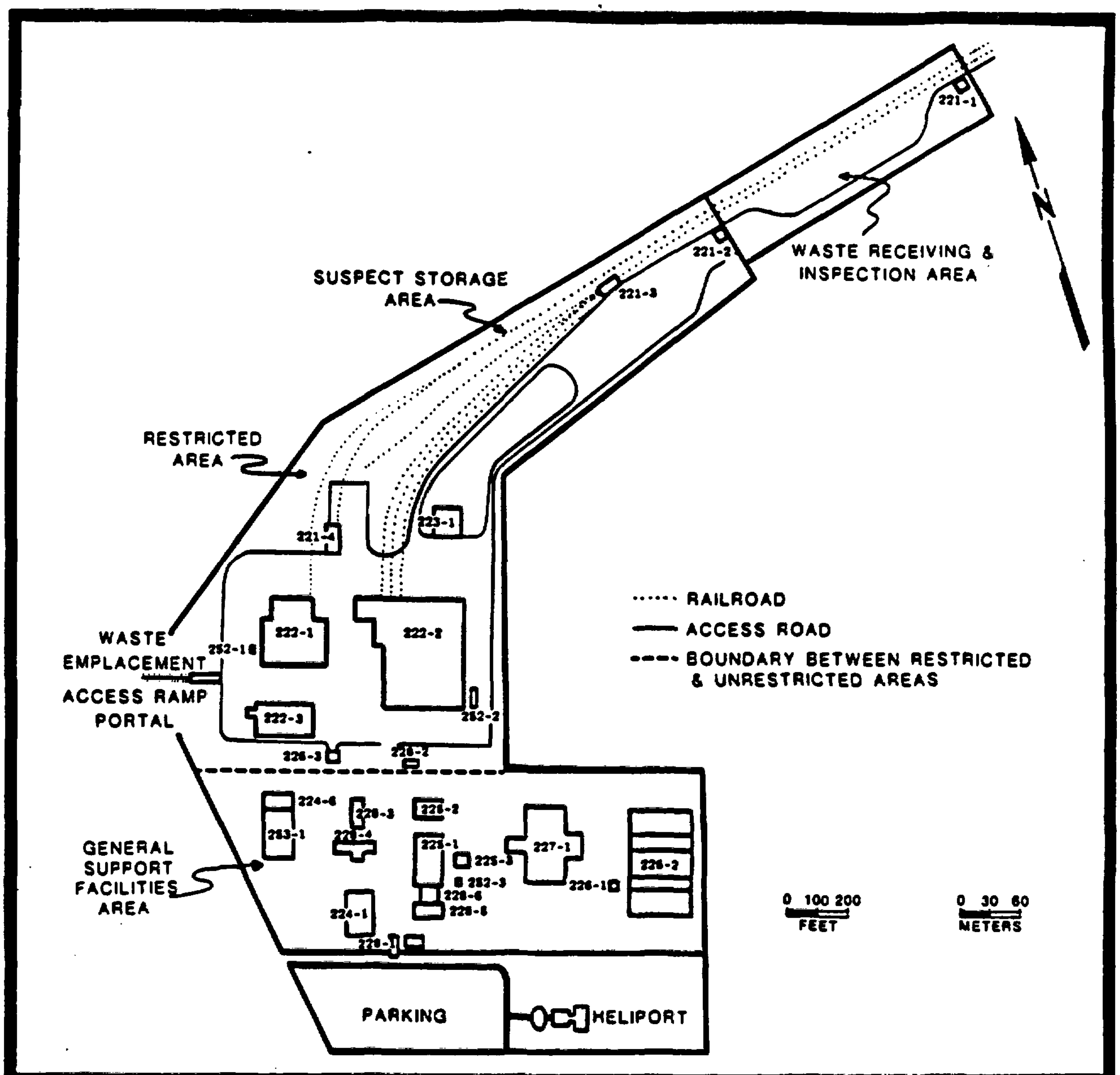

221-1 SECURITY
221-2 HEALTH PHYSICS
221-3 WASHDOWN FACILITY
221-4 DECONTAMINATION BUILDING
222-1 WASTE HANDLING BUILDING NO. 1
222-2 WASTE HANDLING BUILDING NO. 2
222-3 PERFORMANCE CONFIRMATION FACILITY
223-1 WASTE TREATMENT BUILDING
224-1 UNDERGROUND PERSONNEL FACILITY
224-6 MAIN SUBSTATION & STANDBY GENERATOR BUILDING
225-1 ADMINISTRATION BUILDING
225-2 MOCKUP BUILDING
225-3 COMPUTER BUILDING
226-1 MOTOR POOL & FACILITY SERVICE STATION
226-2 SHOPS
226-3 RESTRICTED AREA GARAGE
227-1 CENTRAL WAREHOUSE
228-1 SECURITY STATION NO. 1
228-2 SECURITY STATION NO. 2/ HEALTH PHYSICS STATION NO. 3
228-3 FIRE STATION
228-4 MEDICAL CENTER & DORMITORY
228-5 FOOD SERVICE FACILITY
228-6 TRAINING AUDITORIUM
252-1 WATER CHILLERS NO. 1
252-2 WATER CHILLERS NO. 2
252-3 WATER CHILLERS NO. 3
253-1 UTILITY ELECTRIC SUBSTATION

Figure A-5. Preliminary site plan for proposed surface facilities for a two-stage repository. Modified from MacDougall (1985).

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Electric transmission lines would be extended to Yucca Mountain from existing local utility lines on the NTS and a new substation would be constructed at the site.. Utilities that support the repository would include an electric power building with emergency electrical generating equipment. Steam generating equipment, compressor and chiller systems, and cooling towers with water treatment equipment would be included if needed. A system for treating and distributing potable water and water for fire protection would be required. New wells with storage provisions are expected to supply all the water required during construction and operation of the repository. Finally, stations for dispensing gasoline and diesel fuel would be required at the site.

A.2.1.2 Access to the subsurface

Six access openings would connect the subsurface with the surface areas. These openings would be used for ventilation air supply and exhaust, the transport of materials, and personnel access. As currently designed for vertical waste emplacement, they are described as follows:

1. The men-and-materials shaft would be used to transport personnel and materials to and from the underground facilities. This shaft would be 7.6 m (25 ft) in diameter and approximately 335 m (1,110 ft) deep.

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2. The waste-handling ramp would be used to transport the waste underground. This ramp would be 7.4 m (24 ft) in diameter and approximately 2,042 m (6,700 ft) long.

3. The mined-material handling ramp would be used for the mined-material conveyor system and as an exhaust outlet for construction area ventilation. The ramp would be 5.8 m (19 ft) in diameter and approximately 1,417 m (4,650 ft) long.

4. The waste-emplacement area exhaust shaft would serve as the exhaust outlet for ventilation during waste emplacement. This 6.1-m (20-ft) diameter shaft would be approximately 304 m (1,000 ft) deep.

5. The 3.7-m (12-ft) diameter exploratory shaft, constructed during site characterization, would be used to supply air for repository waste-emplacement operations. It would be approximately 450 m (1,480 ft) deep.

6. The 1.8-m (6-ft) diameter emergency egress shaft of the exploratory shaft test facility would be used to supply air to the repository waste-emplacement support facilities. This shaft would be approximately 365 m (1,200 ft) deep.

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A.2.1.3 The subsurface facilities

The subsurface facilities would be located within Yucca Mountain, approximately 1.7 km (1 mile) west of the proposed location of the surface facilities complex (Figure A-4). This facility would encompass approximately 615 ha (1,520 acres) of subsurface area. The repository horizon would be more than 230 m (750 ft) below the surface within the Topopah Spring Member of the Paintbrush Tuff. The water table in the vicinity of Yucca Mountain is approximately 200 to 400 m (650 to 1,300 ft) below the potential repository horizon. Except for possible scattered pockets of perched water, the underground openings are expected to be dry. An artist's rendition of the proposed subsurface facilities is shown in Figure A-6.

The subsurface facilities consist of main access drifts to the emplacement areas, the emplacement drifts, and service areas near the shafts and ramps. The layout of the facilities depends upon whether the waste is emplaced vertically or horizontally. For vertical emplacement, waste disposal containers would be emplaced in vertical boreholes in the floors of the emplacement drifts. An extraction ratio of 24 percent has been adopted for the vertical emplacement alternative (Dravo, 1984). Cross-sectional dimensions of these openings are listed in Table A-1. The total amount of rock excavated for the facility would be about 21.6 million tons.

For horizontal emplacement, waste disposal containers would be emplaced in horizontal boreholes in the draft pillars (walls). The subsurface layout for horizontal waste-emplacement requires considerably less excavation. The total amount of rock excavated for the facility would be about 6.6 million

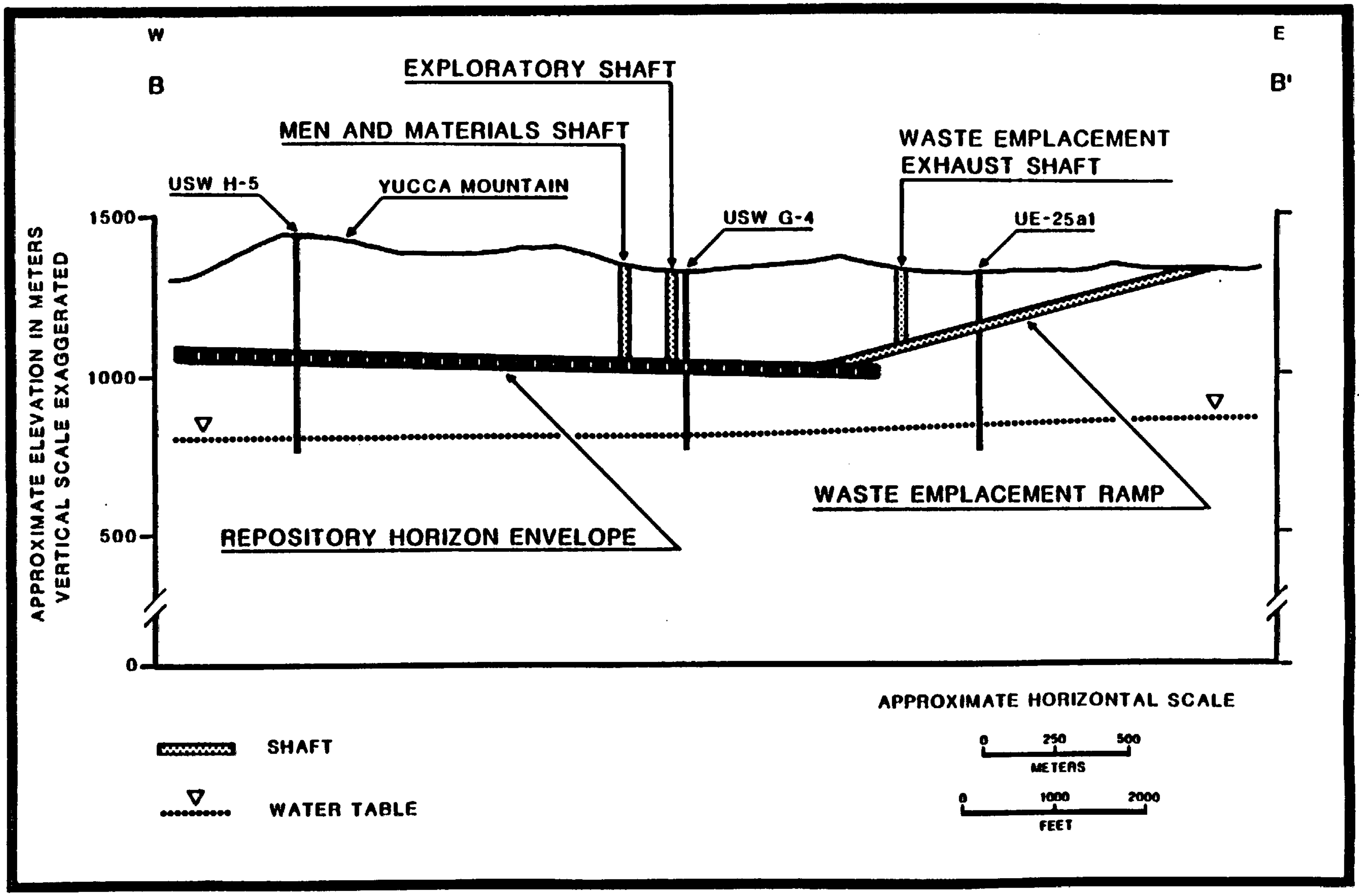

Figure A-6. Artist's rendition of the proposed surface facilities.

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Table A-1. Dimensions of underground openings for vertical and horizontal waste emplacement[a]

Opening	Vertical Emplacement				Horizontal Emplacement			
	Height		Width		Height		Width	
	meters	(feet)	meters	(feet)	meters	(feet)	meters	(feet)
Access corridors	4.6	(15)	6.4	(21)	4.6	(15)	6.4	(21)
Emplacement drifts	6.4	(21)	4.6	(15)	4.6	(15)	6.4	(21)

[a]Data from MacDougall (1985).

tons. Table A-1 lists the dimensions of the openings for horizontal waste emplacement.

Design work completed to date indicates that area and geometric requirements, mine ventilation requirements, the requirements for stability of the underground workings, and retrievability considerations will be satisfied by a conventional room and pillar design. Excavation may be conducted by using either a drill-blast-mucking technique or a continuous mechanical miner.

Conventional mining equipment, as well as machinery designed specifically to transport wastes to the emplacement locations, would be required underground. The service areas required underground include medical facilities, warehouses, personnel change rooms, and maintenance areas.

The excavated rock would be placed near the site in a Hypalon-lined rock-storage pile. The rock-storage pile would be constructed on the surface by using conventional mined-rock handling equipment that would be sprayed

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with water to suppress dust. Runoff from precipitation would be intercepted by dikes, ditches, and liquid-collection sumps. The present design does not require backfilling of the excavated access and emplacement drifts to maintain the structural integrity of the underground openings. If backfilling a portion of the repository is required before closure and decommissioning, some of the excavated rock would be used for that purpose.

A.2.1.4 Other construction

Construction away from the main surface facilities complex would consist primarily of an access route connecting with U.S. Highway 95, a rail line possibly from Dike Siding, a bridge across Fortymile Wash, the mined rock handling and storage facilities, and ventilation facilities above each exhaust shaft. These facilities, as well as other installations and construction, are discussed in the following sections.

A.2.1.4.1 Access route

A highway for truck and automobile access would be constructed between U.S. Highway 95 and the site. The two-lane highway would originate approximately 1.0 km (0.6 mi) west of the Town of Amargosa Valley. The highway would be 9 m (30 ft) wide and 26 kilometers (16 mi) long; it would be rated for trucks with a gross weight of 36 metric tons (80,000 lb). Each roadway shoulder would be 2.5 m (8 ft) wide. The total required right-of-way would be about 31 m (100 ft); the total land area needed will be about 79 ha (195 acres).

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The highway would cross Fortymile Wash via a bridge. The preliminary repository concept calls for a single bridge carrying both highway and rail traffic, although construction of two separate bridges may be considered.

A.2.1.4.2 Railroad

For rail access to the site, rail spur access options are presently being evaluated. A railhead facility would be constructed at Yucca Mountain to provide for railcar handling and temporary storage. Detailed plans for this facility have not been formulated.

A.2.1.4.3 Mined rock handling and storage facilities

Surface facilities for receiving the rock mined during construction of the underground openings would include a surge bin for temporary storage, a conveyor system for moving the mined rock to the rock-storage pile, and a stacking conveyor for placing the rock on the storage pile.

A.2.1.4.4 Shafts and other facilities

Exhaust shafts for the mine and emplacement areas, described in Section A.2.1.2, would be located away from the surface complex. The exact locations

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would depend on the design of the underground facilities. The configuration, assuming that ramps for waste-emplacement access and mined material removal would be used, is shown in Figure A-4. A fenced waste-emplacement ventilation exhaust and filtration facility would be installed at the surface and would require an area of less than 1 ha (about 1 to 2 acres). The exhaust stack at this facility would extend about 31 m (100 ft) above the land surface. Improved roads would connect this site to the surface complex.

Other facilities located away from the main surface complex include water storage, explosive magazines, mineshaft areas, and sewage treatment facilities and effluent evaporation ponds. Approximately 10 ha (25 acres) would be developed to construct these facilities. Other identified remote facilities include a visitor center and a sanitary landfill. The locations and extent of the visitor center and sanitary landfill have not been defined.

A.2.2 OPERATIONS

The operations period is the time following receipt of the first waste into the repository (after receipt of the NRC license to receive and possess radioactive material) until site decommissioning begins. The operations period of a repository for radioactive waste at Yucca Mountain would begin in the fifth year after the start of facility construction with Stage 1 emplacement operations. Stage 2 emplacement operations would begin approximately seven years after start of construction. As noted in Section A.2.1, the operations period overlaps the completion of the Stage 2 facilities (end of Phase 2 construction).

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The operations period is divided into two phases: a 28-year emplacement phase followed by a 22-year caretaker phase. Performance confirmation will be conducted over the entire operations period.

A.2.2.1 Emplacement phase

The activities planned for the emplacement phase include waste receipt, processing, and placement; continued underground construction of waste-emplacement rooms and supporting services; the initial retrieval option period; and storage and management of mined rock for potential use as backfill.

A.2.2.1.1 Waste receipt

Radioactive waste would be shipped to the repository by rail or by truck in Federally licensed casks. Assuming 250 operating days per year, the design basis for waste receiving facilities is four truck and two rail shipments per operating day. Thus, the receiving facilities are designed to accommodate approximately 1,000 truck and 500 rail shipments per year.

During Stage 1 operations, surface and underground facilities would be constructed to receive and emplace a limited amount (400 MTU per year) of spent, unconsolidated fuel. This would be packaged at the site for disposal

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in the repository. The Stage 2 facilities to be completed three years later than the Stage 1 facilities, would have a capacity of 3,000 MTU per year and they would be capable of receiving other types of waste and of consolidating spent fuel. Receipt rates would gradually increase in the early years of repository operation (Table A-2).

During Stage 2 operations, the repository would receive an average of 4,348 pressurized-water-reactor (PWR) and 5,263 boiling-water-reactor (BWR) assemblies per year (Table A-3). Assuming that 30 percent of these assemblies (1,304 PWR and 1,579 PWR) would be shipped by truck and 70 percent (3,044 PWR and 3,684 BWR) would be shipped by rail, and assuming that truck casks have a capacity of 2 PWR and 5 BWR assemblies and rail casks have a capacity of 14 PWR and 36 BWR assemblies, the repository would receive 968 truck casks and 321 rail casks of fuel each year.

The receiving facilities would provide for

1. Rail and truck inspection stations where both incoming and outgoing traffic would be inspected (where, for example, radiation surveys, security inspections, and shipping document transactions would take place).

2. A suspect storage area where incoming shipments that do not meet repository acceptance standards would be held until corrective measures are taken.

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Table A-2. Spent-fuel waste receipts by year, metric tons uranium equivalent[a]

Repository year	Stage 1	Stage 2	Annual total	Cumulative total
5	400	NA[b]	400	400
6	400	NA[b]	400	800
7	400	NA[b]	400	1,200
8	400	500	900	2,100
9	400	1,400	1,800	3,900
10-30	NA[b]	3,000	3,000	69,900
31	NA[b]	100	100	70,000

[a]Data from MacDougall (1985).
[b]NA = not applicable.

Table A-3. Waste quantities by waste category[a]

Stage	Waste type[b]	Total quantity (assemblies)	Average annual receipt (assemblies)
1	Spent Fuel - PWR	2,898	580
	Spent Fuel - BWR	3,511	700
2	Spent Fuel - PWR	101,454	4,348
	Spent Fuel - BWR	122,794	5,263

[a]Reflects 70,000 metric tons of uranium (MTU) as spent fuel.
[b]PWR = pressurized water reactor; BWR = boiling water reactor.

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3. A loading area for incoming and outgoing shipments.

4. A vehicle washdown facility.

5. A loading and unloading bay where the shipping packages would be removed from and loaded onto their carriers.

6. A decontamination station in the waste-handling building where waste packages would be checked and decontaminated.

7. A station in the waste-handling building where cask closure(s) would be prepared for connecting the casks to the hotcell port for unloading (Figure A-5).

After the casks are unloaded, the spentfuel assemblies would be packaged in the Stage 1 waste-handling building, or they may be disassembled and individual fuel rods consolidated into specially designed waste packages in the Stage 2 waste-handling building. This description assumes that the facilities for consolidating the spent-fuel assemblies would be located at the repository as described in MacDougall (1985).

A.2.2.1.2 Waste emplacement

Waste emplaced at the repository would consist predominantly of spent fuel that has been out of the reactor for at least 10 years. In addition, onsite-generated low-level waste would be disposed of in the repository. Estimates are not available at this time, but quantities of these wastes are expected to be small.

Before disposal, spent fuel would be sealed in waste disposal containers designed to meet the minimum lifetime requirements set by the NRC (10 CFR Part 60). To meet these requirements, the minimum lifetime of the waste packages would be between 300 and 1,000 years under the expected subsurface environmental conditions in the repository. These waste disposal containers are one component of a system of engineered barriers, including waste forms, overpacks, and packing materials that may be used as part of the repository system.

After the waste disposal containers have been judged to be suitable for emplacement, they would be held temporarily in a surge-storage area. This surge storage would allow incoming waste to be unloaded and prepared for disposal at a faster rate than it can be emplaced, thus reducing the yard-storage time. The design rate of waste emplacement, however, would be determined to minimize the length of time required for surge storage. After surge storage, the waste disposal containers would be transported to the waste emplacement access ramp by waste transporters and transferred to the underground facility. The waste disposal containers would be placed either in vertical holes in the floors of the storage drifts (vertical emplacement) or in long horizontal holes in the walls (horizontal emplacement). If the waste is placed horizontally, each borehole would contain up to 34 waste disposal containers; if vertically, each borehole would contain one waste disposal container (MacDougall, 1985).

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The surface and subsurface facilities at the repository that handle radioactive waste would be operated at less than atmospheric pressure. Exhaust air from the surface facilities would be processed through a pre-filter and a series of high efficiency particulate filters before being discharged into the atmosphere. Exhaust from the underground waste-storage rooms would be directed to a surface building where the exhaust would be monitored and filtered, if necessary, prior to being discharged into the atmosphere. The ventilation system for the underground construction areas would be physically separated from the waste-emplacement ventilation circuit.

A.2.2.2 Caretaker phase

The caretaker phase of up to 22 years would begin following the last emplacement of waste and would continue until the start of the decommissioning period. This phase would include the balance of the retrieval option period and possible retrieval time for the emplaced waste.

A decision to close and decommission the repository could be made at any time during the caretaker phase. If a decision to retrieve the emplaced waste is made during the caretaker phase, the lifetime of the Project would be extended up to approximately 30 years during which actual waste retrieval would be accomplished.

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A.2.3 RETRIEVABILITY

The Yucca Mountain repository would be designed to allow retrieval of emplaced waste as required by 10 CFR 60.111. The requirements state that waste must be retrievable for a period of up to 50 years after waste emplacement begins. The requirements also state that if retrieval becomes necessary, the waste should be retrieved in about the same amount of time that was devoted to the initial construction and the emplacement of the waste. The capability to retrieve emplaced waste packages would be maintained until the satisfactory completion of a performance confirmation program as stipulated by 10 CFR 60.111 and until decommissioning activities are authorized by the NRC (unless a longer or shorter time period is specified by the Secretary of Energy and approved by the NRC).

The capability for retrieving the waste disposal containers would be demonstrated prior to a decision to backfill the emplacement drifts and would be maintained regardless of whether the emplacement drifts have been backfilled. Therefore, the decision to backfill would be based, in part, on an evaluation of the advantages of early backfilling versus the disadvantages of increased difficulty of retrieval.

A.2.4 DECOMMISSIONING AND CLOSURE

After the planned 22-year caretaker phase during which retrievability must be ensured and after the performance confirmation program has been

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completed, the DOE would request NRC approval for an amended license for closure of the repository. After approval had been granted, decommissioning of the repository would begin. To decommission the subsurface facilities, salvageable materials would be brought to the surface. During closure, all subsurface access areas (e.g., shafts and ramps) would be sealed by using multiple materials and techniques to ensure that the seal offers isolation properties equivalent to or better than the host rock (Fernandez and Freshley, 1984).

Surface structures would be decontaminated and dismantled. Some contaminated material may be placed underground prior to the sealing of shafts. The surface areas would be reclaimed. Permanent markers would be erected to inform future generations about the presence of the repository. Development of such markers or a marking system is in progress. All records concerning the repository would be maintained by appropriate Federal, State, and local agencies. It is expected that the records and markers would be kept in perpetuity.

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APPENDIX A REFERENCES

Bedmar, A. P., 1983. "Single Well Techniques Using Radioactive Tracers," in Tracer Methods in Isotope Hydrology, Proceedings of an Advisory Group Meeting Organized by the International Atomic Energy Agency and Held in Vienna, 27 September to 1 October 1982, IAEA-TECDOC-291, International Atomic Energy Agency, Vienna, Austria, pp. 17-46.

Bertram, S. G., 1984. NNWSI Exploratory Shaft Site and Construction Method Recommendation Report, SAND84-1003, Sandia National Laboratories, Albuquerque, New Mexico.

BLM/DOE (Bureau of Land Management/Department of Energy), 1982. Cooperative Agreement Between Bureau of Land Management, Las Vegas District, and U.S. Department of Energy, Nevada Operations Office, DE-GM08-82N10302, N5-2-2, 1786, Las Vegas, Nevada.

Department of the Air Force, 1983. Permit to Use Property on Nellis Air Force Range, Nye County, Nevada, DACA09-4-80-332.

DOE (U.S. Department of Energy), 1979. Environmental Aspects of Commercial Radioactive Waste Management, DOE/ET-0029, Vol. 3, Appendix C, Washington, D.C.

DOE (U.S. Department of Energy), 1981. "Environmental Protection, Safety, and Health Protection Program for DOE Operations," DOE Order 5480.1A, Washington, D.C.

DOE (U.S. Department of Energy), 1983. "General Design Criteria Manual," DOE Order 6430.1, Washington, D.C.

DOE (U.S. Department of Energy), 1984. "Environmental Protection, Safety, and Health Protection Standards," DOE Order 5480.4, Washington, D.C.

DOE (U.S. Department of Energy), 1985. "Mission Plan for the Civilian Radioactive Waste Management Program, Overview and Current Program Plans," DOE/RW-005, three volumes, Washington, D.C.

DOE (U.S. Department of Energy), 1986. "Environmental Assessment Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0073, three volumes, Washington, D.C.

Dravo Engineers, Inc., 1984. An Evaluation of the Effects of Horizontal and Vertical Emplacement on Mining at the Yucca Mountain Repository Site, SAND83-7443, Sandia National Laboratories, Albuquerque, New Mexico.

Fernandez and Freshley, 1984.

MacDougall, H.R. (comp.), 1985. Two-Stage Repository Development at Yucca Mountain: An Engineering Feasibility Study, SAND85-1351 (Rev. 1), Sandia National Laboratories, Albuquerque, New Mexico.

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MacDougall, H. R., et al. 1987. "Site Characterization Plan Conceptual Design Report," NNWSI Project, SAND84-2641, Sandia National Laboratories, Albuquerque, New Mexico.

NWPA (Nuclear Waste Policy Act), 1983. "Nuclear Waste Policy Act of 1982," Public Law 97-425, 42 USC 10101-10226, Washington, D.C.

Rao, S. M., 1983. "Use of Radioactive Tracers in Studies on Infiltration Through Unsaturated Zone," in Tracer Methods in Isotope Hydrology, Proceedings of an Advisory Group Meeting Organized by the International Atomic Energy Agency and Held in Vienna, 27 September to 1 October 1982, IAEA-TECDOC-291, International Atomic Energy Agency, Vienna, Austria, pp. 47-66.

State of California, "Mine Safety Orders," Administrative Code, Title 8, Chapter 4, Subchapter 12, State of California.

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CODE OF FEDERAL REGULATIONS

10 CFR Part 60, 1983. Title 10, "Energy," Part 60, "Disposal of High-Level Radioactive Wastes in Geologic Repositories," U.S. Government Printing Office, Washington, D.C.

10 CFR Part 960, 1984. Title 10, "Energy," Part 960, "General Guidelines for the Recommendation of Sites for Nuclear Waste Repositories; Final Siting Guidelines," 49 FR 47714, Vol. 49, No. 236, December 6, 1984, pp. 47714-47769.

10 CFR Part 961, 1985. Title 10, "Energy," Part 961, "Standard Contract for Disposal of Spent Nuclear Fuel and/or High Level Radioactive Waste," U.S. Government Printing Office, Washington, D.C.

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APPENDIX B

RADON/RADON DAUGHTER PRODUCT AND WORKING LEVELS

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APPENDIX B

RADON/RADON DAUGHTER PRODUCTS AND WORKING LEVELS

INTRODUCTION

The soil in the natural environment contains many radionuclides. Typically the radioactivity in soil consists of K-40, Rb-87, Th-232, U-238, and the decay product of Th-232 and U-238. Table B-1 summarizes the distribution of these radionuclides in some soils. Both K-40 and Rb-87 decay into stable elements, while both Th-232 and U-238 decay through a complex chain (Tables B-2 and B-3) that includes isotopes of the inert gas radon.

The Thorium (Th-232) series and the Uranium (U-238) series decay schemes have a number of characteristics in common:

1. They have a number of radionuclides in the decay chain with half-lives greater than one year which produce radium isotopes Ra-224 and Ra-226. Since these radionuclides are not gaseous, they build up in the soil/rock until they reach secular equilibrium. Secular equilibrium means that the activity and production of the shorter-lived daughter radionuclides is equal to that of the very long-lived parent isotopes (Th-232 and U-238). Since the concentration of these radionuclides is affected by leaching, the equilibrium concentration may not actually occur in the soil/rock.

Table B-1. Summary of concentrations of major radionuclides in major rock types and soil[a]

Rock type	Potassium-40: Percent total potassium	Potassium-40: pCi/g	Rubidium-87: ppm total rubidium	Rubidium-87: pCi/g	Thorium-232: ppm	Thorium-232: pCi/g[b]	Uranium-238: ppm	Uranium-238: pCi/g[c]
Igneous rocks								
Basalt (crustal average)	0.8	7	40	0.9	3-4	0.3-0.4	0.5-1	0.2-0.3
Mafic[d]	0.3-1.1	2-9	10-50	0.2-1	1.6, 2.7	0.2, 0.3	0.5, 0.9	0.2, 0.3
Salic[d]	4-5	30-40	170-200	4-5	16, 20	1.7, 2.2	3.9, 4.7	1.3, 1.6
Granite (crustal average)	>4	>30	170-200	4-5	17	1.9	3	1
Sedimentary rocks								
Shale	2.7	22	120[e]	3	12	1.3	3.7	1
Sandstones:								
clean quartz	<1	<8	<40[e]	<1	<2	<0.2	<1	<0.3
dirty quartz	2?	10?	90?	2?	3-6?	0.3-0.7?	2-3?	1?
arkose	2-3	16-24	80-120[e]	2	2?	0.2?	1-2?	0.3-0.7?
Beach sands (unconsolidated)	<1	<8?	<40?	<1?	6	0.7	3	1
Carbonate rocks	0.3	2	10[e]	0.2	2	0.2	2	0.7
Soils[f]	1.5	12	65[e]	1.4	9	1	1.8	0.6

[a] Estimated values are followed by a question mark.

[b] To obtain series equilibrium alpha, beta, or approximate gamma (excluding bremsstrahlung and x radiation) activity, multiply by 6, 4, or 3 respectively.

[c] To obtain series equilibrium alpha, beta, or approximate gamma (excluding bremsstrahlung and x radiation) activity, multiply by 8, 6, or 3 respectively.

[d] From Clark et al. (1966); for potassium and rubidium, the range of values for rocks within the class is given; for thorium and uranium, the median and mean value are given, respectively.

[e] Estimated by application of crustal abundance ratio with respect to potassium.

[f] In situ gamma-spectral measurements at 200 locations by Lowder et al. (1964).

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Table B-2. Thorium series (4n)[a]

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities[b]: α		β		γ	
$^{232}_{90}Th$	Thorium	1.41×10^{10}y	3.95 4.01	(24%) (76%)	--		--	
$^{228}_{88}Ra$	Mesothorium I	6.7y	--		0.055	(100%)	--	
$^{228}_{89}Ac$	Mesothorium II	6.13h	--		1.18 1.75 2.09	(35%) (12%) (12%)	0.34c[c] 0.908 0.96c	(15%) (25%) (20%)
$^{228}_{90}Th$	Radiothorium	1.910y	5.34 5.43	(28%) (71%)	--		0.084 0.214	(1.6%) (0.3%)
$^{224}_{88}Ra$	Thorium X	3.64d	5.45 5.68	(6%) (94%)	--		0.241	(3.7%)
$^{220}_{86}Rn$	Emanation Thoron (Tn)	55s	6.29	(100%)	--		0.55	(0.07%)
$^{216}_{84}Po$	Thorium A	0.15s	6.78	(100%)	--		--	
$^{212}_{82}Pb$	Thorium B	10.64h	--		0.346 0.586	(81%) (14%)	0.239 0.300	(47%) (3.2%)
$^{212}_{83}Bi$	Thorium C	60.6m	6.05 6.09	(25%) (10%)	1.55 2.26	(5%) (55%)	0.040 0.727 1.620	(2%) (7%) (1.8%)
64.0% → $^{212}_{84}Po$; 36.0% → $^{208}_{81}Tl$								
$^{212}_{84}Po$	Thorium C'	304ns	8.78	(100%)	--		--	
$^{208}_{81}Tl$	Thorium C"	3.10m	--		1.28 1.52 1.80	(25%) (21%) (50%)	0.511 0.583 0.860 2.614	(23%) (86%) (12%) (100%)
$^{208}_{82}Pb$	Thorium D	Stable	--		--		--	

[a]This expression describes the mass number in this series, where n is an integer. Example:

$^{232}_{90}Th$ (4n).....4(58) = 232

[b]Intensities refer to percentage of disintegrations of the nuclide itself, not to original parent of series.
[c]Complex energy peak which would be incompletely resolved by instruments of moderately low resolving power such as scintillators.

Table B-3. Uranium series (4n + 2)[a] (page 1 of 2)

Nuclide	Historical name	Half-life	Major radiation energies (MeV) and intensities[b] α		β		γ	
$^{238}_{92}U$	Uranium I	4.51 x 10^9y	4.15 4.20	(25%) (75%)	--		--	
$^{234}_{90}Th$	Uranium X_1	24.1d	--		0.103 0.193	(21%) (79%)	0.063c[c] 0.093c	(3.5%) (4%)
$^{234}_{91}Pa^m$	Uranium X_2	1.17m	--		2.29	(98%)	0.765 1.001	(0.30%) (0.60%)
99.87% / 0.13%								
$^{234}_{91}Pa$	Uranium Z	6.75h	--		0.53 1.13	(66%) (13%)	0.100 0.70 0.90	(50%) (24%) (70%)
$^{234}_{92}U$	Uranium II	2.47 x 10^5y	4.72 4.77	(28%) (72%)	--		0.053	(0.2%)
$^{230}_{90}Th$	Ionium	8.0 x 10^4y	4.62 4.68	(24%) (76%)	--		0.068 0.142	(0.6%) (0.07%)
$^{226}_{88}Ra$	Radium	1602y	4.60 4.78	(6%) (95%)	--		0.186	(4%)
$^{222}_{86}Rn$	Emanation Radon (Rn)	3.823d	5.49	(100%)	--		0.510	(0.07%)
$^{218}_{84}Po$	Radium A	3.05m	6.00	(≈100%)	0.33	(≈0.019%)	--	
99.98% / 0.02%								
$^{214}_{82}Pb$	Radium B	26.8m	--		0.65 0.71 0.98	(50%) (40%) (6%)	0.295 0.352	(19%) (36%)
$^{218}_{85}At$	Astatine	≈2s	6.65 6.70	(6%) (94%)	?	(≈0.1%)	--	

Table B-3. Uranium series (4n + 2)[a] (page 2 of 2)

Nuclide	Historical name	Half life	α		β		γ	
			Major radiation energies (MeV) and intensities[b]					
$^{214}_{83}Bi$	Radium C	19.7m	5.45 5.51	(0.012%) (0.008%)	1.0 1.51 3.26	(23%) (40%) (19%)	0.609 1.120 1.764	(47%) (17%) (17%)
99.98% ↓ / 0.02% ↓								
$^{214}_{84}Po$	Radium C'	164μs	7.69	(100%)	--		0.799	(0.014%)
$^{210}_{81}Tl$	Radium C"	1.3m	--		1.3 1.9 2.3	(25%) (56%) (19%)	0.296 0.795 1.31	(80%) (100%) (21%)
$^{210}_{82}Pb$	Radium D	21y	3.72	(.000002%)	0.016 0.061	(85%) (15%)	0.047	(4%)
$^{210}_{83}Bi$	Radium E	5.01d	4.65 4.69	(.00007%) (.00005%)	1.161	(≈100%)	--	
≈100% ↓ / .00013% ↓								
$^{210}_{84}Po$	Radium F	138.4d	5.305	(100%)	--		0.803	(0.0011%)
$^{206}_{81}Tl$	Radium E"	4.19m	--		1.571	(100%)	--	
$^{206}_{82}Pb$	Radium G	Stable	--		--		--	

[a]This expression describes the mass number of any member in this series, where n is an integer. Example:

$^{206}_{82}Pb$ (4n + 2).....4(51) + 2 = 206

[b]Intensities refer to percentage of disintegrations of the nuclide itself, not to original parent of series.
[c]Complex energy peak which would be incompletely resolved by instruments of moderately low resolving power such as scintillators.

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2. The radium isotopes decay into isotopes of the inert gas radon. This gas diffuses through soil/rock and may reach the atmosphere before it decays. If the radon isotopes decay while still in the soil/rock matrix, they will be of little interest since the isotopes will not constitute a significant health hazard; however, the isotopes may still be measured by the Pb-210 from the Uranium series.

3. If the radon decays in the atmosphere, then the subsequent daughter products will tend to attach to the aerosol particulates in the air. These particulates may be inhaled and deposited in the lungs. Then the radioactive decay (particularly the alpha decay) may represent a human health hazard. (See National Research Council, 1980; and ICRP 1981, 1985, and 1986.)

The major differences between these two series, relative to health protection concerns, is that, because of the relatively short half-life of Ra-220 (55 seconds) in the Thorium series, very little of this radon isotope escapes from the rock or soil matrix. The radon isotope in the Uranium series, Ra-222, has a much longer half-life (3.8 days), so a much larger portion of this isotope reaches the atmosphere.

Because radon is an inert gas, the health hazard associated with it is not from the gas itself, but from the daughter products which are inhaled and subsequently deposited in the lungs. Working levels (WLs) are used to quantify the potential radon/radon daughter product concentration in a way useful in evaluating hazards. One working level is defined as any combination of

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short-lived radon daughters in one liter of air which will result in the eventual emission of 1.3 x 10^5 million electron volts (MeV) of alpha particulate energy. This is equivalent to the original definition which was 100 pCi of radon in secular equilibrium with its daughters in one liter of air. WL is a measure of exposure rate, while working-level month (WLM) is a measure of integrate exposure. A WLM is defined as exposure at a rate of one WL for 170 hours, which is the length of a typical working month. The current limit for radon/radon daughter product exposure is four working-level months in one year (WLM/y). WLM/y are calculated by

$$\text{Exposure (WLM/y)} = \text{Concentration (WL)} * \frac{\text{Time (hours)}}{\text{170 hours/month}}$$

One year

One WLM/y is equivalent to about 0.7 rads/y or, equivalently, 10 rem/y to the bronchial epithelium (NCRP, 1984).

The monitoring associated with the radiological monitoring program will consist of integrating samplers, continuous monitors, and grab samplers. The next section will discuss the integrating samplers which use track etch techniques; then the other monitoring/sampling techniques will be addressed.

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B.1 INTEGRATING RADON SAMPLERS

Two systems are projected for use in these activities. One system, currently supplied by Terredex, measures radon concentrations; the other system under consideration measures radon daughter product concentrations and is available from RAD Services and Instrumentation, Ltd. Everyone involved in these activities must participate in the EPA Office of Radiation Programs' (ORP) Radon/Radon Progeny Measurement Proficiency Program (RTIS, 1987). Suppliers shall provide the data necessary for the NNWSI Project to review their performance in this program.

B.1.1 RADON INTEGRATING SAMPLERS (IS)

The Terredex IS for measuring radon in air is based on producing alpha-particle tracks in a plastic material. One such device utilizes a small strip of the plastic detector material taped to the bottom of a plastic cup (Figure B-1). A filter is attached to the top of the cup through which radon easily diffuses, although the particulates to which the radon daughter products attach cannot. When the radon decays, the radon daughter products deposit on the inside surface of the cup, including the surface of the plastic detector. When the Po-218 and Po-214 atoms which have deposited on the detector decay, they produce alpha-particle tracks in the plastic material. The detector does not respond to beta particles or gamma rays; therefore, a correction for ambient background is not required.

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Figure B-1. Terrradex integrating radon sampler.

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The alpha-track method is relatively insensitive; therefore, under normal environmental conditions, exposure periods ranging from one month to one year are typically used. After the detector is exposed, it is returned to the manufacturer for analysis. The analysis consists of etching the plastic detector to make the alpha tracks visible, and then determining the track density by manually scanning and counting tracks or using an automated optical scanning system. The track density and the time of exposure are then used to calculate an average radon concentration value. (Jenkins (to be published); personnel communication to be published.)

Terredex indicates that the Type F IS used in this activity has a detection range from 0.2 to 20,000 pCi/l-months. The IS returned to Terredex will routinely contain unexposed ISs and ISs exposed to a known concentration of radon in an ORP facility located in Las Vegas, Nevada.

B.1.2 RADON DAUGHTER PRODUCT INTEGRATING SAMPLER (IS)

RAD M-1s, radon daughter product IS (radon daughter product IS), is the Solid State Track detector version of the Radon Daughter Product Integrated Sampling Unit. This radon daughter product IS collects the daughter products on a filter medium and then measures the alpha dose from them using a track etch detector. The primary advantage of the track detector is that the efficiency can be calculated by the instrument geometry which is a straight-line alpha trajectory from source (filter paper) to the detector. Experimental calibration is therefore not required and the accuracy of measurement

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is solely dependent upon the volume of air sampled. By adhering to the standard operating procedure, a single measurement can be expected to have a precision of within 22 percent of the true value (at 95 percent confidence level). The precision has been well-established by both laboratory and field intercomparison with the time average of Kusnetz results. The intercomparison includes the DOE Laboratories of both the Environment Measurement Laboratory in New York and the Bendix Field Engineering Laboratory of Grand Junction. The limit of sensitivity is 0.0001 working levels.

The RAD M-1 Surveymeter (Figure B-2) consists of two parts--the pump and the detecting head assembly. Accuracy of measurements made by this surveymeter requires an exact record of the flow rate of the pump and the length of time the pump ran. The pump is designed for continuous and stable operation. It can be used for sampling periods ranging from three days to two weeks. A one-week sampling period is recommended. Each pump is checked initially after running continuously for ten days. Checking again prior to use is not necessary, but a recalibration after five service intervals is recommended. The person using the M-1 must accurately record start date and time and stop date and time.

The detector is a polycarbonate plastic compound used for solid-state alpha track registration. When used within a properly designed instrument, it is able to discriminate between alpha particles from Po-218 and those from Po-214. The working level (WL) measurement is based on the formula:

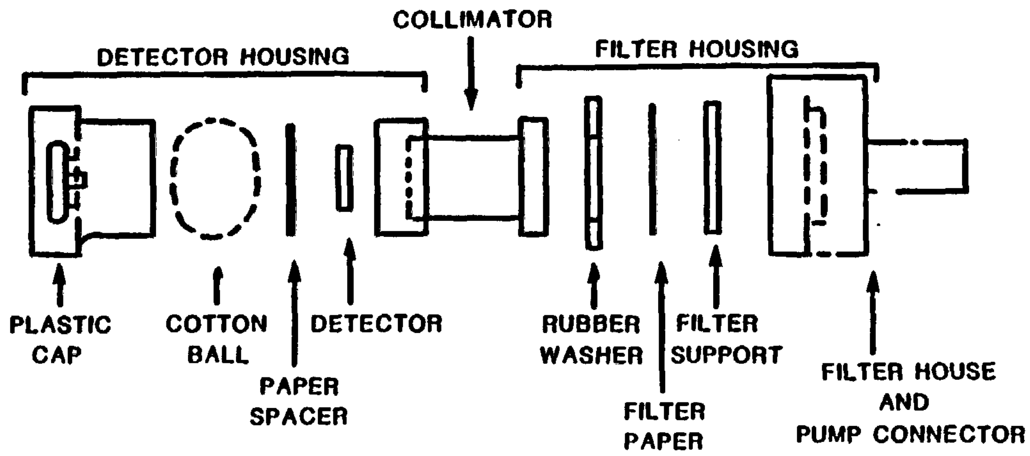

Figure B-2. Radon daughter product IS (RAD M-1 Surveymeter).

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$$WL_{Rn222} = \frac{6\ R_A + 7.68\ R_C}{1.3 \times 10^5\,(E)\,(V)} \qquad \text{(B-1)}$$

where

R_A = number of tracks for Po-218;

R_C = number of tracks for Po-214;

E = alpha counting efficiency (tracks/disintegration); and

V = liters of air drawn through the filter (liters/hr x hrs).

Accuracy of the instrument depends upon the accuracy to which the total sampled air volume is known. In the absence of a means of measuring this quantity, it is essential that the average flow rate during the sampling period be close to that measured when the instrument was initially set up. The pump used in this surveymeter is designed to be stable after a short warm-up period. Variations in flow rate during the short warm-up period do not significantly change the average for periods of one day or longer. Long-term tests have shown that the maximum deviation from the mean flow rate is less than 10 percent.

B.2 CONTINUOUS RADON MONITOR (CRM) AND BATCH RADON SAMPLER (BRS)

Both the CRM and the BRS are now available for use from Pylon Systems based on a Pylon Model AB-5 Radiation System. Different detection configurations are used to perform these functions, although the BRS function could be

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performed by the CRM configuration by altering the programmable sampling mode.

B.2.1 CRM CONFIGURATION

The CRM configuration consists of a 20-liter electrostatic chamber (the PMT-TEL) which is attached to the AB-5. The AB-5 provides the controlled vacuum supply as well as the signal evaluation capability.

The PMT-TEL consists of a 20-liter electrostatic chamber with an aluminum conductor which serves as the collector or cathode. This cathode has an electrical potential of 1,800 volts. Power to the cathode is supplied by four 1.5 volt ("c" cell) alkaline batteries or from AC line power by means of an optional battery eliminator (Figure B-3). A built-in AC-DC convertor in the TEL steps up the incoming 6 volts to 1,600 volts. The wall of the electrostatic chamber acts as an anode and is at ground potential. The cathode overlays an alpha sensitive scintillator which is mounted on a lucite light pipe. The light sensitive PMT meets the top of the light pipe with the protruding end of the PMT being protected by the PMT housing. Air to be tested for radon gas is drawn into the PMT-TEL by a pump in the AB-5.

Radon gas in the TEL decays into Po-218^{+} which is attracted to the negatively charged cathode. Po-218^{+} decays into Pb-214 which, in turn, decays into Bi-214 and Po-214 as shown in Table B-3. Po-210^{+} and Po-214^{+} emit alpha particles. These particles impact with the scintillator, which then produces light pulses. The light pulses are transmitted by the light

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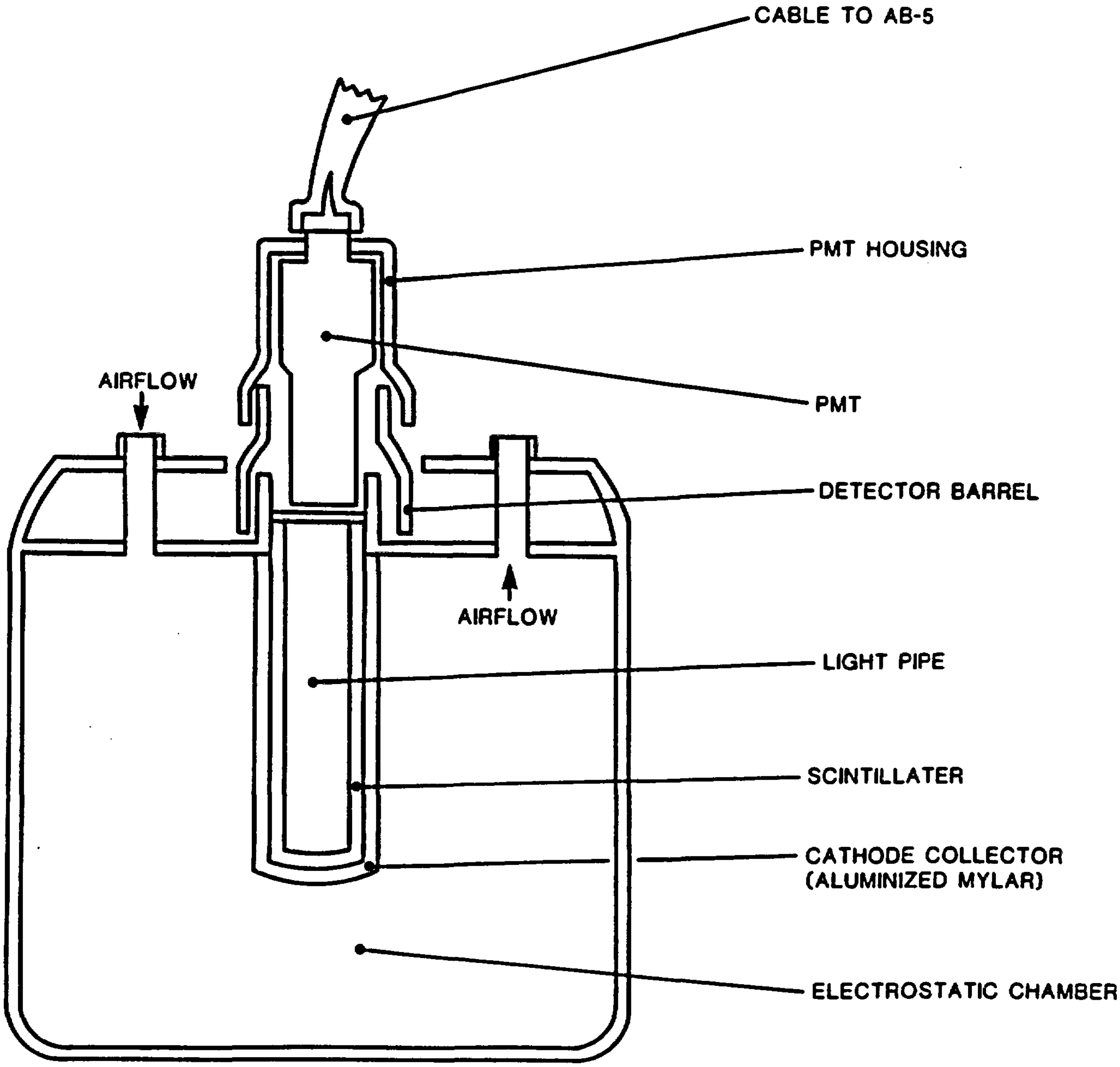

Figure B-3. Cross section of PMT-TEL (simplified).

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pipe to the PMT, where they are amplified and sent via a cable to the AB-5, where they are counted. The AB-5 displays the counts and can either be set to print the counts on a printer or to transmit the counts to a computer. The AB-5 can also store the data for later printout, display, or transfer to a computer.

Since radon gas decays and emits alpha particles in a predictable manner, there is a direct relationship between the number of light pulses counted by the PMT-TEL/AB-5 and the amount of radon gas in the air being tested. The PMT-TEL has sensitivity to radon gas of 25cpm/pCi/l. The sensitivity value is calculated as follows:

$$S = \frac{\text{net counts of light pulses/minute}}{\text{known amount of radon}} \qquad \text{(B-2)}$$

where net counts of light pulses are the total number pulses counted by the AB-5 less the number of counts due to background and the amount of radon is known precisely.

When the sensitivity of the PMT-TEL has been determined, the sensitivity value can then be used to measure the amount of radon gas present to be tested. The formula is:

$$\text{Radon level} = \frac{\text{net count/interval}}{\text{(interval length)} \times \text{sensitivity}} \qquad \text{(B-3)}$$

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The basic configuration of the CRM is illustrated in Figure B-4. Further detail on the AB-5 is provided by Figure B-5.

B.2.2 BRS CONFIGURATION

To take a sample of air at any specific time, a batch sample is used. Batch sampling systems collect a sample of existing air and then evaluate it, unlike continuous systems (CRMs), which give you a running average value. Batch samples can be taken of either the radon or radon daughter product concentration.

B.2.2.1 Radon batch measurements

To measure radon concentration using batch sampling, simply shut off the CRM pump after the sampling period, and continue counting the sample as it decays. The typical method using the CRM configuration to obtain a batch sample involves setting a 10-minute sampling period. The AB-5 is set to run on 10-minute intervals with six intervals per cycle. The counts for the five intervals when the pump is not being run are used. The formula is:

$$\text{Radon level} = \frac{1}{S}\,(Cn - K\,(Cn\text{-}1)) \qquad \text{(B-4)}$$

where

Cn = net sum of counts over 50 minutes (intervals 2-5) of the n^{th} cycle

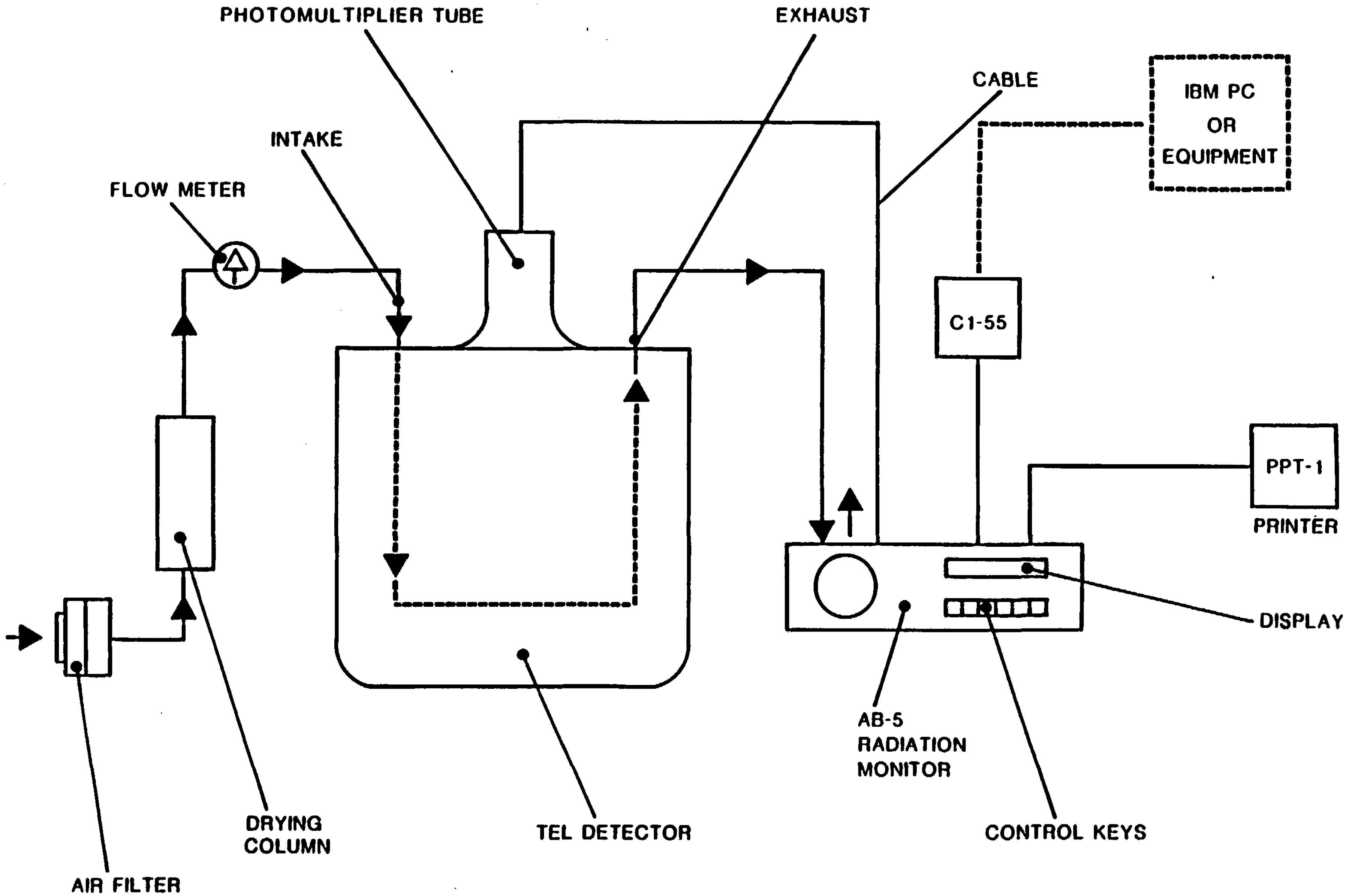

Figure B-4. Diagram of layout of PMT-TEL/AB-5 system.

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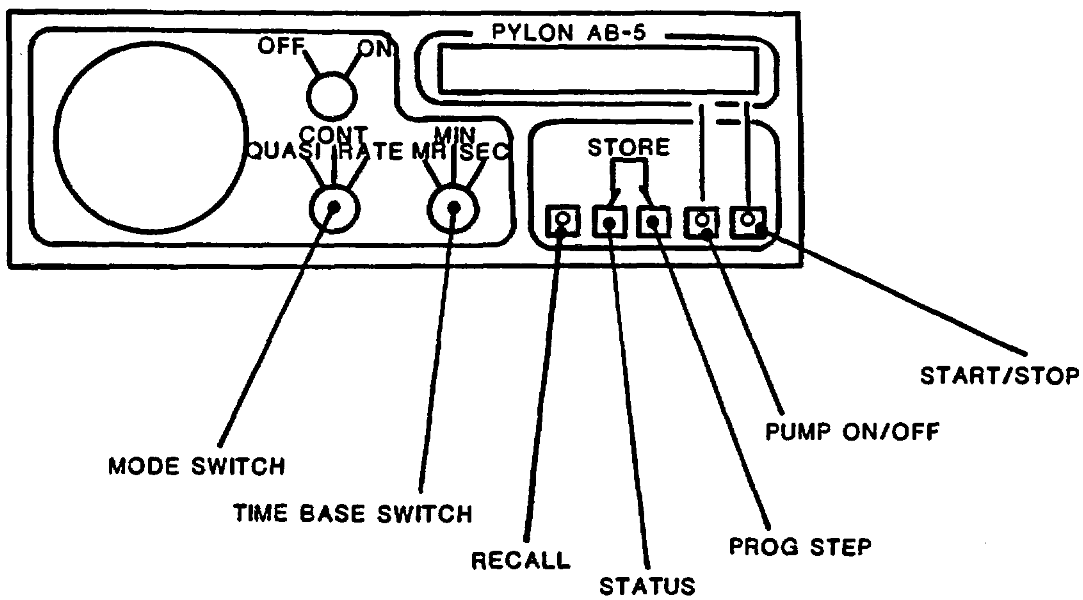
FRONT PANEL



REAR PANEL

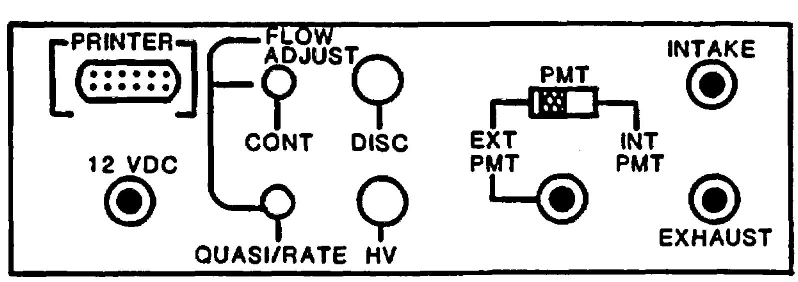


Figure B-5. Pylon Model AB-5 radiation system.

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Cn-1 = net sum of counts over 50 minutes (intervals 2-5) of the previous cycle

S = Sensitivity

= 50(1-K) times the unusual cell efficiency

B.2.2.2 Radon daughter product measurements

Pylon Model AEP-47 Alpha Detection Assemblies are used with the Pylon Model AB5 Portable Radiation Monitor for measuring radon daughters, thoron daughters, and other alpha-emitting airborne particulates. They are designed for accurate and reliable measurements and are particularly well-suited for automated monitoring applications. The AEP detector, as shown in Figure B-6, has a wide sampling port designed to provide optimum sampling characteristics. Plateout on the inlet surface is minimized and, at the same time, interference from cross drafts at the sampling filter surface is eliminated. The filter is thus essentially open-faced. Because the active material is collected on the side of the filter away from the detector, the build-up of dust and contamination on the surface of the light shield inside the detector is prevented. The silver-activated zinc sulfide scintillator is covered by an aluminized mylar light shield to prevent interference from ambient light. The scintillator is insensitive to gamma and beta radiation. A 0.125-inch lucite light pipe provides support to the ZnS(Ag) scintillator and improves optical coupling to the photomultiplier tube in the AB-5. There is negligible variation in counting efficiency across the diameter of the scintillator.

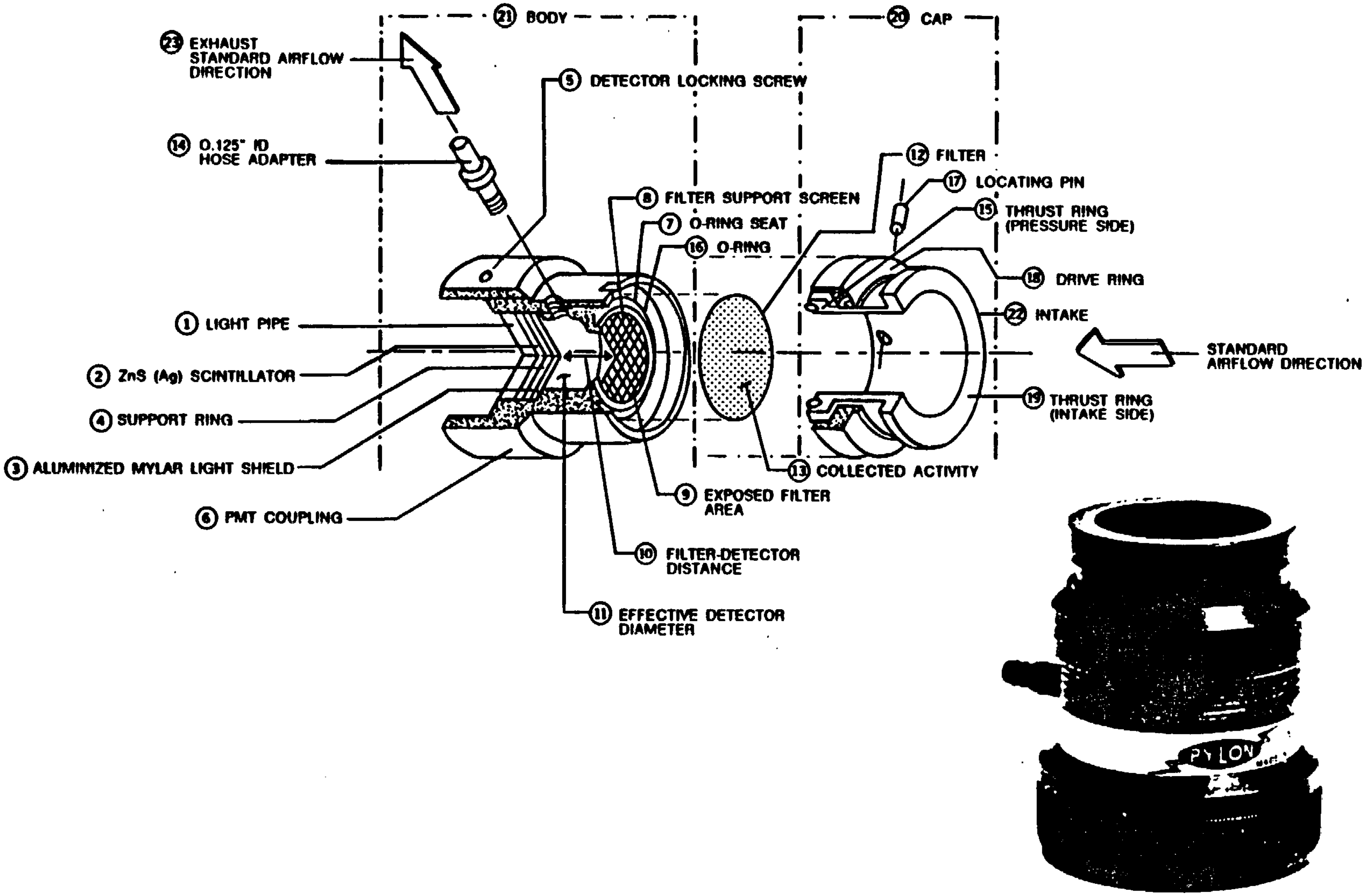

Figure B-6. AEP assembly.

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The currently available BRS is the Pylon AEP-47. The AEP-47 is intended for use with 47mm-diameter filters. The Pylon AB-5 with AEP-47 detector is designed to measure alpha-emitting particulates within the energy range of 4.5 to 9.0 MeV with sensitivity decreasing somewhat below 5.5 MeV. This is ideal for measuring radon daughters (6.0 and 7.7 MeV) and thoron daughters (6.0 and 8.8 MeV). This sampler can be used to assess daughter product concentrations using the Kusnetz (Kusnetz, 1956) or Tsivgolov (Thomas, 1972; Tsivgolov et al., 1953) methods.

B.2.3 CALIBRATION OF THE CRM AND BRS

These instruments and their associated procedures will be calibrated and evaluated using three basic methods. The first is the routine calibration of the equipment using NRS traceable radon/radon daughter product sources. The second method is calibration in the ORP facility in Las Vegas, Nevada. The final method is calibration and evaluation through participation in the ORP Radon/Radon Progeny Measurement Proficiency Program (RTIS, 1987).

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APPENDIX B REFERENCES

Bureau of Radiological Health, 1970. "Radiological Health Handbook," U.S. Department of Health, Education, and Welfare, Public Health Service Publication No. 2016, U.S. Government Printing Office, Washington, D.C.

Clark, S. P., Jr., et al., 1966. "Abundances of Uranium, Thorium, and Potassium," pg. 521, in Handbook of Physical Constants, Revised Edition, Clark, Sydney P., Jr. Ed., Geological Society of America Memoir 97, Geological Society of America, Inc., New York.

ICRP (International Commission on Radiation Protection), 1981. "Limits for Inhalation of Radon Daughters by Workers," Annals of the ICRP, Publication 32, Pergamon Press.

ICRP (International Commission on Radiation Protection), 1985. "Radiation Protection of Workers In Mines," Annals of the ICRP, Publication 47, Pergamon Press.

ICRP (International Commission on Radiation Protection), 1986. "Lung Cancer Risk from Indoor Exposures to Radon Daughters," Annals of the ICRP, Publication 50, Pergamon Press.

Jenkins, Phillip H. (to be published). "Radon Measurement Methods: An Overview," Monsanto Research Corporation - Mound, personal communication NNWSI letter number NNA.871007.0052.

Kusnetz, H. L., 1956. "Radon Daughters in Mine Atmospheres - A Field Method for Determining Concentrations," American Industrial Hygiene Association Quarterly, Volume 17.

Lowder, W. M., et al., 1964. "Field Spectrometric Investigations of Environmental Radiation in the U.S.A.," in The Natural Radiation Environment, Adams, J.A.S. and Lowder, W.M., Eds. University of Chicago Press, Chicago, Illinois, pg. 597.

National Research Council, 1980. "The Effects on Population of Exposure to Low Levels of Ionizing Radiation: 1980," Committee On the Biological Effects of Ionizing Radiation, National Academy Press, Washington, D.C.

NCRP (National Council on Radiation Protection and Measurements), 1975. "Natural Radiation Background Radiation In the United States," NCRP Report No. 45, National Council on Radiation Protection and Measurements, Washington, D.C.

NCRP (National Council on Radiation Protection and Measurements), 1984. "Exposures From The Uranium Series With Emphasis On Radon and Its Daughters," NCRP Report No. 77.

Pylon Electronic Development Company, Ltd., 1987a. "Pylon Model PMT-TEL Trace Level Radon Gas Detector Instruction Manual," personal communication, NNWSI letter number NNA.870921.0020.

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Pylon Electronic Development Company, Ltd., 1987b. "Pylon Model AEP-25, AEP-47 Alpha Detector Assembly Instruction Manual," personal communication, NNWSI letter number NNA.870921.0018.

RAD Service & Instrument Ltd., no date. "Radon/Thoron Daughter Monitor," personal communication, NNWSI letter number NNA.871007.0052.

RTIS (Radon Technical Information Service), 1987. "Radon/Radon Progeny Measurement Proficiency Program," Office of Radiation Programs, U.S. Environmental Protection Agency (EPA-52011-87-002).

Thomas, J. W., 1972. "Measurement of Radon Daughters in Air," Health Physics, Volume 23, pg. 783.

Tsivogolov, E. C., Ayer, H. E., and Holaday, D. A., 1953. "Occurrence of Nonequilibrium Atmospheric Mixtures of Radon and Its Daughters," Nucleonics, Volume 1, pg. 40.

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APPENDIX C

METHODS FOR DATA HANDLING AND INTERPRETATION

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APPENDIX C

METHODS FOR DATA HANDLING AND INTERPRETATION

The levels of radioactivity involved in environmental media are very low and even small fluctuations in the background (i.e., true level or value of the contaminant whether measured or not) could mask a release from a facility, thus preventing an accurate assessment of the impact, if any. These fluctuations may be either internal or external in nature. An internal fluctuation may be due to counting statistics, sampling procedures, radiochemical procedures, or instrument stabilities. External fluctuations may result from variations in cosmic ray intensity, global fallout from weapons testing, emissions from other facilities and activities in the general vicinity, or variability in meteorological/climatological conditions.

The problem is to reduce the occurrence of unexplained fluctuations through proper control of appropriate internal factors, or to effectively identify the cause of the fluctuations, whether internal or external in nature. Internal fluctuations tend to be more procedural in nature and may be limited by improved methods of sampling, of analysis, or by organizational measures. The external fluctuations are typically beyond control, but may be observed and measured within some statistically significant range since most of the fluctuations are expected to be small in amplitude. Careful statistical analysis is required for proper evaluation of unexpected fluctuations and routine observations.

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To ensure a data set that lends itself to the various statistical methodologies available, certain general objectives must be achieved. These include, but are not limited to:

1. Developing an easily accessible data base management system.

2. Obtaining a minimum number of years of background data covering all critical pathway nuclide/media combinations analyzed by sample type and location.

   a. To evaluate predictable periodictius (seasonal, diurnal, etc).

   b. To identify any existing anomalies associated with specific media and locations.

   c. To evaluate validity of indicator and control sample locations.

   d. To define the expected statistical characteristics of the data.

   e. To determine interferences or contributions to background fluctuation due to other facilities.

3. Establishing uniform methods of data evaluation to develop the generic statistical models that allow for prediction of changes in background levels.

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For the purposes of this program, the recommendations and guidance established in Watson (1980) will be incorporated to the extent practical, to assure the quality and usability of the analytical data produced. More specific direction for maintaining analytical sensitivity and consistency in the mathematical definitions are available in Currie (1985) and Brodsky (1986). Specific statistical methodologies and standard analytical guidance is being developed for inclusion in the Environmental Radiological Technical Procedures Manual (ERTPM). This Standard Analysis Guide will provide the day to day guidance for data handling, reduction and evaluation. The following briefly describes some techniques that will be used for interpretation of data.

Mechanical or graphic representation of data, typically on probability paper of some kind by type within homogeneous groups (i.e., gross alpha activity at each continuous air sampling station and specific radionuclide/ media), provides one of the simplest interpretive techniques for recognition of significant trends. Groups of data will typically be tested on the basis of parameters such as geographical location, time of sampling, sample media, radionuclide of concern, meteorological conditions, etc. (Dunham (1974) and Waite (1976)).

It is planned that for a specific data set for which the distribution is unknown, a log-normal one will be the first alternative tried. Because the data set is presented graphically, the mean, standard deviation, expected upper limits, and potential facility contribution or offsite facility influence can be readily determined visually. An important aspect of log-normal distribution plotting is that some indication of data or sample

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representativeness can be visually obtained. Nonrepresentative or nonbackground data sets are reflected by a change in the standard geometric deviations of the plot becoming bimodel in character.

Because radiological environmental monitoring programs require state-of-the-art technology applied to small amounts of background radioactivity, some analyses do not result in the detection of activity. For significant numbers of data, particularly those from which a chemical or instrumental background must be subtracted, net values may be obtained that are lower than the detection level of the system. In spite of the fact that a negative value for an arithmetic concentration measurement does not represent a physical reality, a valid long-term arithmetic concentration average of many measurements can be obtained only if all of the values (both the very large and the very small, including zero and negative values) are reported and included in the analysis of the data.

If a large fraction of the data group is below the analytical detection level, special considerations are needed to determine the long-term average concentration and the standard deviation. A conventional arithmetic average is not a good measure of central tendency. The average is dominated by the (statistical) unrepresentativity of those few largest values in a data set and is probably not representative of the "real" environmental average. Probability plotting is the preferred method for handling these skewed data sets. The method is valid so long as a few data exceed the detection limit, although as a practical matter the confidence level may be low if fewer than 10 positive values are involved with the fitting.

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After groups or subgroups of data have been arranged so they are separately homogenous, averages and standard deviations may be obtained from the probability plots. These may in turn be tested quantitatively with ordinary statistical methods. Results of these numerical tests may verify the homogeneity of groupings or establish the differences, if any, related to the data groupings.

The presence of a distribution mode that is distinct from background usually indicates local contamination. The presence of only one "slope" in a probability plot is indicative of background concentrations, whereas bimodal distributions suggest an outside influence. The 84.1 percent/50 percent ratio of a log-probability curve is an index of the random statistical variability to be expected in environmental radiological data, but systematic variations in data occur on temporal or seasonal cycles. Awareness of these yearly fluctuations can be achieved by running geometric means of radionuclide activity versus time on a semilog graph. The significance of apparent deviations from the expected value is generally determined by assessing the occurrence probability of such a deviation by conventional control chart methods.

By using log-normal distribution for interpreting environmental surveillance data, especially gross count data and most radionuclide/sample media combinations, assessment of local impacts on the environment, if any, is made apparent through the change in slope of the log-probability graph. No change in slope confirms that no detectable influence has occurred for the specific data set. The key to this kind of analysis is to treat the data as groups, not as individual data points. Because the technique suggested is graphic,

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whether or not the assumption of log normality is correct, can be identified visually.

The interpretation of the TLD field exposure data is usually carried out on the basis of the total field exposure not on the basis of the log-normal probability distribution frequently used for nuclide/media specific evaluation. To differentiate between potential facility related exposure and all exposure components, unrelated to the facility, each field site TLD measurement is made up of three analytical components: (1) an environmental specific component, (2) a field site (monitoring location) specific component, and (3) a facility contributed component.

The environmental specific component is equal for all field sites and is determined by the average of the field sites' exposures. This component includes the changes in the total measured background, which are assumed to be proportionally the same at all locations in a given measurement period (e.g., seasonal influences, fading, transport, storage, changes in the calibration procedures, etc.) and is an "effective" average environmental exposure.

The second component is a field-site specific value. The difference in the background exposure rate between locations is decisively affected by the specific field-site exposure properties as well as by the local exposure and absorption of building materials. This component represents the differences of the field-site exposure rate to the environmental average. The field-site specific component is calculated from the background (pre-operational) data.

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The differences between the average environmental exposure and the site specific parameter represent the expected background exposure for each field site within a given measurement period. These differences are the expectance values. The third component which represents the facility contribution, is given by the difference between the measured values and the expectance values.

This method of TLD interpretation allows a control or check to be made of the quality of the background measurements, by comparing them with statistically significant expectance values. The expectance values are defined and calculated as a difference between the average of all field-site measurements over the controlled measurement period, and the site specific parameters. These parameters are determined on the basis, and as a result, of the pre-operational measurements. This avoids the need to use one or more control locations, as in other methods.

Data interpretation for radon monitoring requires more specific development and application of multivariable statistical methodologies to assess accurately diurnal seasonal and/or climatically induced variability in emanation rates (variate radon flux). Regardless of the final statistical model used for evaluations of the radon flux and quantification of the potential release from the site, the analysis will be conducted in accordance with the requirements of TPB-ER-017, Environmental Monitoring Radiological Reports/Plans, Analysis, Computer Program Usage, and Readiness Reviews.

With the complexity of the background for which the environmental radiological monitoring program for the NNWSI Project is required to characterize

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extensive statistical treatment of all data will be necessary. As data is collected and evaluated a reliable statistical baseline model will be developed. In this instance a clean distinction between "baseline" and "background" is being made. Baseline (baseline model) means a numerical approximation of the "real" background. Background refers to the "reality" of low concentration levels of radionuclides (contaminants) as it exists at any given time, whether measured or not. The baseline model is the value compared against measured data to determine whether the background is exceeded. Therefore, continual assessments of statistical treatments of data are needed to assure a precise site specific baseline model and enhancement of productive models for impact assessment. Development of statistical treatment methodologies to be issued with the ERTPM as the Standard Analysis Guide will be in accordance with established procedure and requirements for the conduct or development of analysis, computer codes, and programs, and reporting of assessments.

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APPENDIX C REFERENCES

ANSI (American National Standards Institute), 1975. Performance, Testing and Procedural Specifications for Thermoluminescence Dosimetry (Environmental Applications), ANSI N545-1975.

Bevington, P. R., 1969. Data Reduction and Error Analysis for the Physical Sciences, McGraw-Hill Book Co., New York, New York.

Brodsky, A., 1986. Accuracy and Detection Limits for Bioassay Measurements in Radiation Protection, NUREG-1156.

Currie, L. A., 1984. Lower Limit of Detection: Definition and Elaboration of a Proposed Position for Radiological Effluent and Environmental Measurements, NUREG/CR-4007.

Czannecki, J., 1983. "An Interpolation Method of TLD-Environmental Data," J. Czannecki, Health Physics, Vol. 45, July 1983, pp 173-179.

Dunham, D. H., et al., 1974. "Some Practical Applications of the Log-normal Distribution for Interpreting Environmental Data", 20th Annual Health Physics Society Meeting, Philadelphia, Pennsylvania.

EML (Environmental Measurements Laboratory), 1979. "Evaluation of Methods for the Determination of X- and Gamma-Ray Exposure Attributable to a Nuclear Facility Using Environmental TLD Measurements," NUREG/CR-0711, (EML-355), June 1979.

Gilbert, R. O., and R. B. Kinnison, 1980. "Statistical Methods for Estimating the Mean and Variance from Radionuclide Data Sets Containing Negative Unreported or Less-Than Values," Health Physics, Vol. 40 (March), pp. 377-390.

Goldstein, A., 1964. Biostatistics. MacMillan Publishing Co., New York, New York.

Ku, H. H., 1969. Precision Measurement and Calibration: Statistical Concepts and Procedures, National Bureau of Standards, U.S. Department of Commerce, SP 300.

NCRP (National Council on Radiation Protection and Measurements), 1976. "Environmental Radiation Measurements," NCRP Report 50.

NCRP (National Council on Radiation Protection and Measurements), 1985. "A Handbook of Radioactivity Measurements Procedures," NCRP Report 58.

Oberhofer, M., and A. Scharmann, 1981. Applied Thermoluminescence Dosimetry, ISPRA.

DRAFT

SAIC (Science Applications International Cororation), "Environmental Monitoring Radiological Reports/Plans, Analysis, Computer Program Usage, and Readiness Reviews," TPB-ER-017 in the Environmental Radiological Monitoring Technical Procedure Manual.

Waite, D. A., et al., 1974. "Interpretation of Near Background Environmental Surveillance Data By Distribution Analysis," IAEA-SM-202/706.

Watson, 1980. Upgrade Environmental Radiation Data, EPA/520/1-80-012.

Wheeler, J. B., et al., 1976. ASTM Manual on Presentation of Data and Control Chart Data, STP 15D, American Society for Testing and Materials (ASTM), Philadelphia, Pennsylvania.

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APPENDIX D

ANALYTICAL PROCEDURES AND CAPABILITIES

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APPENDIX D

ANALYTICAL PROCEDURES AND CAPABILITIES

PREFACE

Appendix D contains generalized information of the analytical techniques and quality control programs employed by various support organizations providing analytical services for the environmental radiological activities. The bulk of the analytical work is presently being handled by the U.S. Environmental Protection Agency (EPA), Environmental Monitoring and Support Laboratory - Las Vegas (EMSL-LV), Nuclear Radiation Assessment Division (NRAD). Additional information on EMSL-LV analytical capabilities is available in EMSL-LV-0539-17, NRO-SOPs, and associated QA Plans.

Information concerning the assessment techniques for the integrating/passive track etch radon samplers is presented in Appendix B.

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D.1 GERMANIUM DETECTOR GAMMA-RAY ANALYSIS

Concentrations of gamma-ray emitting nuclides can be quantitatively determined without chemical separation by gamma-ray counting. Unaltered environmental samples (solid or liquid) are counted with large volume hyper-pure Ge detectors for periods of 12 hours or longer depending upon the abundance of activity. This method is most applicable for analysis of nuclides that emit gamma rays with energies of 100 KeV to 3,000 KeV. Computer controlled gamma-detection systems allow the processes of sample counting and spectral analysis to be automated.

Nuclide	Minimum aliquot	Normal minimum detectable activity (μCi/g)
Fe-59	50 ml	1×10^{-7}
Mn-54	50 ml	5×10^{-8}
Co-58	50 ml	5×10^{-8}
Co-60	50 ml	7×10^{-8}
Cr-51	50 ml	3×10^{-7}
Zn-65	50 ml	1×10^{-7}
Mo-99	50 ml	3×10^{-8}
Ce-141	50 ml	5×10^{-8}
Ce-144	50 ml	2×10^{-7}
Cs-134	50 ml	5×10^{-8}
Cs-137	50 ml	5×10^{-8}
I-131	50 ml	5×10^{-8}

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D.2 GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES

All airborne particulate samples contain both natural and man-made radioactivity. A screening technique is used to determine the quantities of beta-emitting nuclides. Based on results obtained from this screening technique, the need for radiochemical analysis is determined.

<u>Precision and accuracy</u>

Inaccuracies are primarily attributable to samples containing beta emitters of different energies than the calibration standards, a large amount of particulate matter being accumulated on the filter creating some self-absorption, and some of the collected particulate matter flaking off the filter.

Analyzing filters containing known amounts of Sr-90 and Cs-137 produces results within 10 percent of the known value at the 95 percent confidence level. For standard samples close to background, the 95 percent confidence interval is approximately 5 pCi per filter.

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D.3 GROSS ALPHA AND BETA IN WATER

A screening technique is used to determine the quantities of alpha- or beta-emitting radionuclides present. A known volume of sample is concentrated, dried in a planchet, and counted in a low-background internal proportional counter. The activity determined by this method is not indicative of any specific nuclide. Tritium and other volatile radionuclides (e.g., radioiodine) cannot be determined by this method.

Precision and accuracy

Gross alpha and beta measurements by this method have an inherent inaccuracy in that samples may contain alpha and beta emitters with energies different from the calibration standards. In such circumstances, the counting efficiencies (cpm/dpm) used will not produce accurate information for the radionuclides in the sample. Therefore, this method is, at best, good only for semiquantitative analysis. The importance of precision (or repeatability) is that a given water source may be checked periodically for gross alpha and beta and any significant changes in the results over time may indicate a need for specific analysis. It is necessary then that such changes be real and not a result of poor precision.

Analytical results of spiked water containing 50 pCi/liter Cs-137 and 5 pCi/liter Am-241 indicate accuracies with deviations from known values of less than 10 percent at the 95 percent confidence level.

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D.4 Ra-226 AND Ra-228 IN WATER, SOIL, AIR, AND BIOLOGICAL TISSUE

Radium is precipitated from a specially prepared aliquot of sample with barium sulfate. Barium-radium-sulfate is dissolved and transferred to an emanation tube and the radon allowed to come to equilibrium, approximately 30 days. Rn-222 ($T_{1/2}$ = 3.825 days) is separated and collected from the liquid by a de-emanation technique. The Rn-222 is counted by alpha scintillation 4 1/2 hours after de-emanation, at which time the short-lived progeny have reached 97+ percent of equilibrium.

Precision and accuracy

The expected precision for Ra-226, based on the 95 percent confidence level analytical error, is 0.3 pCi/liter for samples up to 1.0 pCi/liter and 30 percent for samples above 1.0 pCi/liter.

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D.5 NUCLIDE: C-14

Samples are oxidized and the evolved CO_2 is bubbled through a NaOH solution. The basic solution is buffered with NH_4CI before the carbonate is precipitated as $CaCO_3$. A portion of the precipitate is gravimetrically introduced to a vial and combined with a gel-forming liquid scintillation cocktail that suspends the carbonate as finely dispersed granules suitable for scintillation counting.

Normal minimum detectable activity: 1×10^{-6} μCi/gram in a minimum aliquot of 1 gram of sample media.

DRAFT

D.6 Ni-63 AND Ni-59 ANALYSIS

Principle of method

Nickel carrier is added to the aqueous sample and precipitated as insoluble hydroxides, purified with dimethylglyoxime and collected as the hydroxide dissolved in caproic acid. The solution is mixed with scintillation solution and counted in a scintillation counter to measure Ni-63.

A second aliquot of the sample is processed in the same manner and counted for Ni-59 using a low-energy photon detector.

Normal minimum detectable activity: 9×10^{-1} pCi/gram (10 g minimum aliquot).

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D.7 Sr-89 AND Sr-90 ANALYSIS

Principle of method

Stable strontium carrier is added to an aliquot of the sample. The sample is purified by ion-exchange chromatography and precipitated as the nitrate. The sample is then counted in a gas-flow proportional counter both before and after the ingrowth of the Y-90 daughter. The activity is then calculated from the counting data.

Normal minimum detectable activity: 5 pCi/L or 5 x 10^{-1} pCi/gram of soil (minimal aliquot: 1 liter for water or milk, 10 g for soil).

DRAFT

D.8 Tc-99 ANALYSIS

Principle of method

Sample is prepared, after addition of chemical yield tracers, and then radiochemically purified by passing through a strong-base anion exchange resin. The purified fraction is precipitated as tetraphenylarsonium pertechnetate and beta-counted.

Normal minimum detectable activity: 6×10^{-8} μCi/g (10 g minimum aliquot).

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D.9 I-129 ANALYSIS

Principle of method

Radiochemical purification of iodine is performed using stable iodide carrier for chemical yield monitoring. Low-energy photon spectroscopy is used for counting the final cuprous iodide precipitate.

Normal minimum detectable activity: 5×10^{-7} µCi/g (10 g minimum aliquot).

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D.10 ALPHA EMITTERS -- ACTINIDES

Principle of method

Various chemical separation techniques are used to purify the alpha-emitting actinides. These include coprecipitation, ion exchange, solvent extraction, and electrodeposition. The electrodeposited radionuclides are then counted using alpha spectrometry. Chemical yield is determined by use of appropriate tracers.

Nuclide	Minimum aliquot	Normal minimum detectable activity
Np-237	10 g	1×10^{-6} µCi/g
Am-241	10 g	1×10^{-6} µCi/g
Pu-238	10 g	1×10^{-6} µCi/g
Pu-239	10 g	1×10^{-6} µCi/g
Cm-242	10 g	1×10^{-6} µCi/g
Cm-244	10 g	1×10^{-6} µCi/g

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D.11 RADIOKRYPTON, RADIOXENON

Certain inert gases and tritiated methane are separated and collected from atmospheric samples by a series of cryogenic-gas chromatographic techniques. Water and carbon dioxide are removed by molecular sieve-13X at room temperature. Krypton, xenon, and methane are collected on charcoal at liquid nitrogen temperature. They are transferred to molecular sieve-5A where they are separated from any remaining oxygen, argon, nitrogen, and each other. The separated gases are transferred to liquid scintillation vials and counted in a liquid scintillation spectrometer.

At the current Kr-85 level of about 24 pCi/m^3, the 2-sigma counting error is about 3 pCi/m^3. Analysis of split samples has shown that laboratory analytical errors are of about the same value. The ambient concentration of radioxenon is essentially zero. Most measured concentrations of radioxenon are less than the detection limit, of about 10 pCi/m^3.

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D.12 TRITIUM (H-3) IN WATER

Principle of method

Water samples are distilled, and the distillate is electrolyzed with added sodium hydroxide. Enriched samples are then assayed using liquid scintillation techniques.

Normal minimum detectable activity: 0.01×10^{-6} μCi/gram (250 g minimum aliquot) for enriched samples.

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D.13 TRITIUM (H-3) IN AIR

Principle of method

An atmospheric sample is passed through a molecular sieve to remove the water vapor. Tritium-free hydrogen is added as a carrier. The carrier, hydrogen and atmospheric hydrogen, is converted to water using a palladium black catalyst. This water is collected in a second molecular sieve trap. The water collected on these traps is removed by heating and subsequently analyzed for tritium.

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D.14 THERMOLUMINESCENT DOSIMETRY

Thermoluminescent dosimeters (TLDs) are used to measure environmental radiation exposure at selected locations. Several individuals (members of the public) are being monitored by the EPA/NRAD so that potential differences between personnel and environmental results can be evaluated. The dosimetry network consists of monitored locations encircling the Nevada Test Site (NTS). The dosimetry array permits an estimate of average background exposure and detection of potential increases due to NTS operations. Environmental stations are changed quarterly, while personnel TLDs are changed monthly.

The general protocol for processing a TLD is as follows:

1. A TLD is randomly selected for deployment after ensuring it is clean and undamaged. Normally Panasonic UD-802s are used for personnel and UD-814s for the environment.

2. The TLD is placed in an empty TLD magazine and then in the TLD reader and readout with a record of the readout being retained.

3. The TLD is packaged in the specified manner for the personnel or environmental station, and the TLD holder is labeled with the appropriate information.

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4. A field data card accompanies the TLD. It is completed by the monitor or technician issuing the dosimeter. The data card is stored by the monitor until the TLD is collected.

5. When the TLD is collected, it is returned to dosimetry along with the completed field data card.

6. The dosimeter is inspected for damage and processing acceptability.

7. A standard format is used to process the TLDs, and a hard copy of the results is saved.

8. The dosimeter is returned to the inventory for reuse.

9. After approval of the Health Physicist, the dosimeter result and other pertinent information are transferred for permanent storage.

For more information on any of these steps refer to the appropriate section of this operations manual.

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D.15 NRAD QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

Goals

The goals of EMSL-LV quality assurance/quality control are to ensure the collection and analysis of environmental samples with the highest degree of accuracy and precision obtainable with state-of-the-art instrumentation, and to achieve the best possible completeness and comparability given the extent and type of networks from which samples are collected. To meet these goals, it is necessary to devote strict attention to sample collection, sample analysis, quality control, and quality assurance procedures.

Sample collection

The collection of samples by the NRAD is governed by a detailed set of standard operating procedures (SOPs). These SOPs cover frequency and method of collection, type of collection media, sample containment and transport, sample preservation, sample identification and labeling, and the operating parameters for the instrumentation. Sample control is an important part of these activities because it not only permits tracking from collection to analysis for each sample, but also for the samples chosen for replicate analysis.

These procedures provide assurance that sample collection, labeling, and handling are standardized to minimize sample variability due to inconsistency among these variables.

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Sample analysis

All of the sampling networks operated by the EMSL-LV have individual Quality Assurance Program Plans (QAPPs). The procedures required by these plans ensure that the results of analysis will be of known quality and will be comparable to results obtained elsewhere with equivalent procedures (Table D-1). These plans are summarized in the following sections.

External quality assurance (QA)

External QA provides the data from which the accuracy of analysis (a combination of bias and precision) can be determined. Bias is assessed from the results obtained from intercomparison study samples and from samples "spiked" with known amounts of radionuclides. The NTS offsite radiological safety program participates in intercomparison study programs that include environmental sample analysis, thermoluminescent dosimetry, and whole-body counting. Also, samples which are undisclosed to the analyst are spiked by adding known amounts of radionuclides and then entered into the normal chain of analysis.

Data for precision are collected from duplicate and replicate analyses. At least 10 percent of all samples are collected in duplicate. When analyzed, the data indicate the precision of both sample collection and analysis. Replicate counting of at least 10 percent of all samples yields data from which the precision of counting can be determined.

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Table D-1. Typical sensitivities and sample sizes at commercial laboratories for special projects (page 1 of 2)

Analysis	Isotope	Minimum aliquot	Normal minimum detectable activity (μCi/g)
Combustion - liquid scintillation counting	H-3	1 g	1×10^{-6}
	C-14	1 g	1×10^{-6}
Radiochemical separation X-ray spectroscopy	Fe-55	10 g	9×10^{-7}
Aliquoting - Ge(Li) spectroscopy	Fe-59	50 ml	1×10^{-7}
	Mn-54	50 ml	5×10^{-8}
	Co-58	50 ml	5×10^{-8}
	Co-60	50 ml	7×10^{-8}
	Cr-51	50 ml	3×10^{-7}
	Zn-65	50 ml	1×10^{-7}
Radiochemical separation - beta counting	Sr-89	10 g	5×10^{-8}
	Sr-90	10 g	4×10^{-8}
Aliquoting - Ge(Li) spectroscopy	Zr-95	50 ml	1×10^{-7}
Yielded by gamma spectroscopy beta counting	Tc-99	10 g	6×10^{-8}
Aliquoting - Ge(Li) spectroscopy	Mo-99	50 ml	3×10^{-8}
	Ce-141	50 ml	5×10^{-8}
	Ce-144	50 ml	2×10^{-7}
	Cs-134	50 ml	5×10^{-8}
	Cs-137	50 ml	5×10^{-8}
R-Chem, N.N.A./LSC	I-129	10 g	5×10^{-7}
Aliquoting - Ge(Li) spectroscopy	I-131	50 ml	5×10^{-8}
Aliquoting - gamma well counting	Gross gamma	50 ml or 1 g	2×10^{-6}
Radiochemical separation-alpha spectrometry	Np-237	10 g	1×10^{-6}
	Am-241	10 g	1×10^{-6}
	Pu-238	10 g	1×10^{-6}
	Pu-239	10 g	1×10^{-6}

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Table D-1. Typical sensitivities and sample sizes at commercial laboratories for special projects (page 2 of 2)

Analysis	Isotope	Minimum aliquot	Normal minimum detectable activity (μCi/g)
Radiochemical separation-liquid scintillation counting	Pu-241	10 g	3×10^{-7}
Radiochemical separation-alpha spectrometry	Cm-242	10 g	1×10^{-6}
	Cm-244	10 g	1×10^{-6}
Aliquoting - ashing gross alpha counting	Gross alpha	50 ml or 1 g	7×10^{-6}

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Internal quality control (QC)

Internal QC consists of those procedures used by the analyst to ensure proper sample preparation and analysis. The principal procedures used are the following:

- Instrument background counts.
- Blank and reagent analyses.
- Instrument calibration with known nuclides.
- Laboratory control standards analysis.
- Performance check-source analysis.
- Maintenance of control charts for background and check-source data.
- Scheduled instrument maintenance.

These procedures ensure that the instrumentation is not contaminated, that calibration is correct, and that standards carried through the total analytical procedure are accurately analyzed.

Analytical methods are further checked by laboratory participation in the semiannual DOE Quality Assessment Program conducted by the Environmental Measurements Laboratory (EML), New York, New York; and in the intercomparison studies conducted by the World Health Organization's International Reference Center for Radioactivity located in France.

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Validation

After the results are produced, supervisory personnel examine the data to determine whether or not the analysis is valid. This includes checking all procedures from sample receipt to analytical result, with particular attention to the internal QA data and comparison of the results with previous data from similar samples at the same location.

Any variant result or failure to follow internal QA procedures during sample analysis will trigger an internal audit of the analytical procedures or a re-analysis of the sample or its duplicate.

Audits

All analytical data are reviewed by personnel of the Dose Assessment Branch for completeness and consistency. Investigations are conducted to resolve any inconsistencies, and corrective actions are taken if necessary. SOPs and QAPPs are revised as needed following review of procedures and methodology. The EMSL-LV QA Officer audits the operations periodically.

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APPENDIX E

OVERVIEW AND SUMMARY OF ENVIRONMENTAL RADIOLOGICAL SAMPLING ACTIVITIES

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APPENDIX E

OVERVIEW AND SUMMARY OF ENVIRONMENTAL RADIOLOGICAL SAMPLING ACTIVITIES

PREFACE

This appendix is a compilation of tables and figures developed to provide an overview of the numerous radiological sampling and monitoring activities. The various sampling activities are discussed in detail within the text of the Radiological Monitoring Plan, Section 4.3.

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Table E-1. Overview of environmental radiological sampling (page 1 of 2)

Sample type	Sample method	Nominal collection frequency
AIR		
Particulate filter	Continuous	Filter exchange weekly
Charcoal cartridge	Continuous	Cartridge exchange weekly
Cascade impactor filters	Intermittent	Near field stations once or twice a year
Radon	Integrating Continuous	Monthly sampler exchange Weekly data collection
Tritium	Continuous	Weekly
Inert gas	Continuous	Weekly
WATER		
Ground/drinking water	Grab	Annual at far-field wells As available for USGS, near-field wells
Surface water	Grab	Annual
Ephemeral streams	Grab	As available
SEDIMENT		
Surface water bodies	Grab	Annual
Ephemeral streams		
Surface	Grab	Concurrent with spring freshet
Depth	Grab	Once concurrent with initial surface sample
SOIL		
Surface	Grab	Annually at air sampling stations, once for archiving at all sample locations

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Table E-1. Overview of environmental radiological sampling (page 2 of 2)

Sample type	Sample method	Nominal collection frequency
SOIL (continued)		
Depth	Grab	Once at selected locations (TBD)
Drift face	Grab	TBD
AMBIENT RADIATION		
Thermoluminescent dosimeters	Integrating	Quarterly dosimeter exchange
Pressurized ion chambers	Continuous	Weekly data collection
Aerial survey	Flyover	Once per program phase
BIOTA		
Milk	Grab	Monthly
Produce		
Vegetables	Grab	Annually
Meat	Grab	Annually
Field crops	Grab	Annually
Forage species	Grab	Annually
Game birds	Grab	TBD
Indicator species		
Small mammals	Grab	Semi-annually
Large herbivorous	Grab	TBD
Mammals		
Predators	Grab	TBD

See Table E-13 for comprehensive list of acronyms used in this Appendix.

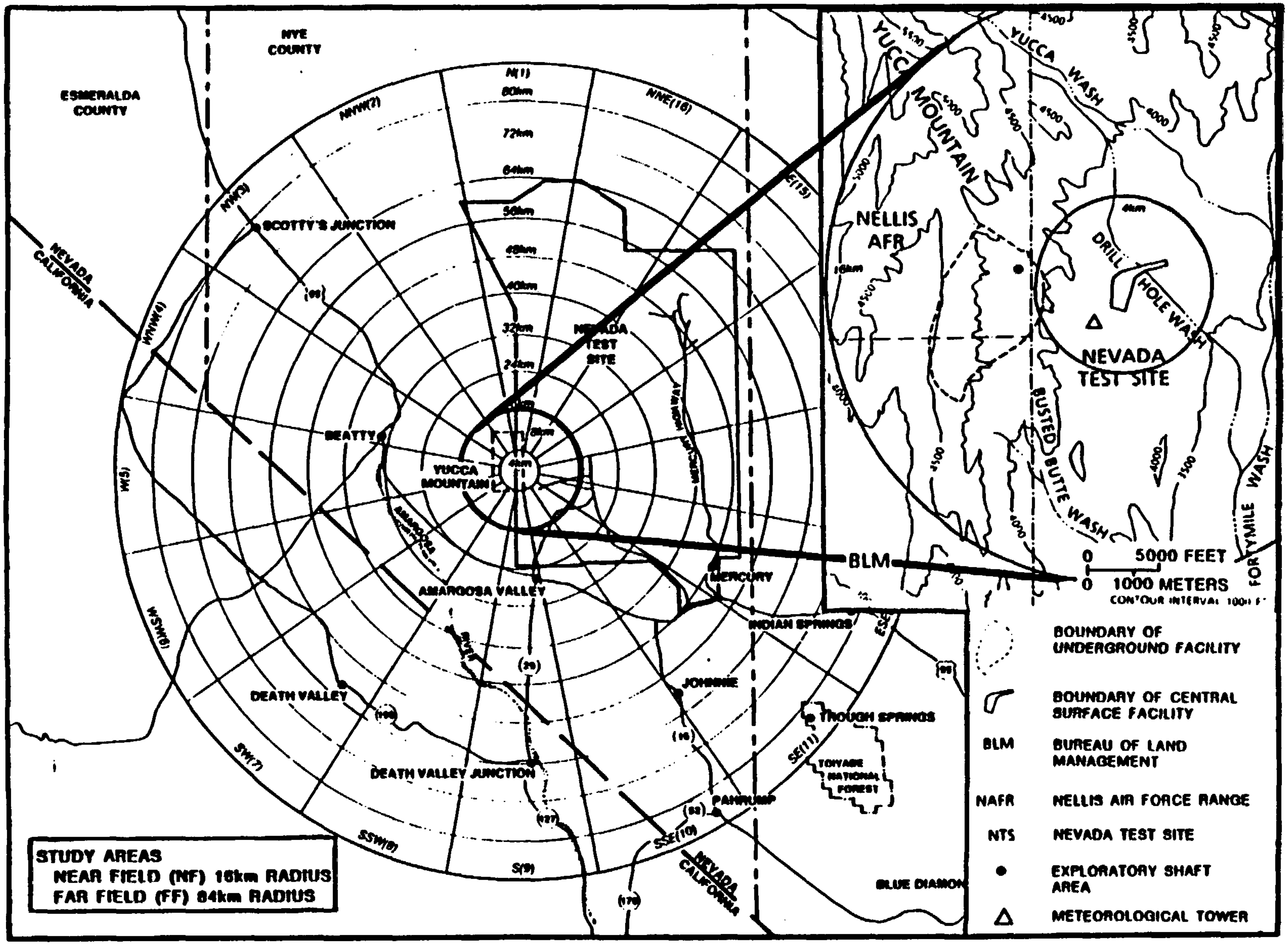

Figure E-1. RMP study area.

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Table E-2. Implementation schedule for RMP activities[a]

Activity	Implementation phase
Air sampling/NF station 6 (AP, AI)	9/87[c]
Air sampling/NF stations (AP, AI)	10/87 to 12/87
Air sampling/FF stations (AP, AI)	10/87 to 2/88
Water sampling (DW/SU)	10/87 to 2/88
Catch Basin survey	1/88 to 6/88
Water sampling (Catch Basins)	6/88 to 9/88
Radon integrating samplers (IS)	9/87[c]
Radon continuous monitoring (CRM)	10/87
Soil/sediment (NF) sampling (SO/SD)	10/87 to 12/88
In situ gamma spectral analysis	11/87 to 12/89
Milk sampling (MSN)	Ongoing[b]
Onsite biota sampling	10/87 to 2/89
Land use survey (biota in human food pathway)	12/87 to 12/89
TLD monitoring	10/87 to 12/87
High-pressure ion chamber (PIC) monitoring	10/87 to 2/88
ARS survey, RSL	TBD
TLD monitoring (selected members of the public)	Ongoing[b]

[a]See Table E-13 for list of acronyms.
[b]This is an ongoing Nevada Test Site activity conducted by EPA, NRAD.
[c]Implementation per PSCRMP.

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Table E-3. Analyses for air monitoring samples[a] (page 1 of 2)

Sample media	Analysis
1. Air particulate filter (AP)	Gross beta counts on weekly filter Gross alpha counts on weekly filter Gamma spectroscopy in quarterly composite of weekly filters Alpha spectrometry or specific radiochemical analysis on quarterly filter composite: Po-210, Pb-210, Th-230, Np-237, Ra-226, Pu-238, Pu-239, Pu-240, Am-241, Am-243, Th-232, Cu-243, and Cu-244 Specific chemical analysis of quarterly composites: Sr-90, Sr-89, C-14, I-129, Tc-99, and Pu-241 Total uranium (non-routine analysis)
2. Charcoal cartridge (AI)	Gamma spectral analysis of weekly collected cartridge for I-131
3. Inert-gas collector (IGT)	Radioxenons Xe-133, Xe-135, and radiokrypton Kr-85 weekly collection of compressed gas, cryogenic gas chromatographic separation and liquid scintillation counting
4. Tritium (IGT)	H-3 collected weekly on molecular sieve column, extracted and counted by liquid scintillation
5. Radon (RA)	
Passive track etch integrating sampler (IRS)	Monthly collection and sent to manufacturer for processing - Radon
TEL-continuously recording radon monitor (CRM)	Ionization chamber readings transferred to weekly PC from AB-5 field based micro data logger - Radon
Augmented track etch	Monthly collection - Radon daughter products

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Table E-3. Analyses for air monitoring samples[a] (page 2 of 2)

Sample media	Analysis
6. Particulate size sample (PS)	Periodic collection of filters by low-volume cascade impactor for size segregation and determination of weight fractions (non-routine EMG for actual particle sizing)

[a]Stations: NF: 1, 3, 6, 7, 8, 9, 10, 11, 13, 17 (Figures 4-5, -13, and -14); FF: 1 through 26 (Figures 4-6, -7, and -8).

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Table E-4. Analyses for water and sediment monitoring samples[a]

Sample media	Analysis
Groundwater and surface water (GW, SU)	Annual sample collection Gross alpha and gross beta screening counts Gamma spectroscopy for gamma emitters Co-58, Co-60, Cs/Ba-137m, Mn-54, Cs-134, Fe-59, Cr-51, Zn-65, and Ce-144 Alpha spectroscopy on radiochemical analysis for alpha emitters Np-237, Am-241, Pu-238, Pu-239, Pu-240, Cm-242, and Cm-244 Specific radiochemical analysis Tc-99, Ni-59, Zr-93/Nb-93m, and H-3
Drinking water (DW)	Same as GW and SW EPA drinking water criteria (40 CFR 141)
Ephemeral streams (SE)	Annual spring freshet or sufficient precipitation event Same analysis as surface water
Sediment (SD)	Concurrent with SU and SE samples Same analysis as GW and SU

[a]Stations: NF: 23, 22, 19, 18, 56, 17, 11, Catch basins and USGS wells (Figure 4-5). Any well within 84 km of the Yucca Mountain site that is entered and pumped as an activity associated with the NNWSI Project will be sampled. Only a limited number (≈10%) of the samples will receive the full suite of analysis indicated. Most samples will be archived and screened for future analysis as necessary. Specific analysis for such nuclides as Ni-59 may be conducted on only 5% of water samples being analyzed; FF: 1, 2, 4, 5, 6, 8, 9, 12, 14, 15, 16, 18, 19, 20, 21, 23, 24 and additional EPA-NRAD stations (Figures 4-15, and -16).

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Table E-5. Analyses for soil samples[a]

Sample media	Analysis
Surface soil (SO)	Annual sample collection for analysis Gross alpha and beta (field surveys) Gamma spectroscopy for gamma emitters Specific radionuclide analysis: Sr-90, Y-90, Zr/Nb-95, Ce/Pr-144, Pu-238, Pu-239, Pu-241, Am-241, Ra-226, Np-237, Te-99, I-129, C-14, Po-210, and uranium
Soil at depth (SS)	Same radionuclide analysis as for surface soil Soil density Soil moisture Chemical composition
Drift wall (DW)	Same radionuclide analysis as surface soil plus: Th-237, Th-238, Th-230, Ra-228, Ra-224, Ra-226, U-238, U-234, and Po-210

[a]In addition to the primary soil sampling stations coinciding with air sampling stations and indicator species locations, surface soil samples will be collected at all environmental sampling locations and selected areas of significant surface disturbances, and then archived. Soil sampling stations-NF: (1) Same as air sampling stations (1, 3, 6, 7, 8, 9, 10, 11, 13, 17; Figure 4-5), (2) Indicator species areas (2, 4, 5, 14, 37, 12 and 58; Figure 4-5), and (3) Underground mining area drift face; FF: Same as air sampling stations (Figure 4-6).

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Table E-6. Analyses for biota samples[a]

Sample media	Analysis
Milk (MSN)	Monthly EPA collected and analyzed for gamma emitters (routinely) Sr-89 and Sr-90 (intermittent) H-3 (routinely) Alpha spectroscopy Radiochemical analysis (special) I-129
Produce (human consumption)	Gamma emitters Alpha spectroscopy and specific radiochemical separation Pu-239 and Pu-241 Specific radioanalytic analysis C-14, Sr-89, Sr-90, and Ni-63
Beef	Gamma emitters Alpha spectroscopy and specific radio-analytical processes Pu-239 and Am-241 Specific radioanalytic analyses Sr-90, C-14 I-129 (thyroid tissue)
Deer and cattle forage	Gamma emitters Alpha spectroscopy and specific radiochemical separation Pu-239, Am-241, Cu-244, and Np-237 Specific radioanalytic analysis Si-90 and C-14
Indicator species (small mammal)	Gamma emitters Alpha spectroscopy and radioanalytical separation Pu-239/240, Am-241, and Np-237 Specific radionuclide analysis I-129, Pu-241, C-14, Tc-99, Sr-90, Sr-89, Ni-63, and Ni-59

[a]Biota sampling stations - NF: 2, 4, 5, 14, 12, 37 and 58 (Figure 4-5); FF: TBD (except EPA, MSN (Figure 4-17)).

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Table E-7. Ambient radiation

Sample media	Analysis
TLD (thermoluminescent dosimeter)	dose (mrem/qtr)
PIC (pressurized ion chamber)	exposure rate (μR/hr)
Aerial radiological survey	exposure rate (Cs-137 equivalent μR/hr)

Table E-8. Environmental radiological surveillance--monitoring and sampling, near-field locations (page 1 of 5)

Station	Sample types	Program	Description*
1	AP, AI, PS, SO, RA, PIC, TLD	NNWSI	ES1 & ES2 Area (W 2.5 km) (R:4 Θ ≈ 125 m, 2 Θ CW N and S, and 6 Θ muck area)
2	IS, FD	NNWSI/EG&G	2 areas in Coyote Wash up and down draw from ES (W 3 km)
3	AP, AI, PS, SO, PIC	NNWSI	NTS-10 ym (W 3.5 km)
4	TLD, IS	NNWSI	UE-25a (WNW 2.5 km)
5	IS, FD	NNWSI/EG&G	(W 1 km)
6	R, AP, AI, IGT, PS, SO, TLD	NNWSI	NTS-60 R (SSW 1 km)
7	RA	NNWSI	(4 Θ -200 m N, S, E, and W of SFA)
8	AP, AI, PS, SO, FD	NNWSI	(NE 5.5 km)
9	AP, AI, PS, SO	NNWSI	UE-25WT x 16 (N 3 km)
10	AP, AI, PS	NNWSI	RDH and PL crossing (ESE 10 km)
11	AP, AI, PS, SO, GW	NNWSI/REECo	NTS well J-13 (SSE 6 km)
12	IS, FD	NNWSI/EG&G	(SSE 5 km)
13	AP, AI, PS, SO	NNWSI	USW WT 7 (WSW 6 km)
14	IS	NNWSI/EG&G	ROSFA

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Table E-8. Environmental radiological surveillance--monitoring and sampling, near-field locations (page 2 of 5)

Station	Sample types	Program	Description*
15	TLD	NNWSI	NTS Area 25, Support Area (SE 16 km)
16	FD	NNWSI/EG&G	(E 5 km)
17	AP, AI, PS, SO, GW	NNWSI/REECo	NTS well J-12 (SSE 11 km)
18	SE, SD	NNWSI	Fortymile Wash (SSE 10 km)
19	SE, SD	NNWSI	Fortymile Wash (SSE 7 km)
20	FD	NNWSI/EG&G	(SE 5 km)
21	TLD	NNWSI	UE-25WT + 13 (SE 4 km)
22	SE, SD	NNWSI	Fortymile Wash (SE 4 km)
23	SE, SD	NNWSI	Fortymile Wash (E 3 km)
24	TLD	NNWST	(ENE 3 km)
25	FD	NNWSI/EG&G	(E 2 km)
26	FD	NNWSI/EG&G	(NE 2 km)
27	FD		(SE 2 km)
28	FD	NNWSI/EG&G	(S 5 km)
29	TLD		(S 5 km)

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Table E-8. Environmental radiological surveillance--monitoring and sampling, near-field locations (page 3 of 5)

Station	Sample types	Program	Description*
30	TLD	NNWSI	UE-25C (S 3 km)
31	FD	NNWSI/EG&G	(S 2 km)
32	FD	NNWSI/EG&G	(E 1 km)
33	FD	NNWSI/EG&G	(N 1 km)
34	FD	NNWSI/EG&G	(N 2 km)
35	FD	NNWSI/EG&G	(N 5 km)
36	TLD	NNWSI	(NNW 1 km)
37	IS	NNWSI/EG&G	(NNW 1 km)
38	FD	NNWSI/EG&G	(W 1 km)
39	FD	NNWSI/EG&G	(SW 2 km)
40	FD	NNWSI/EG&G	(NW 2 km)
41	TLD	NNWSI	USW G-2 (NW 5.5 km)
42	FD	NNWSI	(NW 5 km)
43	TLD	NNWSI	USGS-M IBIS
44	TLD	NNWSI	USW H-3 (SW 5 km)

Table E-8. Environmental radiological surveillance--monitoring and sampling, near-field locations (page 4 of 5)

Station	Sample types	Program	Description*
45	FD	NNWSI/EG&G	(SW 5 km)
46	TLD	NNWSI	(SW 5.5 km)
47	TLD	NNWSI	USW WT-10 (SW 7.5 km)
48	TLD	NNWSI	USW H-6 (W 5 km)
49	FD	NNWSI/EG&G	(W 5 km)
50	TLD	NNWSI	(W 5.5 km)
51	TLD	NNWSI	USW VH-1 (WSW 14 km)
52	TLD	NNWSI	USW VH-3 (WSW 17 km)
53	TLD	NNWSI	(W 14.5 km)
54	TLD	NNWSI	USW WT-22 (WNW 14.5 km)
55	TLD	NNWSI	(NNW 15.5 km)
56	GW/DW	NNWSI	NTS well J-11 (ESE 15.5 km)
57	FD	NNWSI/EG&G	(S 1 km)
58	IS	NNWSI/EG&G	USW WT-11 (SSW 10 km)
TBD	GW	NNWSI/USGS	TBD (test wells)

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Table E-8. Environmental radiological surveillance--monitoring and sampling, near-field locations (page 5 of 5)

Station	Sample types	Program	Description*
TBD	SW	NNWSI	TBD (catch basin water holes)
TBD	GB	NNWSI/EG&G	(W/in 8 km)
All	SA	NNWSI	At initiation of sampling at site
TBD	FG	NNWSI	in situ gamma spectroscopy

*Information in parentheses designates an estimated radial distance and sector coordinate from Figure 4.3.4-4.

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Table E-9. Environmental radiological surveillance--air and soil sampling and monitoring, far field locations (page 1 of 2)

Station	Sample types	Program[a]	Description
1	AP, AI, SO	NRAD	Tonopah Test Range
2	AP, AI, SO	REECo/NTS	NTS Area 20 Dispensary
3	AP, AI, SO	NRAD	Twin Spring Ranch
4	AP, AI, SO	REECo/NTS	NTS Area 16, Substation
5	AP, AI, IGT, SO	NRAD	Rachel
6	AP, AI, SO	REECo/NTS	NTS Area 2, Compound
7	AP, AI, SO	NRAD	Crystal Springs (Hiko)
8	AP, AI, IGT,SO	NRAD	Alamo
9	AP, AI, SO	REECo/NTS	NTS Area 1, BJY Intersection
10	AP, AI, SO	REECo/NTS	NTS Area 6, CP complex
11	AP, AI, IGT, SO	NRAD/NNWSI	Indian Springs
12	AP, AI, IGT, SO	NRAD	Las Vegas
13	AP, AI, SO	REECo/NTS	NTS Area 23, Mercury
14	AP, AI, IGT, SO	NRAD	Pahrump

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Table E-9. Environmental radiological surveillance--air and soil sampling and monitoring, far field locations (page 2 of 2)

Station	Sample types	Program[a]	Description
15	AP, AI, SO	NNWSI	Johnnie
16	AP, AI, SO	NNWSI	Amargosa Farms Area
17	AP, AI, IGT, SO	NRAD	Amargosa Valley (Lathrop Wells)
18	AP, AI, SO	NRAD	Death Valley Junction
19	AP, AI, SO	NNWSI	Amargosa Farms Area
20	AP, AI, SO	NRAD	Death Valley
21	AP, AI, IGT, SO	NNWSI	Furnace Creek
22	AP, AI, IGT, SO	NRAD	Beatty
23	AP, AI, SO	NRAD	Scotty's Junction
24	AP, AI, IGT, SO	NRAD	Goldfield
25	AP, AI, IGT, SO	NNWSI	Amargosa Farms Area
26	AP, AI, SO	NNWSI	Air Force Installation, Toliche Peak
--	IGT	NRAD	8 additional EPA monitoring stations in Nevada and Utah

[a]Most of the NRAD sampling program designations are a part of EPA, NRADs existing Surveillance Networks in support of NTS monitoring activities. This NRAD, NTS information will be available for NNWSI information, as appropriate.

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Table E-10. Environmental radiological surveillance--water and sediment sampling, far field location (page 1 of 2)

Station	Sample types	Program[a]	Description
11	SU/SD	NNWSI	S 56 km Amargosa River
17	SU/SD	NNWSI	W 32 km
13	SU/DW	NNWSI	Armagos Farms
1	GW/DW	NRAD	ESE 80 km USAF Well #2
2	GW/DW	NRAD	ESE 80 km Indian Springs
3	DW	NNWSI	SE 80 km Trough Springs
4	GW/DW	REECo	ESE 48 km Mercury
5	GW/DW	NRAD	SSE 80 km Pahrump/Calvada Well #3
6	GW/DW/SU/SD	NRAD	56 km Crystal Pool
7	GW	NRAD	S 60 km well 18S/51E-7db
8	GW/DW	NRAD	SE 170 km Lake Mead intake (Boulder City)
9	GW/DW	NRAD	SE 130 km well #28 Las Vegas
12	GW/DW/SU/SD	NRAD	S 40 km Fairbanks Spring
14	GW/DW	NRAD	S 30 km Lathrop Wells
15	SU/SD	NNWSI	SW 60 km Death Valley

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Table B-10. Environmental radiological surveillance--water and sediment sampling locations far field locations (page 2 of 2)

Station	Sample types	Program[a]	Description
16	GW/DW	NRAD	W 32 km NECO/US Ecology
18	GW/DW	NRAD	WNW 34 km Beatty
19	GW/DW/SU/SD	NRAD	NW 30 km Coffer's Well 11S/48-1dd
20	GW/DW/SU/SD	NRAD	WNW 40 km Gross Springs (Oasis Valley)
21	GW/DW	NRAD	ENE 130 km Alamo, City Well #4
23	GW/DW	NRAD	NE 110 km Tempiute (Union Carbide well)
24	GW/DW	NRAD	NE 140 km Crystal Springs (Hiko, NV)
10	GW	NRAD	S 50 km Well 175/50E-14CAC

[a]Most of the NRAD sampling program designations are a part of EPA, NRADs existing Surveillance Networks in support of NTS monitoring activities. This NRAD, NTS information will be available for NNWSI information, as appropriate.

Table E-11. Environmental radiological surveillance--biota sampling, far field locations (page 1 of 1)

Station	Sample types	Program[a]	Description
MSN	MI	NRAD	23 stations (NV, CA, UT) w/in 300 km of NTS
TBD	Produce		TBD
TBD	BF (LI, LU, KI, BL, BO)	NRAD	Herd grazed NE of NTS
TBD	Domestic food animals	NNWSI	TBD
TBD	GB	NNWSI	TBD
TBD	FD	NNWSI	TBD
TBD	FC	NNWSI	TBD (8 areas w/in 84 km)

[a]Most of the NRAD sampling program designations are a part of EPA, NRADs existing Surveillance Networks in support of NTS monitoring activities. This NRAD, NTS information will be available for NNWSI information, as appropriate.

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Table E-12. Meteorological monitoring sites

Site	UTM coordinates zone 11 (m)	Nevada system (ft)	Latitude-Longitude (deg. min. sec)	Elevation (MSL)
NTS-60 Repository (R)	550,776E 4,077,427N	569,127E 761,795N	36°50'33" 116°25'49"	3751 ft 1143 m
NTS-10 Yucca Mountain (YM)	547,660E 4,078,781N	558,826E 766,434N	36°51'20" 116°28'19"	4849 ft 1478 m
NTS-10 Coyote Wash (CW)	548,884E 4,078,689N	562,876E 766,195N	36°51'17" 116°27'05"	4193 ft 1278 m
NTS-10 Alice Hill (AH)	553,122E 4,079,787N	576,810E 769,661N	36°51'51" 116°24'14"	4047 ft 1234 m
NTS-10 Fortymile Wash (FW)	554,396E 4,068,691N	580,882E 733,230N	36°45'51" 116°23'27"	3124 ft 952 m

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Table E-13. Acronym and abbreviation list (page 1 of 2)

Acronym or abbreviation	Definition
AI	gaseous iodine
AP	air particulate
ARS	aerial radiological survey, DOE Remote Sensing Laboratory, EG&G/EM
ASN	air surveillance network, EPA-NRAD air monitoring stations
CRM	continuous radon monitor
DN	dosimetry network, EPA-NRAD TLD monitored sites
DS	deer scat
DW	drinking water
EG&G	biological field studies conducted by EG&G, Santa Barbara
EMG	electron micrograph (scanning electron microscopy)
FC	forage species/cattle
FC	feed crops (stock feed)
FD	forage species/deer
FF	far-field locations
FG	field gamma spectroscopy
FR	fruit
GB	game birds
GR	grain crop
GW	ground water
IGT	inert gas/tritium
IRS	integrating radon sampler
IS	indicator species
LTHMP	long-term hydrological monitoring program, EPA-NRAD groundwater sampling network for NTS offsite
ME	meat/domestic food animals
MI	milk
MSN	milk surveillance network, EPA-NRAD milk sampling sites

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Table E-13. Acronym and abbreviation list (page 2 of 2)

Acronym or abbreviation	Definition
NF	near-field locations
NGTSN	Noble Gas and Tritium Surveillance Network, EPA-NRAD sampling locations
NRAD	Nuclear Radiation Assessment Division, EPA-LV
NTS	Nevada Test Site
NTS-10 YM	Yucca Mountain 10-meter meteorological tower
NTS-10 CWN	Coyote Wash North 10-meter meteorological tower
NTS-60 R	repository facility 60-meter meteorological tower
PG	pasture graze (stock feed)
PR	produce/food crop
PS	particulate size
R	radon monitor/sampler (single site)
RA	radon area (multiple sample site)
REECo	Reynolds Electrical and Engineering Company
RSFA	repository surface facility area (conceptual)
RT	root vegetables
SA	soil for archiving
SD	sediment
SE	surface water/ephemeral streams
SM	small mammal (IS)
SO	soil (routine)
SS	subsurface soil samples
SU	surface water
TBD	to be determined
TTR	Tonopah Test Range
USGS-M xxxx	USGS geodetic survey markers "name"
VE	leafy vegetables

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APPENDIX F

SAMPLE ARCHIVING

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APPENDIX F

SAMPLE ARCHIVING

Complete and unequivocal preservation of samples for long-term storage (archiving) is a practical impossibility. Regardless of the nature of the sample, complete stability for every constituent can never be achieved. At best, preservation techniques can only retard the chemical and biological changes that inevitably continue after the sample is removed from an environmental matrix (the parent source). Certain changes occur in the chemical structure of the constituents that are a function of physical conditions. In water samples, metal cations may precipitate as hydroxides or form complexes with other constituents. Metal cations may also adsorb onto container surfaces (glass, plastic, quartz, etc.). Cations or anions may change valence states under certain reducing or oxidizing conditions. Other constituents may dissolve or volatilize. Biological changes taking place in either a water or soil sample may cause valence changes in contaminants. In water samples, soluble constituents may be converted to organically bound materials in cell structures, or cell lysis may result in release of cellular material into solution. The nitrogen and phosphorus cycles are examples of biological influence on sample composition. As a general rule, it is best to analyze samples as soon as possible after collection.

Methods of preservation are relatively limited and are intended generally to (1) retard biological action, (2) retard hydrolysis of chemical compounds and complexes, (3) reduce volatility of constituents, and (4) reduce absorption effects. Preservation methods for water samples are

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generally limited to pH control, chemical addition, refrigeration, and freezing. Drying or freezing are typically the only preservation methods used for soil/sediment samples.

Archiving (long-term storage) of samples, regardless of the preservation technique used, if any, will present some unique problems for interpretation of analytical results. The process described below is intended to provide a simple and economical approach to archiving water and soil samples, and storage of sample residues. In this case sample residue means the end product of the radioanalytical process used to determine specific radionuclide activity. Specific procedures for preparation of samples for archiving will be prepared and reviewed periodically for adequacy in maintaining the integrity of each archived sample.

Sample residues, such as deposited radionuclides on small counting disks or a precipitate on a membrane filter, will be retained from the analytical laboratory after completion of the analytical process and verification of the reported results. Not all sample residuals are in a matrix that lends itself to being stored for long periods of time. Therefore careful evaluation of each residual type will be made prior to preparing specific procedures for the handling and storage of these materials. Typically a residual medium will be placed in a glass sample jar of appropriate size, sealed, labeled, and placed in secure storage cabinets at a sample storage facility.

Soil/sediment samples, after being split and sieved, will be carefully dried, placed into glass wide-mouth sample jars (approximately 1 L), and the jars will be sealed with a paraffin or other nonreactive sealant to limit

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moisture intrusion into the sample container. Drying of soil/sediment samples is not expected to alter the containment (radionuclides) of potential interest. Sealing the sample container is necessary to keep moisture content low and limit potential biological activity. Archived samples will be periodically checked to verify that the jars are securely sealed and that biological activity, if any, is limited. If a sample shows signs of unusual biological activity, it may have to be dried a second time.

Water samples for archiving will be split into three representative, unfiltered, and thoroughly mixed 500 aliquots, and sealed in glass reagent bottles with glass stoppers. A paraffin/plastic seal compound of high purity will be used as the primary sealing compound for the water samples. A very secure seal is necessary to prevent sample evaporation, contamination from the environment, and excessive biological activity. It is essentially impossible to archive a water sample and successfully maintain the integrity of the sample during storage. The glass containers will allow for acid stripping or other chemical removal of nuclides that may become adsorbed on the container walls. Additional evaluation will be necessary to ensure that radionuclides of potential interest within a sample can be adequately recovered from the sample or container to provide qualitative and quantitative information. NCRP (1976) provides a brief overview of the numerous difficulties and problems that may be encountered while trying to preserve, treat, and store samples in such a way as to provide the desired results.

The selection of the various archiving steps noted herein are based on both simplicity and the assumption that the radionuclides of primary interest in the samples will not be lost with time. Special handling of an archived

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sample may be required to achieve the desired nuclide(s) of interest, when and if analysis of an archived sample is required. Additional studies concerning sample preservation and storage techniques are needed.

Because of the need to try to evaluate the archiving and storage techniques, especially for water samples, a special series of "archived control" water samples will be prepared for a long-term testing program. These special archive controls should be of at least two or three types, including blanks, carrier controls, and spike/tracer controls. A blank archive control is a sample aliquot that will be processed identical to the parent source sample. An archive carrier control is a sample aliquot that will have a carefully controlled quantity of a specific carrier or complexing agent added prior to being sealed for storage or archiving. The spike/tracer control is an aliquot of a sample to which a small amount of specific radionuclide(s) will be added.

Several aliquots of each of the various types of archive controls will be needed from each of the special source samples to initiate this long-term evaluation process. In addition to the indicated treatments for preparing the various archive controls, aliquots of the source sample will be tested to provide a baseline analysis of the existing sample composition (chemical constituency).

To conduct a thorough experiment of this nature would require an excessive number of sample aliquots and an extensive list of treatment conditions. An extensive experiment is beyond the scope of this program. The limited tests outlined above are intended to provide additional information

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that should prove useful to the analyst who may be tasked with interpreting results obtained from analysis of archived water samples.

The steps necessary to initiate this "archive control" experiment are being developed and will be implemented via the Branch Technical Procedures-Environmental Radiological procedures in accordance with required quality requirements.

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APPENDIX F REFERENCES

NCRP (National Council on Radiation Protection and Measurements), 1976. "Environmental Radiation Measurements," NCRP No. 50.

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APPENDIX G

GROUNDWATER SAMPLING CONSIDERATIONS.

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APPENDIX G

GROUNDWATER SAMPLING CONSIDERATIONS

The unstable nature of many chemical, physical, and microbial constituents in groundwater and subsurface materials limits sample collection and analysis options. Groundwater normally moves very slowly. This results in a slow rate of change in water quality parameters. However, the subsurface (hydrogeologic zone) is a unique heterogenous environment and maintaining the integrity of a sample from the time of collection to the time of analysis is often a very difficult process. Because the physical, chemical, and microbial aspects of this subsurface environment are so closely interrelated, it is very difficult to deal with one aspect without affecting the others. In selecting groundwater sampling procedures, aspects of all parameters must be considered in an effort to maintain sample integrity (representativeness).

Special precautions must be taken to ensure that the sample taken from a monitoring well is representative of the groundwater at that location, and that the sample is neither altered nor contaminated by the sampling and handling process. To obtain a representative sample of the groundwater, it must be understood that the composition of the water within the well casing and in close proximity to the well is probably not representative of the overall groundwater quality at that sampling site. This is due to the possible presence of drilling contaminants near the well and because important environmental conditions, such as the oxidation-reduction potential, may differ drastically near the well from the conditions in the surrounding

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water-bearing materials. General water quality will affect the radiological component of a sample, therefore it is highly desirable that a well be pumped or bailed until the well is thoroughly flushed of standing water and contains fresh water from the aquifer of interest before a sample is collected from the well. The recommended length of time required to pump or purge a well before sampling is dependent on many factors, including the characteristics of the well, the hydrogeological nature of the aquifer, the type of sampling equipment being used, and the parameters being sampled.

This purge period may range from the time needed to pump or bail one well bore volume to the time needed to pump several bore volumes. A common practice is to pump or bail the monitoring well until a minimum of four to ten bore volumes have been removed. Another, more appropriate method for determining the optimum pumping time required before a representative water sample can be obtained from a monitoring well is to assess specific chemical parameters in the field as the well is being pumped or bailed. Each well will have a unique optimum pumping time requirement. The three major contributors to the pumping time requirement are the length of the well casing in contact with the saturated portion of the aquifer, the flow rate, and the chemical parameter of interest. By first determining the pumping requirement for appropriate constituents (chemical, radiological) in the well, it is possible to calculate the overall pumping requirement. The longest of the individual pumping requirements is used for the overall requirement to ensure that a representative sample of the groundwater is collected. Parameters typically analyzed are pH, alkalinity, chloride, nitrate, iron, sulfate, and specific conductivity. This particular series of

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chemical analyses can be easily performed in the field using readily available, typically inexpensive equipment.

An optimum pumping time can easily be established by plotting the chemical data and making the following assumptions:

- The water from the well is representative of the groundwater at the time when the graph shows chemical stability. Chemical stability is represented by a flat line or band (given analytical error) on the graph.

- The total volume of water pumped is a critical factor. (A well pumped at half of the discharge rate will take twice as long to reach the same chemical stability.)

In a desert environment, optimum pumping may not be feasible since the flow rate in the aquifer may be very low. In cases where such pumping would exhaust the available water supply for a significant period, the ideal approach will be modified based on feasibility considerations.

The type of pumping system used is a function of the type and size of well construction, pumping level, type of pollutant, analytical procedures, and presence or absence of permanent pumping fixtures. Ideally, sample withdrawal mechanisms should be completely inert; economical; easily cleaned, sterilized, and reused; easy to operate at remote sites; and capable of delivering continuous but variable flow rates for purging the well and sample collection.

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Most water supply wells contain semi-permanently mounted pumps which limit the options available for groundwater sampling. The advantage of in-place pumps are that water samples are readily available and non-representative stagnant water in the well bore is generally not a problem. The disadvantages are that excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point, and that water supply wells may produce water from more than one aquifer. The advantage to collecting water samples from monitoring wells without in-place pumps is in the flexibility of selecting equipment and procedures. The principal disadvantage is the possibility of a nonrepresentative sample either through collecting stagnant water that is in the well bore, or through introduction of contamination from the surface by the sampling equipment or procedures. Some commonly used systems are briefly described in the following sections.

Bailers

Bailers represent one of the oldest and simplest methods of sampling water wells. A bailer may be in the form of a weighted bottle or capped length of pipe on a rope, or some modification thereof, which is lowered and raised, generally by hand. A modified bailer sampler can be used for sampling surface waters as well as groundwaters.

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Advantages:

1. They can be constructed from a wide variety of materials compatible with the parameter of interest.

2. Economical and convenient enough that a separate bailer may be dedicated to each well to minimize cross-contamination.

3. No external power source is required.

Disadvantages:

1. It is sometimes impractical to evacuate stagnant water in a well bore with a bailer.

2. Transfer of water sample from bailer to sample bottle can result in aeration.

3. Cross-contamination can be a problem if the equipment is not adequately cleaned after each use.

<u>Suction lift pumps</u>

Suction lift pumps are a variety of pumps available that can be used when the water table is within suction lift (i.e., less than about 20 feet). Centrifugal pumps are the most commonly available, are highly portable, and

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have pumping rates from 5 to 40 gpm. Most of these require a foot-value on the end of the suction pipe to aid in maintaining a prime. Peristaltic pumps are generally low-volume suction pumps suitable for sampling shallow, small diameter wells. Pumping rates are generally low. Hand-operated diaphragm pumps are available that can be operated over a wide range of pumping rates, which facilitates rapid evacuation of a well bore initially, and lower controlled pumping rates for subsequent sampling.

Advantages:

1. Generally, suction lift pumps are readily available, relatively portable, and inexpensive.

Disadvantages:

1. Sampling is limited to groundwater situations where water levels are less than about 20 feet.

Portable submersible pumps

Groundwater investigations routinely require the collection of samples from depths which often exceed the limitations of conventional sampling equipment. A submersible pump can be lowered or raised in a monitoring well. The entire assembly is usually mounted in a pickup or a van.

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Advantages:

1. Portability. They can be used to sample several monitoring wells in a brief period of time.

2. Depending on the size of the pump and pumping depths, relatively large pumping rates are possible.

Disadvantages:

1. Submersible pumps currently available require a minimum well casing inside diameter of three inches.

2. They require the services of a relatively large service-type vehicle - either a van or truck.

3. With conventional construction materials, they are not suitable for organics sampling.

Air-lift samplers

A high-pressure hand pump and any reasonably flexible tubing can be used as a highly portable air-lift sampler. A small air compressor and somewhat more elaborate piping arrangements may be required to sample at greater depths. The primary limitations to these samplers are the potential alteration of water quality parameters, the amount of air pressure that can

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be safely applied to the tubing, and finding a suitable source of compressed air.

Advantages:

1. They can be used as portable or permanently installed sampling systems.

2. They can be used to both pre-pump and sample.

Disadvantages:

1. They are not suitable for pH sensitive parameters, such as metals.

2. If air or oxygen is used, oxidation is a problem.

Gas-operated squeeze pumps

These systems consist principally of a collapsible membrane inside a long, rigid housing; a compressed gas supply; and appropriate control valves. When the pump is submerged, water enters the collapsible membrane through the bottom check valve. After the membrane has filled, gas pressure is applied to the annular space between the rigid housing and membrane, forcing the water upward through a sampling tube. When the pressure is released, the top

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check valve prevents the sample from flowing back down the discharge line, and water from the well again enters the pump through the bottom check valve.

Advantages:

1. A wide range in pumping rates is possible.

2. A wide variety of materials can be used to meet the needs of the parameters of interest.

3. The driving gas does not contact the water sample, which eliminates possible contamination or gas stripping.

4. They can be constructed in diameters as small as one inch - permitting use of small economical monitoring wells.

5. They are highly portable.

Disadvantages:

1. Large gas volumes and long cycles are necessary for deep operation.

2. Pumping rates cannot match rates of submersible, suction, or jet pumps.

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3. Commercial units are relatively expensive - approximately $1,000 for units currently available.

Gas-driven piston pumps

Double-action piston pumps operated by compressed gas are also available. A driving gas enters and exhausts from gas chambers between two pistons and an intermediate connector that joins them. Built-in check valves at each end of the pumps allow water to enter the cylinders on the suction stroke and to be expelled to the surface on the pressure stroke. Pumping rates vary with the pumping head, but pumping rates of 2.5 to 8 gallons/hour have been noted at 100 feet of pumping head.

Advantages:

1. They isolate the sample from the operating gas.

2. They require no electrical power source.

3. They operate continuously and reliably over extended periods of time.

4. They use compressed gas economically.

5. They can be operated at pumping heads in excess of 500 meters.

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Disadvantages:

1. They are relatively expensive - in excess of $3,000 for the continuously operating unit.

2. Particulate material may damage or inactivate the pump unless the suction line is filtered.

3. Low pumping rates.

Table G-1 provides a summary of guidelines for sampling practices generally for various categories of water quality pollutants. Sampling for radiological constituents is not incompatible with sampling for water quality pollutants. Radioactive isotopes possess the same chemical properties as the stable isotopes of a given element. The precautions and process applicable for collecting and handling samples of a specific element or compound apply likewise to its radioactive forms. Some of the information obtained and summarized in Table G-1 may be of use for adequately interpreting radioanalytical results from groundwater samples (the exception being those methodologies associated with organics).

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Table G-1. Guidelines for sampling practices (page 1 of 4)

Measurement	Well construction	Sampling method
	PHYSICAL PROPERTIES	
Color Conductance Hardness Odor pH Residue Filterable Non-filterable Total Volatile Settleable Matter Temperature Turbidity	All of the drilling and construction methods described in the test are acceptable. The use of water or drilling mud will not significantly affect the samples if the well is pumped prior to sampling for a sufficient time to clear the well of drilling fluids. This can be determined in the field using a conductivity meter.	All of the methods described in the text are acceptable. The easiest method should be used providing the sampling device is rinsed thoroughly between sampling events. Devices which affect the gas composition of the sample will affect the pH.
	METALS	
Dissolved Suspended Total Mercury Dissolved Total	All of the drilling and construction methods described in the text are acceptable except bentonite clays or other clay-based drilling muds, which should not be used if possible. Plastic casing is preferable to metal casing.	All of the methods described in the text are acceptable provided the groundwater is not aerated during the sampling. The sampling device should be metal free and should be rinsed throughly between sampling events.

Table G-1. Guidelines for sampling practices (page 2 of 4)

Measurement	Well construction	Sampling method
	INORGANICS, NON-METALLICS	
Acidity	All of the drilling and construction methods described in the text are acceptable. The use of water or drilling mud will not significantly affect the samples if the well is pumped prior to sampling for a sufficient time to clear the well of drilling fluids. This can be determined in the field using a conductivity meter.	All of the methods described in the text are acceptable although methods such as bailers, squeeze pumps, and piston pumps which minimize changes in dissolved gas composition of the sample are preferable if the parameters being measured are affected by pH or dissolved gas changes.
Alkalinity		
Bromide		
Chloride		
Cyanides		
Fluoride		
Iodide		
Nitrogen		
Ammonia		
Kjeldahl, Total		
Nitrate plus nitrite		
Nitrate		
Nitrite		
Dissolved Oxygen		
Probe		
Winkler		
Phosphorus		
Ortho-phosphate Dissolved Hydrolyzable		
Total		
Total, Dissolved		

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Table G-1. Guidelines for sampling practices (page 3 of 4)

Measurement	Well construction	Sampling method
	INORGANICS, NON-METALLICS (continued)	
Silica		
Sulfate		
Sulfide		
Sulfite		
	ORGANICS - ROUTINE ANALYSES	
COD Oil & Grease Organic Carbon MBAS	All of the drilling and construction methods described in the text are acceptable, with exceptions noted below.	All of the methods described in the text are acceptable, provided the sampling device is rinsed throughly between sampling events, with exceptions noted below.
	Exceptions: Methods of Appendix B should be used for "Oil and Grease" when a separate organic phase is present in the aquifer. For high sensitivity "Organic Carbon" analyses, methods for "Organics" by chromatographic methods, presented below, are preferable.	
	ORGANIC - TO BE DETERMINED USING HIGH SENSITIVITY ANALYSES BY CHROMATOGRAPHIC METHODS	
Purgeable (VOA) Non-purgeable	Desirable for wells to be constructed without the use of contaminating drilling fluids and casings. Casing in order of preference should be Teflon, stainless steel. If possible, plastic casing should not be used.	Samples to be analyzed for purgeable volatile organics (VOA) should be collected by a glass or Teflon bailer after the well is throughly flushed with non-aerating pump. Vacuum and air-lift pumps

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Table G-1. Guidelines for sampling practices (page 4 of 4)

Measurement	Well construction	Sampling method
ORGANIC - TO BE DETERMINED USING HIGH SENSITIVITY ANALYSES BY CHROMATOGRAPHIC METHODS		
		should not be used. Samples to be analyzed for trace levels of organics should be be collected with Teflon or glass systems.
MICROORGANISMS		
Bacteria Fungi Protozoa Viruses	All of the methods described in the text are acceptable with the exception of biodegradable drilling muds such as Revert, which should not be used. All components of a well casing sandpack pump should be chlorinated after completion, and then thoroughly pumped to remove any residual chlorine.	All of the methods described in the text are acceptable if the device can be sterilized before use.

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APPENDIX G REFERENCES

Campbell, M. D., and J. H. Lehr, 1973. Water Well Technology, McGraw-Hill Book Company, New York.

EPA (U.S. Environmental Protection Agency), 1977. "Procedures Manual for Ground Water Monitoring at Solid Waste Disposal Facilities," EPA/530/SW-611, August.

EPA (U.S. Environmental Protection Agency), 1979. Handbook for Analytical Quality Control in Water and Wastewater Laboratories. EPA-600/4-79-019, EMSL, Cincinnati, Ohio.

EPA (U.S. Environmental Protection Agency), 1979. "Methods for Chemical Analyses of Water and Wastes," EPA-600/4-79-020, March.

EPA (U.S. Environmental Protection Agency), 1982. Handbook for Sampling and Sample Preservation of Water and Wastewater, EPA 600/4-82-029.

Keys, W. Scott, and L. M. MacCary, 1971. "Application of Borehole Geophysics to Water-Resources Investigations," U.S. Geological Survey Techniques of Water-Resources Investigations, Book 2, Chapter E-1, pp. 1-126.

McMillion, L. G., and J. W. Keeley, 1968. "Sampling Equipment for Ground Water Investigations," Ground Water Journal, Vol. 6, No. 2, March-April.

PNL (Pacific Northwest Laboratories), 1982. "Requirement for Sampling Ground Water Wells on the Hanford Site," PNL-4192.

Robertson, D. E., et al., 1985. "Evaluation of a Large-Volume Water Sampling Technique for Determining the Chemical Speciation of Radionuclides in Groundwater," PNL-SA-12502.

Schamhurst, N. L. Defining an Optimum Pumping Time.

USGS (U.S. Geological Survey), 1977. National Handbook of Recommended Methods for Water-Data Acquisition. Interagency Advisory Committee on Water Data, Office of Water Data Coordination, Reston, Virginia.

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APPENDIX H

PROJECT-RELATED FIELD STUDY PROGRAMS

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APPENDIX H

PROJECT-RELATED FIELD STUDY PROGRAMS

Section 6.0 of the RMP discusses the various types of data necessary to support the scope of radiological analysis and impact assessments for the NNWSI Project. There are numerous field activities and study plans being prepared in direct support of requirements and issues detailed in documents such as the EMMP, SCP, and RCP. Figure H-1 depicts the general hierarchy of documents in relation to the RMP. These documents provide detailed information on activities and tasks that will provide vast quantities of data during the various phases of the Project. To conduct the radiological monitoring program in the most cost effective manner (by limiting duplication of effort whenever practical), data from numerous sources will be relied upon extensively as summarized in Table H-1. Table H-1 is not a comprehensive listing of all activities to be conducted for the NNWSI Project. A detailed data/program matrix will be developed as each of the field activities and study plans is finalized.

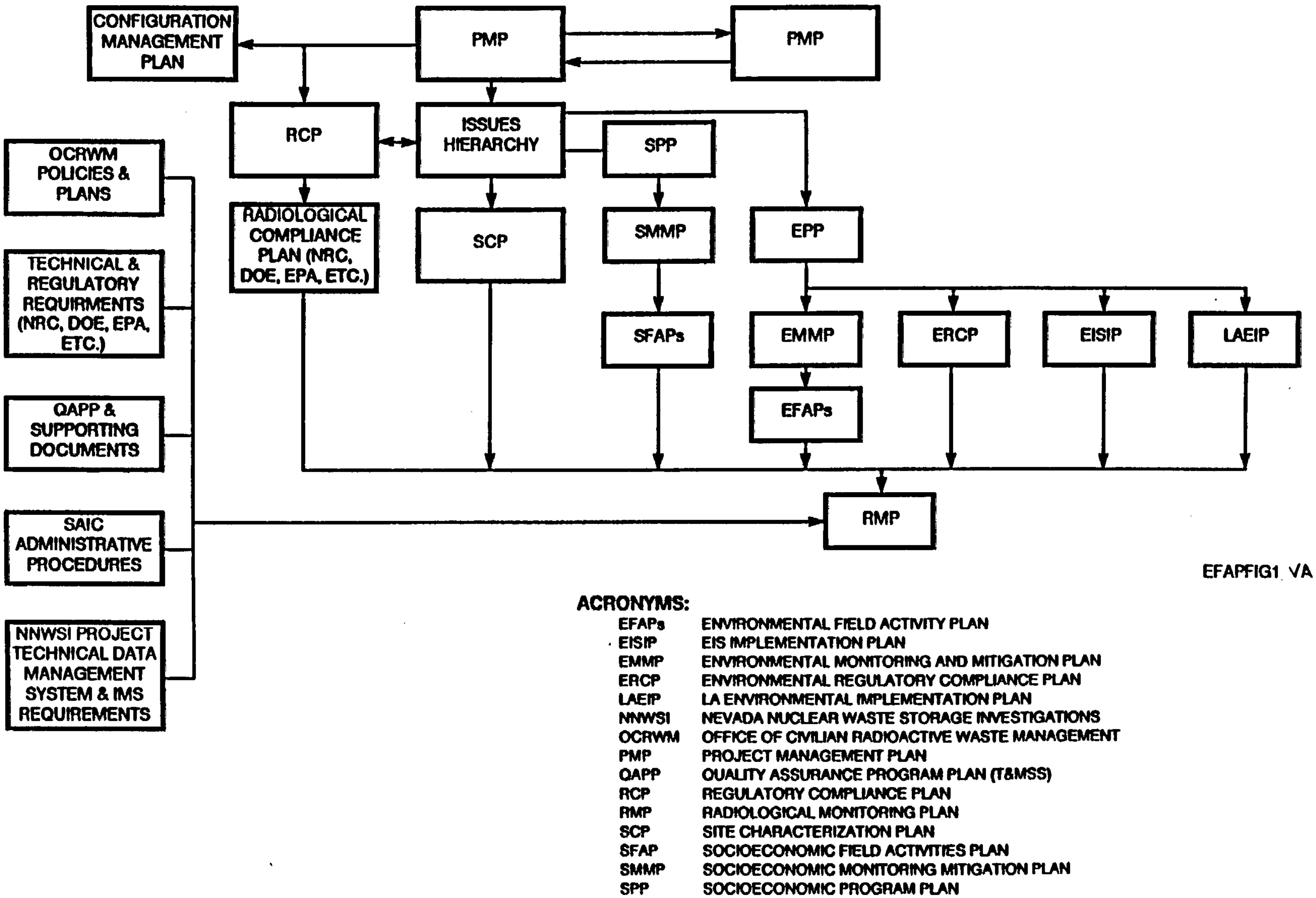

Figure H-1. Related program documents.

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Table H-1. Overview of information requirements from related field activities and study plans (page 1 of 3)

Environmental Monitoring and Mitigation Plan (EMMP)
    Environmental Field Activities Plans (EFAP)

- Terrestial Ecosystems
  - Activity Surveys
    - Areas of special interest
  - Support Studies (population densities/ranging)
    - Lagomorphs
    - Predators
    - Deer
    - Game Birds
  - Sampling Activities
    - Indicator species
    - Vegetation
    - Game
    - Scats
- Meteorology/Air Quality Monitoring
  - Average atmospheric lid (ceiling) height
  - Precipitation
  - Temperature
  - Vertical temperature gradient
  - Wind direction frequency
  - Reciprocal average wind speed
  - Average wind speed (16 quadrant radial grid)
  - Pasquill (7) stability categories
  - Dispersion (χ/Q) values
  - TSP/cascade impactor
  - PM-10 particulate monitoring
- Water Resources
  - Source survey
  - Use parameters
  - Chemical characteristics
- Cultural Resource Studies
  - Archaeological Studies
    - Field surveys
      - reconnaissance
      - mapping
  - Native American Studies
    - Site visits
      - mapping

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Table H-1. Overview of information requirements from related field activities and study plans (page 2 of 3)

Soil
- Characteristics (density, moisture, chemical)
- Weathering

Radiological Studies
- Radionuclide/environmental media specific data

Land Use Studies
- (see SCP/Socioeconomic Field Activities Plan)

Site Characterization Plan

Geohydrological Field Activities
- Water Table Monitoring and Sampling
- Pumping and Tracer Tests
  - Chemical composition
- Stream Flows Monitoring
- Playa Coring Study
- Infiltration Testing

Socioeconomic Program Plan
Socioeconomic Field Activities Plan

Population Density and Distribution
- highly populated areas (urban centers)
- population density (regional)
- members of public
  - restricted area access
  - unrestricted area access

Population Forecasts (projected for all phases of Project)
Workforce Distribution/Forecast
- restricted area
- unrestricted area

Agricultural Resource Base
- Animal products
  - production
  - consumption

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Table H-1. Overview of information requirements from related field activities and study plans (page 3 of 3)

Crop/Produce Census
production
consumption
distribution
Land Use Practices
Pasturage
Crop Rotation
Irrigation
Agri-management Practices

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APPENDIX I

ACRONYMNS AND ABBREVIATIONS

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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
BTP	Branch Technical Procedure
CCB	Change Control Board
CCF	Correspondence Control Facility
CFR	Code of Federal Regulation
CRM	Continuous radon monitor
DMS	NNWSI Project Technical Data Management System
DOE	U.S. Department of Energy
DOE/HQ	U.S. Department of Energy Headquarters
DOE/NV	U.S. Department of Energy, Nevada Operations Office
E-MAD	Engine Maintenance, Assembly and Disassembly
EA	Environmental Assessment
EIS	Environmental Impact Statement
EML	Environmental Monitoring Laboratory (EPA)
EMMP	Environmental Monitoring and Mitigation Plan
EMSL	Environmental Monitoring Systems Laboratory (EPA)
EPA	U.S. Environmental Protection Agency
EPP	Environmental Program Plan
ERDA	Environmental Research and Development Administration
ERM	Environmental Radiological Monitoring
ES&H	Environmental Health and Safety

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ESF	exploratory shaft facility
ER	Environmental Report
FY	fiscal year
HLW	high-level waste
HPED	Health Physics and Environment Division (DOE/NV)
ICRP	International Commission on Radiation Protection
IMS	NNWSI Project Information Management System
KEV	thousands of electron volts
LLD	lower limit of detection
MEV	millions of electron volts
MPC	maximum permissible concentration
MRAD	1 rad x 10^{-3}
MREM	1 rem x 10^{-3}
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Protection Act
NNWSI	Nevada Nuclear Waste Storage Investigations
NOAA	National Oceanic and Atmospheric Administration
NRAD	Nuclear Radiation Assessment Division (EPA)
NRC	U.S. Nuclear Regulatory Commission; National Research Council
NRDA	Nevada Research and Development Area
NTS	Nevada Test Site
NTSO	Nevada Test Site Support Office
NWPA	Nuclear Waste Policy Act of 1982
OCRWM	Office of Civilian Radioactive Waste Management
PSCRMP	Preliminary Site Characterization Radiological Monitoring Plan
PRAM	Preclosure Risk Assessment Methodology
QA	Quality Assurance

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QAPP	Quality Assurance Program Plan
QC	Quality Control
R	roentgen
RCG	Radiological Compliance Guide
RAD	See Glossary
RAMATROL	Radioactive Material Control Group (REECo)
REECo	Reynolds Electrical and Engineering Company
REM	See Glossary
RFPB	Radiological Field Programs Branch Manager
RMP	Radiological Monitoring Plan
SAIC	Science Applications International Corporation
SAR	safety analysis report
SCP	site characterization plan
SEIG	System Engineering Integration Group
SF	spent fuel
SMF	Sample Management Facility
T&MSS	Technical and Management Support Services Contractor
TLD	thermoluminescent dosimeter
TRU	transuranic (waste)
USGS	U.S. Geological Survey
WHO	World Health Organization
WIPP	Waste Isolation Pilot Plant
WLM	working level month
WMPO	Waste Management Project Office
α	alpha particle
β	beta particle
γ	gamma ray

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χ/Q	Atmospheric dispersion coefficient (Atomic Energy and Meteorology)
μCi	1 Curie x 10^{-6}
μR	1 roentgen x 10^{-6}

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APPENDIX J

GLOSSARY

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APPENDIX J

GLOSSARY

absorbed dose (D)	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (gray) where 1 rad = 0.01 joule/kg material (1 Gy = 1.0 joule/kg material).
accidental radiological releases	Releases of radioactivity that deviate from the planned or expected behavior or course of events in connection with the operation of the facility and that have Environmental Protection or Safety Significance.
actinides	Radioactive elements in the series beginning with atomic number 89 and continuing through 103.
activation products	The group of radionuclides that are formed as a result of the absorption radiation.
accuracy	The degree of agreement of a measurement with an accepted reference or true value. Expressed as

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the difference between the two values, the difference as a percentage of the reference or true value, or as a ratio of the measured value and the reference or true value.

affected Indian Tribe — Any Indian Tribe (1) within whose reservation boundaries a repository for high-level radioactive waste or spent fuel is proposed to be located or (2) whose Federally defined possessory or usage rights to other lands outside the reservation boundaries arising out of congressionally ratified treaties may be substantially and adversely affected by the location of such a facility: provided that the Secretary of the Interior finds, upon the petition of the appropriate governmental officials of the Tribe, that such effects are both substantial and adverse to the Tribe.

affected State — Any State that (1) has been notified by the DOE in accordance with Section 116 (a) of the Nuclear Waste Policy Act as containing a potentially acceptable site; (2) contains a candidate site for site characterization or repository development; or (3) contains a site selected for repository development.

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ALARA (as low as reasonably achievable)	A phrase and acronym used to describe an approach to radiation exposure control or management whereby the exposures and resulting doses to members of the public, workers, or environment are maintained as far below the specified limits as economic, technical, and practical considerations will permit.
aliquot	The fraction of a field sample taken for processing through an analytical procedure (a "laboratory sample" of a field sample).
alluvial fan	A cone-shaped deposit of alluvium made by a stream where it runs out onto a level plain or meets a slower stream. The fans generally form where streams issue from mountains upon the lowland.
alpha particle	A positively charged particle emitted in the radioactive decay of certain nuclides. Made up of two protons and two neutrons bound together, it is identical with the nucleus of a helium atom. It is the least penetrating of the three common types of radiation -- alpha, beta, and gamma.

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alpha spectrometry	A method of identifying and to some extent quantify the type and the radionuclides/radioisotopes present in a material based on the energies of the alpha particles emitted by the material.
ambient radiation monitoring	The measurement of that level of radiation which is present in the surrounding existing environment.
analytical blank	See "blank."
analytical detection limit	See "lower limit of detection."
aquifer	A formation, a group of formations, or a part of a formation that contains sufficient saturated permeable material to yield sufficient quantities of water to wells and springs.
archive	The controlled storage of a sample in a manner to assure maintenance of the chain of custody.
arithmetic mean	The most commonly used measure of central tendency, commonly called the "average." Mathematically, it is the sum of all the values of a set divided by the number of values in the set.

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atmospheric stability class	An index that indicates the atmosphere's ability to disperse airborne releases.
atomic energy defense activity	Any activity of the Secretary of Energy performed in whole or in part in carrying out any of the following functions: Naval reactors development, weapons activities, verification and control technology, defense nuclear materials production, defense nuclear waste and materials byproducts management, defense nuclear materials security and safeguards and security investigations, and defense research and development.
average	See "arithmetic mean."
background (radiological)	The existing radiation/radioactive material present in the ambient environment.
background radiation	Radiation that is produced by sources other than the facility of specific interest, such as naturally occurring radioactive minerals in the earth, cosmic rays, naturally occurring radionuclides in living organisms, fallout from weapons tests, and other radioactive material present at the location of interest.

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baseline (radiological) — The background radiological data for the ambient environment associated with preparation of environmental documentation.

bajada — A broad, gently inclined detrital surface extending from the base of a mountain range out into an inland basin, formed by the lateral coalescence of a series of alluvial fans, and having an undulating character.

beta particle — A negatively charged particle, physically identical with the electron, that is emitted by certain radionuclides.

beta radiation — See "beta particle."

biological half-life — The time required for an organism to eliminate half the amount of a radionuclide ingested or inhaled.

biota — The plants and animals which make up the living part of the environment.

blank (radiological) — A sample of a media being sampled without radiological contaminants normally used to selectively evaluate the accuracy of an analytical process' ability to detect zero

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activity. This value is then used to evaluate, adjust, or correct the routine analytical results.

breakthrough (relative to gaseous collection media)	When the migration of a gas through a collection medium reaches the point where the gas begins passing out of the medium.
by-product material	Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material.
calibration	Adjustment of the system and the determination of system accuracy typically using at least three known sources and instrument measurements. Adjustment of the system accuracy should be conducted using standard operating procedures and sources that are traceable to the National Bureau of Standards (NBS) or other acceptable standards.
check source	A source (e.g., a radioactive source) not necessarily calibrated that is used to confirm the continuing satisfactory operation of an instrument (also reference source).

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committed dose (H_{50})	The predicted total dose equivalent to a tissue or organ over a 50-year period after an intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose is expressed in units of rem (or sievert).
confidence interval	A value interval that has a designated probability (the confidence coefficient) of including some defined parameter of the population.
confidence limits	The outer boundaries of a confidence interval.
continuous monitoring	The real-time measurement using in situ measurement systems.
continuous sampling	Includes both noninterrupted sampling and repetitive sequential collection of small samples obtained automatically at intervals short enough to yield a representative sample for the entire sampling period.
critical pathway	The specific route of transfer of radionuclides from one environmental component to another (e.g., from one trophic level to another) that

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results in the greatest fraction of an applicable dose limit to a population group or an individual's whole body, organ, or tissue.

curie	The amount of radioactive material which produces 3.7 x 10 disintegration per second.
data validation	A systematic review of a data set to identify "outliers" or suspect values. The process uses appropriate statistical techniques to screen out impossible or highly unlikely values.
daughter product	A nuclide that results from radioactive decay. Thus radium-226 decays to radon-222 which, in turn, decays to polonium-218. The radon is the daughter of the radium, and the polonium is the daughter of the radon.
decay (radioactive)	(1) The process whereby radioactive materials undergo a change from one element or state to another, releasing radiation in the process. This action ultimately results in a decrease in the number of radioactive nuclei present in the sample. (2) The spontaneous transformation of one nuclide into a different nuclide or into a different isotope of the same nuclide.

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decay chain	The sequence of radioactive disintegrations in succession from one nuclide to another until a stable daughter product is reached.
decommissioning	The permanent removal from service of surface facilities and components necessary for preclosure operations, after repository closure, in accordance with regulatory requirements and environmental policies.
decontamination	The removal of unwanted material (especially radioactive material) from the surface of, or from within, another material.
detector	A device for converting radiation flux and energy to a signal suitable for measurement purposes.
disposal	The emplacement in a repository of high-level radioactive waste, spent nuclear fuel, or other highly radioactive material with no foreseeable intent of recovery, whether or not such emplacement permits the recovery of such waste.
disposal system	See "repository system."

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dose	The quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body.
dose commitment	The integrated dose that results from an intake of radioactive material when the dose is evaluated from the beginning of the intake to a later time; also used for the long-term integrated dose to which people are considered committed because radioactive material has been released to the environment.
dose equivalent (radiation)	An estimate of the amount of biological damage done by the deposition in tissue of a given unit of absorbed radiation dose. It is obtained by multiplying the absorbed radiation dose by a quality factor. The unit of dose equivalent is the rem.
dose limit	The limit established by the Environmental Protection Agency or the Nuclear Regulatory Commission for the exposure of people to radiation.
effluent	Any treated or untreated air emission or liquid discharge at a DOE site or facility.

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effluent monitoring	The collection and analysis of samples or measurements of liquid, gaseous, or airborne effluents for the purpose of characterizing and quantifying contaminants and process stream characteristics, assessing radiation exposures to members of the public, and demonstrating compliance with applicable standards.
emission	See "effluent."
environmental assessment	The document required by Section 112(b)(1)(E) of the Nuclear Waste Policy Act of 1982. That section also defines what is to be included in an environmental assessment (EA).
environmental impact statement	The document required by Section 114 of the Nuclear Waste Policy Act of 1982.
environmental surveillance	The collection and analysis of samples of air, water, soil, foodstuff, biota, and other media from DOE sites and their environs for purposes of demonstrating compliance with applicable standards, assessing radiation exposures to members of the public, and assessing effects, if any, on the local environment.

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ephemeral stream	Drainage of a stream or portion of a stream which flows briefly in direct response to precipitation in the immediate vicinity, and whose channel is at all times above the water table.
exposure	The radiation dose received by the absorption of radiation or the intake of a radionuclide by any individual.
error	The difference between an observed or measured value and its true value.
facility	A building, structure, or group of buildings or structures that release radionuclides and are subject to the regulations/standards pertinent to this manual.
far field	For this document far field means more than 16 kilometers from the location of the meter tower (Figure 4.3.4-1).
fission product	A nuclide produced by the fission of a heavier element.

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fuel assembly	A single mechanical unit consisting of a number of fuel rods held together by a mechanical support structure designed to maintain proper spacing of the fuel rods and facilitate their handling.
gamma radiation	Electromagnetic ionizing radiation that is emitted from the nucleus during some types of radioactive decay processes. Gamma radiation can penetrate various thicknesses of absorbing material, depending primarily on the energy of the gamma ray and the composition of the material. Gamma radiation is primarily an external radiation hazard.
geologic disposal system	See "mined geologic disposal system."
geologic repository	A system requiring licensing by the Nuclear Regulatory Commission, that is intended to be used, or may be used, for the disposal of radioactive wastes in excavated geologic media. A geologic repository includes: (1) the geologic-repository operations area, and (2) the portion of the geologic setting that provides isolation of the radioactive waste.

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grab sample	A randomly taken, single sample acquired from an effluent stream over a short interval of time.
groundwater	Water below the land surface in a zone of saturation.
groundwater sources	Aquifers that have been or could be economically and technologically developed as sources of water in the foreseeable future.
highly populated area	Any incorporated place (recognized by the decennial reports of the U.S. Bureau of the Census) of 2,500 or more persons, or any census-designated place (as defined and delineated by the Bureau) of 2,500 or more persons, unless it can be demonstrated that any such place has a lower population density than the mean value for the continental United States. Counties or county equivalents, whether incorporated or not, are specifically excluded from the definition of "place" as used herein.
high-level radioactive waste	(A) The highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products

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in sufficient concentrations; and (B) other highly radioactive material that the Nuclear Regulatory Commission, consistent with existing law, determines by rule to require permanent isolation (NWPA, 2(12)).

ingestion-dose pathway — Those components of the food chain or water system that might contribute to the radiation exposure of an individual as the result of an intake of food or water.

impaction — A process by which a particle or droplet is removed from an airstream by striking a surface in contact with the airstream. When a particle grazes a surface and is thus retained, the term "interception" applies.

in-line — A system in which a detector or other measuring device is placed in the effluent stream for purposes of performing measurements on the effluent stream.

inert gas — A chemical stable gaseous element. These gases do not normally react chemically.

license application — An application for a license from the Nuclear Regulatory Commission to construct a repository.

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licensing	The process of obtaining the permits and authorizations required to site, construct, operate, close, and decommission a repository.
low-level waste (radioactive)	Radioactive material that is not high-level radioactive waste, spent nuclear fuel, transuranic waste, or by-product material as defined in Section 11a(2) of the Atomic Energy Act of 1954.
man-rem	A unit used in health physics to compare the effects of different amounts of radiation on groups of people. It is obtained by multiplying the average dose equivalent to the whole body or a given organ or tissue (measured in rems) by the number of persons in that population.
maximally exposed person/individual	A hypothetical person who is exposed to a release of radioactivity in such a way that he receives the maximum possible individual radiation dose or dose committment. For instance, if the release is a puff of contaminated air, the maximally exposed individual is a person at the point of the largest ground-level concentration and stays there during the whole time the contaminated-air cloud remains above. This term is not meant to imply that there

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really is such a person; it is used only to indicate the maximum exposure a person could receive.

maximum individual dose — The highest radiation dose delivered to the whole body or to an organ that a person can receive from a release of radioactivity. The hypothetical person who receives this dose, the maximally exposed individual, is one whose location, activities, and habits maximize the dose.

maximum permissible concentration — The average concentration of a radionuclide in air or water to which a worker or member of the general population may be continuously exposed without exceeding regulatory limits on external or internal radiation doses. Specified in Appendix B of 10 CFR Part 20.

measurement — The accurate quantification of a parameter, a contaminant, or gross content of radioactive material associated with a liquid or airborne effluent stream.

median — The middle value of a set of data when the set of data are ranked in increasing or decreasing order. If there are an even number of values in

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	the set, the median is the arithmetic average of the two middle values; if the number of values is odd, it is the middle value.
membrane filter	One of several commercially available filter media consisting generally of very thin organic-based films having a range of selectable porosities and controlled composition. Very thin, porous metallic filters are also known as membrane filters.
metastable (radionuclide)	A state of temporary nuclear stability which occurs in some types of radioactive decays. During these decays (called isomeric transition), an intermediate product is formed by the first stage of decay. This product has a half-life long enough to be considered a separate isotope.
minimum detection level (MDL)	The minimum concentration of the constituent of species of interest that can be observed by an analytical instrument and distinguished from instrument noise with a specified degree of probability.
mitigation	(1) Avoiding the impact altogether by not taking a certain action or parts of an action.

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(2) Minimizing impacts by limiting the degree or magnitude of the action and its implementation. (3) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment. (4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action. (5) Compensating for the impact by replacing or providing substitute resources or environments.

molecular sieve

A term used to describe the function of zeolite materials, which are clay-like in chemical nature, and from which all water can be removed without alteration of their molecular structure. As a result of this, the material becomes microporous to such an extent that about half its volume is occupied by very small holes or channels. The material thus readily adsorbs molecules of other substances in much the same manner as activated carbon. However, such molecules must be small enough to enter the pores vacated by the water molecules. Because of the limitation placed by the pores on the size of the adsorbed molecules, zeolites act as selective devices which adsorb smaller molecules readily but exclude larger ones. For this reason, they are called molecular sieves.

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monitor	Two definitions: (1) to measure certain constituents or parameters in an effluent stream continuously or at a frequency that permits a representative estimate of the amount over a specified interval of time, and (2) the instrumentation or device used in monitoring.
natural background radiation	Radiation that occurs naturally in the environment from such sources as cosmic rays, the naturally occurring radioactive elements in the earth, and naturally occurring radionuclides in living organisms.
near field	Less than 16 kilometers from the 60-meter tower (Figure 4-5).
Nevada Test Site	The U.S. Department of Energy reservation located in southeastern Nevada (Figure 4-1).
nuclear fuel cycle	Those operations associated with the production of electrical power for public use by any fuel cycle through utilization of nuclear energy.
occupational dose	The radiation dose received by a person in a restricted area or in performing work duties involving exposure to radiation.

occupational exposure — The absorption of radiation or the ingestion of a radionuclide by an individual, on duty, and engaged in operations involving the management, storage, and disposal of radioactive waste.

off-line (monitoring systems) — A system in which an aliquot is withdrawn from the effluent stream for collection or conveyance to a detector or assembly.

offsite — That area not under effective control of persons possessing or using spent nuclear fuel or radioactive waste.

onsite — Area within the boundaries of a facility or site that is or can be controlled with respect to access by the general public.

outlier — An extreme value in a data set so far removed from the other values with which it is associated that the chance probability of its being a valid member of the group is very small. The questionable value may be eliminated from the group on the basis of further statistical investigations of the data set.

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particle	An aggregate of molecules forming a solid or liquid that ranges in size from a few molecular diameters to a few millimeters.
Pasquill stability class	See "atmospheric stability class."
pelage	The condition/state of the fur of an animal.
penetration	The passage of some material through a filter or other collector.
permanent closure	Synonymous with closure.
plate out	A thermal, electrical, chemical, or mechanical action that results in a loss of material by deposition on surfaces between the point the sample was withdrawn, collected, or analyzed.
point source	The single defined point (origin) of an airborne release such as a stack or vent.
population dose	The sum of the radiation doses received by the individual members of a population exposed to a particular source or event. It is expressed in units of man-rem.

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postclosure — Of or pertaining to the period of time, conditions, or events after the closure of the geologic repository.

precision — The degree of exactness of performing an analytical procedure.

preclosure — Of or pertaining to the period of time, activities, operations, and conditions before and during the closure of the geologic repository.

proficiency testing — A special series of planned tests to determine the ability of field technicians or laboratory analysts who normally perform routine analyses. The results may be used for comparison against established criteria, or for relative comparison with the results from another group of technicians or analysts.

proportional sample — An aliquot of samples consisting of a known fraction of the original samples.

quality — The totality of features and characteristics of a material, process, product, service, or

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activity that bears on its capability to satisfy a given purpose.

QA Level I

Those radiological health and safety related items and activities that are important to either safety or waste isolation and that are associated with the ability of a geologic nuclear waste repository to function in a manner that prevents or mitigates the consequences of a process or event that could cause undue risk to the radiological health and safety of the public. Items and activities important to safety are those engineered structures, systems, components, and related activities essential to the prevention or mitigation of an accident that could result in a radiation dose either to the whole body or to any organ of 0.5 rem or greater, either at or beyond the nearest boundary of the unrestricted area at any time until the completion of the permanent closure of the repository. Items and activities important to waste isolation are those barriers and related activities which must meet the criteria that address long-term performance of the engineered and natural barriers to the accessible environment after permanent closure. The criteria for items or activities important

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to safety and waste isolation are found in 10 CFR Part 60 and 40 CFR Part 191.

QA Level II — Those activities and items related to the systems, structures, and components which require a level of quality assurance sufficient to provide for reliability, maintainability, public and repository worker radiological health and safety, and other operational factors that would have an impact on DOE and WMPO concerns, and the environment.

QA Level III — Those activities and items not classified as QA Levels I or II.

quality assurance (QA) — Those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily and safely in service. The goal of quality assurance is to ensure that research, development, demonstration, scientific investigations, and production activities are performed in a controlled manner; that components, systems, and processes are designed, developed, constructed, tested, operated, and maintained according to engineering standards, quality

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practices, and technical specifications/operational safety requirements; and that resulting technology data are valid and retrievable. Quality assurance includes quality control (QC), which comprises all those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements.

quality control (QC) — Those actions necessary to control and verify the features and characteristics of a material, process, product, service, or activity to specified requirements. The aim of quality control is to provide quality that is satisfactory, adequate, dependable, and economic.

quality factor (Q) — The principal modifying factor used to derive the dose equivalent from the absorbed dose. The quality factors to be used are as follows (DOE Order 5480.xx):

Radiation type	Quality factor
x-rays, gamma rays, positrons, electrons (including tritium)	1

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protons and single-charged particles of unknown energy with rest mass greater than one atomic mass unit	10
alpha particles and multiple-charged particles (and particles of unknown charge) of unknown energy	20

rad — The unit of radiation dose. One rad of dose would deliver .01 joule to 1 kg of tissue.

radioactive material — Any material or combination of materials that spontaneously emits ionizing radiation.

radiation dose — The quantity of radiation absorbed per unit of mass by the body or any portion of the body.

radioactive decay — A spontaneous nuclear transformation (disintegration) in which nuclear particles or electromagnetic energy (such as alpha particles, beta particles, or gamma photons) are emitted.

radioactive-waste facility — A facility subject to the licensing and related regulatory authority of the NRC pursuant to

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	Sections 202(3) and 202(4) of the Energy Reorganization Act of 1974 (88 Stat. 1244).
radioisotope	A radioactive isotope of an element.
radiological environmental monitoring	The measurement of radioactive containment concentrations or radiation intensity in the environment.
radiological exposure	The radiation dose received by the absorption of external radiation or the intake of radionuclides.
radionuclide	A radioactive nuclide. There are several hundred known radionuclides, both produced and naturally occurring; radionuclides are characterized by the number of neutrons and protons in an atom's nucleus.
radionuclide emissions	Releases of airborne radioactive materials to the environment.
random samples	Samples obtained in such a manner that all items or members of the lot, or population, have an equal chance of being selected in the sample.

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range	The difference between the maximum and minimum values of a set of values.
reasonably achievable	Mitigation measures or courses of action shown to be reasonable considering the costs and benefits in accordance with the National Environmental Policy Act of 1969 (See "ALARA").
reference source	See "check source."
reliability	The capability of a system to perform a required function under stated conditions for a stated period of time.
release limit	A regulatory limit on the concentration or the amount of radioactive material released to the environment; usually expressed as a radiation dose.
rem	The unit of effective radiation dose which reflects the biological damage capability of the radiation. Specifically 1 rem is equal to the dose in rads times the quality factor.
repeatability	The degree that identical results can be obtained from analysis of identical sample.

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replicability	The precision, usually expressed as a standard deviation, measuring the variability among replicates.
replicates	Repeated but independent determinations of the same sample.
representative sample	A sample taken to depict the characteristics of a lot or population as accurately and precisely as possible. A representative sample may be a completely "random sample" or a "stratified sample" depending upon the objective of the sampling and the characteristics of the conceptual population.
reproducibility	The degree of precision of a laboratory (repeatedly) or different laboratories obtaining the same measurement values of the same sample.
repository	Any system licensed by the NRC that is intended to be used for, or may be used for, the permanent deep geologic disposal of high-level radioactive waste and spent nuclear fuel, whether or not such system is designed to permit the recovery, for a limited period during initial operation, of any materials placed in such a system. Such a term includes both

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surface and subsurface areas at which high-level radioactive waste and spent nuclear fuel handling activities are connected.

sample	Two definitions: (1) A subset or group of objects selected from a larger set, called the "lot," or "population;" and (2) extracted portion or subset of an effluent stream or environmental media.
sample blank	See "blank."
sampling	The extraction of a prescribed portion of an effluent stream or an environmental medium for purposes of inspection or analysis.
scintillation	A flash of light produced in a phospor by an ionization event.
secondary standard	A material having a property that is calibrated against a primary standard.
sensitivity	The minimum amount of a radionuclide or other material of interest that can repeatedly be detected by an instrument, system, or procedure.
sequential sampling	Timed samples collected from an effluent stream.

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shielding	The material interposed between a source of radiation and personnel to protect against radiation exposure; commonly used shielding materials are concrete, water, and lead.
site	For purposes of this document, the site is the near-field area surrounding the 60-meter tower. This is near the location of the potential Yucca Mountain site surface facilities (Figure 4-2).
source (radioactive)	A known amount of radioactive material emanating a characteristic amount of energy in the form of alpha, beta, gamma, or x-ray emissions (or a combination of such emissions).
source	A single process or release point that contributes to or causes a release to the environment and that can be separated from other processes by a break in the flow of material.
spectroscopy	The measure of the energy distribution of the radiation emitted by material.
spent fuel	Nuclear fuel that has been withdrawn from a reactor after irradiation and has not been reprocessed to recover uranium and plutonium.

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spiked sample	A normal sample of material (gas, liquid, or solid) to which a known amount of radioactive material is added. Spiked samples are used to check on the performance of a routine analysis or the recovery efficiency of an analytical method.
stable isotope	A nuclide that does not undergo radioactive decay.
standard	A material having a known property that can be accurately established based on its physical or chemical characteristics.
standard deviation	An indication of the dispersion of a set of results around the average of samples collected or the mean of a population; the positive square root of the sample variance.
testing	Short-term evaluation of radioactive material releases that is representative of typical operations using prescribed techniques.
thermoluminescence	The property possessed by many substances of emitting light when heated. It results from release of energy storage as electron displacements in the crystal lattice.

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thermoluminescent dosimeter (TLD)	A type of dosimeter (or radiation measurement device) containing a "chip" of thermoluminescent material which emits light when subjected to heat. The amount of light emitted is directly proportional to the radiation dose absorbed by the chip, enabling the quantification of this dose.
tolerance limits	A particular type of confidence limit used frequently in quality control work where the limits apply to a percentage of the individual values of the population.
traceability	A documented chain of comparisons connecting a working standard (in as few steps as is practical) to a national (or international) standard, such as a standard maintained by the NBS or other acceptable standards.
tracer (radioactive)	One of several radioactive materials, of short half-life, that is introduced to a groundwater system to aid studies of groundwater movement.
transuranic waste (TRU)	Waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than twenty years, per gram of waste, except for: (1) high-level radioactive

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wastes; (2) wastes that the Department of Energy has determined, with the concurrence of the EPA Administrator, do not need the degree of isolation required by 40 CFR Part 191; or (3) wastes that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.

trenching	The digging of shallow trenches to expose the underlying stratigraphy, structure, etc., for inspection and sampling.
tuff	A compacted pyroclastic deposit of volcanic ash and dust that may contain rock and mineral fragments incorporated during eruption or transport.
validation (of a computer code)	The documented confirmation of the adequacy (i.e., suitability for its intended purpose) of the computer code under review--demonstration that what the software does is appropriate to the problem. Validation includes assurance that any physical model, as embodied in software, is a correct representation of the intended physical system or process.

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verification of computer codes	The documented confirmation that the computer code performs exactly the mathematical and logical operations described in the User's Manual and other documents.
windshield survey	Recording activities of interest in a chosen area by means of observation from a motor vehicle.
whole body	For radiation dose purpose, whole body refers to the uniform exposure of all organs and tissues in a human body.
working level	See Appendix B.